ISSN: 3026-5428

INCOBEST 2023

Universitas Muhammadiyah Surakarta
International Conference on Biology Education, Natural Science, and Technology

"Emerging Issues on Natural Science, Environment, and Its Learning Innovation"

PROCEEDINGS BOOK

International Conference on Biology Education, Natural Science, and Technology (INCOBEST)

June 17th, 2023 - Surakarta

DEPARTMENT OF BIOLOGY EDUCATION
FACULTY OF TEACHER TRAINING AND EDUCATION
UNIVERSITAS MUHAMMADIYAH SURAKARTA

incobest.ums.ac.id

ISSN: 3026-5428

Proceedings Book

International Conference on Biology Education, Natural Science, and Technology (INCOBEST)

"Emerging Issues on Natural Science, Environment, and Its Learning Innovation"

BUILDING C FLOOR 1, CAKAP ROOM FKIP UMS
Jl. A. Yani Tromol Pos 1 Pabelan Kartasura Surakarta, 57162
Phone. (0271) 717417 ext. 2147 , Fax. (0271) 715448
E-mail: incobest@ums.ac.id
Website: http://incobest.ums.ac.id

DEPARTMENT OF BIOLOGY EDUCATION
FACULTY OF TEACHER TRAINING AND EDUCATION
UNIVERSITAS MUHAMMADIYAH SURAKARTA
2023

Copyright@2023 INCOBEST

ISSN 3026-5428

Proceedings Book of
International Conference on Biology Education, Natural Science, and Technology (INCOBEST) 2023
Emerging Issues on Natural Science, Environment, and Its Learning Innovation

Surakarta, October 25th, 2023

Incobest 2023 Secretariat
Department Of Biology Education
Faculty Of Teacher Training And Education
Universitas Muhammadiyah Surakarta
Email: incobest@ums.ac.id
Website: incobest.ums.ac.id

+6281548719313
incobest@ums.ac.id
incobest.ums.id

FOREWORD

Alhamdulillah, with all gratitude for the presence of Allah SWT, who has bestowed His grace, guidance, and inayah so that the Biology Education Study Program, Faculty of Teaching Training and Education (FKIP), Universitas Muhammadiyah Surakarta (UMS) can organize **International Conference on Biology Education, Natural Science, and Technology (INCOBEST) 2023**. The conference with the theme "Emerging Issues on Natural Science, Environment, and Its Learning Innovation" is a manifestation of concern and dedication to the enhancement of research and education quality in Indonesia. Educators (teachers and lecturers) must be aware of strategic issues in the fields of science, environment, and learning innovation in order to adapt and advance their knowledge.

This conference aims to achieve the implementation of the Tri Dharma of Higher Education, encompassing education, research, and community service, and to realize academic freedom by introducing the Biology Education Study Program FKIP UMS as a part of the Institute of Education Personnel, that is capable of collaborating with various educational and non-educational agencies.

The activities of this International Conference have been made possible by the assistance of an array of parties. Thus, on this occasion, appreciation is extended to:

1. Dean of FKIP UMS
2. All committees of INCOBEST 2023.
3. Reviewer team, both internal and external.
4. Participants and speakers.
5. Other parties that cannot be mentioned one by one.

Finally, we hope this International Conference will benefit all parties and improve education in Indonesia.

Surakarta, October 25th 2023

Committee

+6281548719313
incobest@ums.ac.id
incobest.ums.id

FOREWORD

INTRODUCTION

Science and the environment are ever-changing. The world is experiencing one of the most rapid advancements in science and technology. The world has numerous innovations and advancements in various disciplines, including industry, information, and telecommunications, high technology in space, robot technology, and biotechnology and molecular advances. In the era of globalization, where science and technology are one of the indicators of a nation's progress in facing global competition, almost every nation in the world has raced to develop every aspect of their life based on science and technology as a result of the development and progress in these various fields.

John Naisbitt and Patricia Aburdene, in the book 'Megatrends 2000', predicted that one of the 21st-century megatrends is the shift from physical models and metaphors to biological models and metaphors to help us understand today's dilemmas and opportunities. The prediction of John Naisbitt and Patricia Aburdene is realistic. Isn't it that before entering the 21st century, advances in biology have been felt up to the extraordinary advances in modern biology? He continued, we will prepare further on the threshold of a significant era: Biotechnology. In the era of the 21st century, biotechnology, as previously predicted, will be as important as computers. Biotechnology will be booming; at least the first directions of biotechnology that have been developed are in the fields of agriculture and animal husbandry, the food industry, to the clothing and health industries. Biotechnology companies are racing with new drug discovery and development to reach more than 300 drug products and 200 vaccines for diseases worldwide, including cancer, Alzheimer's, heart disease, AIDS, arthritis, and various infectious diseases in developing countries.

The genetic manipulation of plants and animals is another biotechnology development that is advancing rapidly at present. Transgenic vegetation can be produced through genetic engineering. This is an innovation in the development of high-yielding, disease-resistant, and postharvest storage-resistant plants of superior quality.

The accelerated advancement of science and technology has an effect on education. In order to actualize the expectation that education will produce graduates who can compete in the workforce, numerous innovations must be developed. Curriculum modifications at various levels, including elementary, secondary, and tertiary education, seek to equip graduates with life-applicable skills.

The preparation of the Indonesian National Qualifications Framework, a competency alignment framework that can juxtapose, equalize, and integrate between the fields of education and job training as well as work experience in the context of providing recognition of work competence by the structure of work in various sectors, enables the alignment of graduates at various levels of education in Indonesia so that they can compete globally. Regarding Indonesia's national education and training system, the framework is a manifestation of the quality and identity of the Indonesian nation.

Educators (teachers and lecturers), as well as researchers and observers in these disciplines, must be aware of current issues in science, the environment, and learning innovation in order to adapt and continually expand their knowledge. Following the most recent developments in their field is hoped to be a catalyst for improving the quality of research and education in Indonesia.

In response to the extremely rapid development of science, the environment, and learning innovations, the Biology Education Study Program FKIP UMS has scheduled the first **International Conference on Biology Education, Natural Science, and Technology (INCOBEST) 2023 as the continuation of the previous** National Education and

+6281548719313
incobest@ums.ac.id
incobest.ums.id

FOREWORD

Science Seminar (SNPBS) VII 2022 as a form of concern and commitment to the improvement of the quality of research and education in Indonesia. This is the first International Conference to continue SNPBS, which was implemented successfully between 2016 and 2022.

INCOBEST 2023
Universitas Muhammadiyah Surakarta
International Conference on Biology Education, Natural Science, and Technology

COMMITTEE COMPOSITION OF 1ST INCOBEST 2023

Person in charge of activities	:	Chief of Biology Education Department, Faculty Of Teacher Training And Education UMS (Putri Agustina, S.Pd, M.Pd)
Advisory Board	:	Prof. Dr. Sofyan Anif, M.Si Dra. Aminah Asngad, M.Si Dra. Suparti, M.Si Dr. Djumadi, M.Biomed
Chairman of the committee	:	Yasir Sidiq, S.Pd., M.Sc .Ph.d
Secretary and Secretariat	:	Dwi Setyo Astuti, M.Pd Siti Kartika Sari, M.Pd Annur Indra Kusumadani, M.Pd Dr. Paramita Cahyani, M.Pd
Treasure	:	Rina Astuti, M.Pd. Endang Setyaningsih, S.Si, M.Si
Public relations	:	Dra. Hariyatmi, M.Si
Food	:	Ima Aryani, S.Pd, M.Pd
Equipment	:	Rifky Arif Rahmat, S.Pd, M.Pd Mazwar Ismiyanto, M.Pd
Event organizer	:	Erma Musbitha Tyastuti, S.Si, M.Si Dra. Titik Suryani, M.Sc Dr. Triastuti Rahayu, M.Si M. Imam Fatkhurrohman, M.Sc Muhammad Wisnu, M.Biotech
Proceedings and Book of Abstracts	:	Dr. Efri Roziaty, M.Si Dr. Santhyami, M.Si Dr. Ambarwati, M.Si Guntur Nurcahyanto, ST., M.Pd

TABLE OF CONTENT

COVER ..... **i**

FOREWORD ..... **iii**

INTRODUCTION ..... **iv**

COMMITTEE COMPOSITION OF 1ST INCOBEST 2023 ..... **vi**

TABLE OF CONTENT ..... **vii**

KEYNOTE SPEAKERS' MATERIALS

The ecology of Zaprionus genus in Brazil and adaptation process during the bioinvasion
Prof. Dr. Luís Gustavo da Conceição Galego 1

Emerging Innovations In Natural Science Education.
Haniza Hanim binti Mohd Zain, PhD. Assoc Professor 22

Metagenomic studies and their applications.
Dr. Triastuti Rahayu, S.Si., M.Si 23

PARALLEL SESSION SPEAKERS MATERIALS

Development of Android-Based Interactive Teaching Materials Using the Ispring Application with Insight into Sustainable Development.
Nurhasnah, Lufri, Abdul Razak, Festiyed, Prima Aswirna, Windy Kasmita, and Wetri Yesmoneca 33

The Effect of STEM Approach on Students' Critical Thinking Skills.
Media Roza, Minda Azhar, Festiyed, Prima Aswirna, and Rika Purnama Sari 42

Inventory of Montane Zone Weeds in the Selo Tourism Area, Boyolali Regency, Central Java.
Nila Permatasari, and Santhyami 52

Development of Problem-Based HOTS (Higher Order Thinking Skill) Question Instruments on Class VIII Pressure Material.
Rina Irawati, Sukarmin, and Sri Yamtinah 62

The Characteristics of Herbal Tea Combination Between Butterfly Flower with Mint and Pandan Leaf on Drying Duration Variation.
Titik Suryani, Ria Anisa Rahmasari, and Riza Ainun Nisa 68

Preservice Biology Teacher's TPACK Integration into Lesson Planning.
Putri Agustina, Lina Agustina, Rina Astuti, Yesi Chotimah, Putri Gayatri Ramadhanty, and Alanindra Saputra 77

+6281548719313
incobest@ums.ac.id
incobest.ums.id

TABLE OF CONTENT

Students' Creative Thingking Ability in view From The Level of Understanding in Waste Management.
Syarifah Zahrah, Rita Retnowati, and Rita Istiana 84

Monitoring The Correlation of Climatics to The Airborne Bacteria at The Manggarai Station, South Jakarta, Indonesia.
Reza Anindita, Auliya Rahmawati, Maulin Inggraini, Melania Perwitasari, Dede Dwi Nathalia, Maya Uzia Beandrade, and Intan Kurnia Putri 91

The Effect of Active Learning Integrated with Everyone Is A Teacher Here Strategy Based on Questioning and Answering on The Critical Thinking Skills and Biology Learning Retention of Class XI Senior High School Students In The Industrial Agriculture Area.
Kurnia Suciningsih, Bea Hana Siswati, Nadyatul Ilma Indah Savira 101

The Effect of STEM (Science, Technology, Engineering, and Mathematics) based Textbooks in Biotechnology Learning Material on The Critical Thinking Skills and Learning Results of Senior High School Students in The Industrial Agriculture Area.
Kamilatul Khoiroh, Bea Hana Siswati, Kamalia Fikri 109

Quality of *Moringa oleifera* Leaf and Kiambang (*Salvinia molesta*) Solid Organic Fertilizer with Banana Peel Bioactivator.
Desvia Puput Apriani, and Aminah Asngad 122

Quality of Solid Organic Fertilizers for Duck Manure and Trembesi Leaves with Papaya Peel Bioactivator.
Musdhalifah Husna Firdausi, Aminah Asngad 133

Inventory of Moss Plants (Bryophyta) in the Montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province.
Eva Diahayu Wardani and Santhyami 143

Diversity of Ferns (Pteridophyta) in the Montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province.
Indah Rahmawati and Santhyami 152

Quality of Solid Organic Fertilizer from Moringa Leaves and Peanut Shells with Banana Peel Bioactivator.
Nur Afifah Mustikasari, and Aminah Asngad 160

Quality of Liquid Organic Fertilizer Peanut Shells and Tofu Dregs With Banana Stems as Bioactivator.
Muhammad Rizal Kahfi, and Aminah Asngad 171

The Quality of Infrastructure Facilities and the Readiness of Biology Laboratories to Support Learning in High School.
Mei Renni Sholikhah, and Lina Agustina 181

Quality of Duck Manure Fertilizer and Paitan Leaves with the Addition of MOL Papaya Skin.

+6281548719313
incobest@ums.ac.id
incobest.ums.id

TABLE OF CONTENT

Hana Khairunnisa, and Aminah Asngad 193

Quality of Liquid Organic Fertilizer Combination Gamal Leaves and Tofu Dregs with Banana Stem Bioactivator.
Feby Istifarini, and Aminah Asngad 204

The Effects of Socio-Scientific Approach on Junior High School Students' Learning Outcomes.
Salsabila Nur Rahmadhani, Putri Agustina, and Sri Mulyani 215

Study of Science Practicum in Junior High School, Sukoharjo, Indonesia.
Farikha Muya Sarah, Putri Agustina and Harini Hastowati 227

Quality of Kefir Combination Between Soy Milk and Skim Milk On Variation of Sugar and Fermentation Duration.
Masithoh Uswatiningtyas and Titik Suryani 241

Coconut Husks and Eggshells Liquid Organic Fertilizer's Effect on The Growth and Calcium Levels of Kale.
Nabila Junisky Susetyawati and Aminah Asngad 248

Phosphate Solubilisation Index and Antagonism Potential of Frangipani Tree Rhizosphere Bacterial Isolates from Cemetery.
Vika Febriyanti, Erma Musbita Tyastuti, Yasir Sidiq, and Triastuti Rahayu 260

Coconut Husk and Eggshell Liquid Organic Feltilizer Effect On Lettuce Growth And Calcium Levels.
Widya Husnul Khotimah, and Aminah asngad 269

Quality of Kirinyuh Leaf Liquid Organic Fertilizer and Coconut Water Waste With Pineapple Skin Bioactivator.
Arisa Putri Jihan Nitami, and Aminah Asngad 280

Isolation and Characterization of Cellulolytic Bacteria from Bonoloyo, Cemetery.
Wanda Datik Risnasari, Erma Musbita Tyastuti, Yasir Sidiq, and Triastuti Rahayu 291

Application of Project Based Learning Model to Improve Critical Thinking Skills of Students SMA Muhammadiyah 1 Sragen.
Tasya Cahya Dwi Purwanti, and Rina Astuti 299

Quality of Kefir Combination Between of Goat's Milk and Skim Milk on Variations of Sugar and Fermentation Duration.
Erna Kurniawati, and Titik Suryani 305

Quality of Herbal Tea Combination Between Corn Silk and Stevia Leaf on Variation of Temperature and Drying Duration.
Feny Nafiza, and Titik Suryani 314

Isolation and Identification of Soil Bacteria in Pracimaloyo Public Cemetery, Kartasura.
Bagas Adityaradja, Erma Musbita Tyastuti, Yasir Sidiq, and Triastuti Rahayu 326

+6281548719313
incobest@ums.ac.id
incobest.ums.id

TABLE OF CONTENT

LOF Kirinyuh Leaves and Liquid Waste Tempeh with Pineapple Peel Bioactivator: Sensory and Macronutrient Content.
Nur Jati Sekaringsih, and Aminah Asngad 335

Glucose Levels and Organoleptic Quality Probiotic Tepache of Pineapple Peel on Variation of Sugar and Fermentation Duration.
Qurota A'yuni Nuha Sabira, and Titik Suryani 348

Empowerment of Animalia Classification Material: A Review of Literature.
Tunjung Nala Puti, Puguh Karyanto, Umi Fatmawati 356

Quality of Herbal Tea Combination Between Corn Silk and Mint Leaf in a Variation of Temperature and Drying Duration.
Imroatul Husna, and Titik Suryani 368

Number of Erythrocytes of White Rats (*Rattus norvegicus*) Sonded with a Combination of Porang Tuber and Moringa Leaf Extract.
Alya Anggitasari, and Endang Setyaningsih 375

Pakcoy *(Brassica chinensis L.)* Growth Using Moringa Leaf Extract with the Addition of Red Onion Skin.
Dwi Putri Widjaya, and Suparti 385

Mustard (*Brassica Juncea* L.) Growth Hydroponically Using AB-Mix and Liquid Organic Fertilizer Tea Pulp.
Dinda Putri Trisnawati, and Suparti 394

The Effect of Cassava Peel Powder on the Productivity of the Brown Oyster Mushroom (*Pleurotus cystidiosus*).
Emmalia Rahmawati, and Suparti 402

Analysis of Misconceptions on Reproductive System Material in Class XI IPS 2 Students of SMA Negeri 6 Madiun.
Jevi Milda Rahmawati, Ima Agung Nurcahyo, and Cicilia Novi Primiani 411

Inventory of Epiphytic Lichen Foliose on Tea Plants in Ngargoyoso, Karanganyar, Central Java.
Dika Dwi Irnawati, and Efri Roziaty 421

Manuscript Writing Guidelines: Analysis of Creative thinking skills profile of Senior High school students in Madiun City on Biotechnology topic.
Herning Nurdiana, Ima Agung Nurcahyo, and Cicilia Novi Primiani 430

Plasma Protein of Obese White Rats Treated with of Glucomannan Porang Tubers and Moringa Extract.
Sabila Dina Ikhsani, and Endang Setyaningsih 438

Effectiveness of *Flipped Classroom* Model with Instagram in Junior High School.
Mega Amartya Istighfarin, and Lina Agustina 438

+6281548719313
incobest@ums.ac.id
incobest.ums.id

TABLE OF CONTENT

Application of the NHT Model Combined with Question Cards on Biology Learning Outcomes.
Nabilla Riska Nurjannah, and Djumadi 455

Growth Red Spinach (*Amaranthus amoena)* by Hydroponics Using Charcoal Media Husk.
Isherdini, Dyah Salma Nurlaila, and Suparti 464

Oxygen Consumption and BB *Rattus novergicus* Obesity Sonde Treatment Glucomanan Porang Tubers and Moringa Leaf Extract.
Mustika Arum Mayang Sari, and Endang Setyaningsih 473

The Effect of Kepok Banana Skin Liquid Organic Fertilizer (*Musa paradisiaca*) on the Growth of Mustard Plants (*Brasicca juncea* L.).
Isherdini, Berliana Putri Athena, and Suparti 484

The Effect of PBL Learning Model Combined with Rewards and Punishment on Science Learning Outcomes.
Annisa' Tri Yudhatami, and Djumadi 489

Antioxidant Activity and Organoleptic Quality of Probiotic Tepache of Pineapple Peel Sugar Variation and Fermentation Duration.
Fithrotul Haq Rabbani Abdurrahman, and Titik Suryani 502

Analysis of Plant Vegetation in Sekipan Forest Tawangmangu District, Karanganyar District.
Ima Aryani, and Shal Syabela Riskawati 509

Health Examination of The Digestion of Proboscis Monkey (*Nasalis larvatus*) Through Bacteriological Tests on Feces.
Camalia Maisya, Anni Nurliani, Amalia Rezeki, and Rusmiati 518

The Phylogeny of Parasitic Hemiptera Using *Multivariate Statistical Package* Cluster Analysis.
Dwi Setyo Astuti, and Murwanto Setyo Nugroho 533

Identification of Intestine Parasite Worms Eggs in Feces Proboscis Monkey (*Nasalis larvatus*).
Fiqita Giulleta Irtifannisa Rahman, Anni Nurliani, Amalia Rezeki, and Rusmiati 541

Ethnobotanical Study of Tea Plants Based on Local Wisdom in Ngargoyoso District, Karanganyar Regency, Central Java.
Kharisma Margiyana Dinda Hapsari, and Efri Roziaty 550

Scientific Learning with PJBL and PBL Models of Science Process Skills Student Learning Outcomes.
Farid Nur Yusron, Sarwanto, Mohammad Masykuri 557

Water Quality in Satui River and Histological Structure Study of Liver of Baung Fish (*Mystus nemurus*).
Dinda Triana, Heri Budi Santoso, and Anang Kadarsah 564

+6281548719313
incobest@ums.ac.id
incobest.ums.id

TABLE OF CONTENT

Profile of Creative Thinking Skill of New Normal Era at Junior High School Students.
Farida Amrul Almuharomah, Widha Sunarno, and Mohammad Masykuri 572

The Feasibility and Effectiveness of High-Level Thinking Tests on Virus to Mapping The Ability of Prospective Science Teacher (Introduction Study on The Development of Integrated Learning Models).
Annur Indra Kusumadani, Sentot Budi Rahardjo, Sri Yamtinah, and Baskoro Adi Prayitno 580

PBL-Based Science Learning on Living Things Interaction in Junior High School.
Hariyatmi, and Hidayatus Sholihah Tisniasari 587

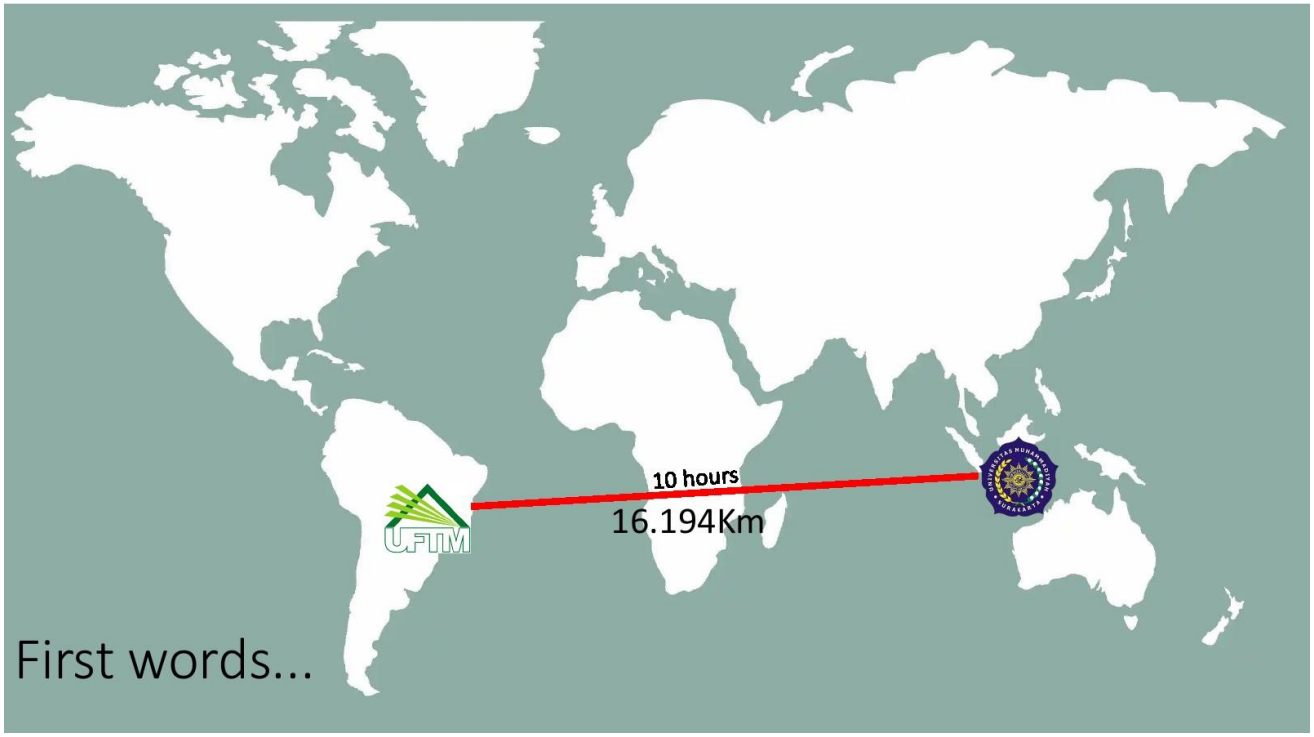
INCOBEST 2023
Universitas Muhammadiyah Surakarta
International Conference on Biology Education, Natural Science, and Technology

INCOBEST
Universitas Muhammadiyah Surakarta
International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

UNIVERSITAS MUHAMMADIYAH SURAKARTA
FAKULTAS KEGURUAN DAN ILMU PENDIDIKAN
PROGRAM STUDI PENDIDIKAN BIOLOGI
Jl. A. Yani Pabelan Kartasura, Tromol Pos 1 Surakarta 57102 Telp. 0271-717417, Psw. 147/326

The ecology of *Zaprionus* genus in Brazil and adaptation process during the bioinvasions.

Prof. PhD. Luís Gustavo da Conceição Galego
Education and Natural and Exact Sciences Institute (ICENE)
Federal University of Triângulo Mineiro (UFTM)



About me:

Majored in:

- Life Sciences

Pos Graduated in:

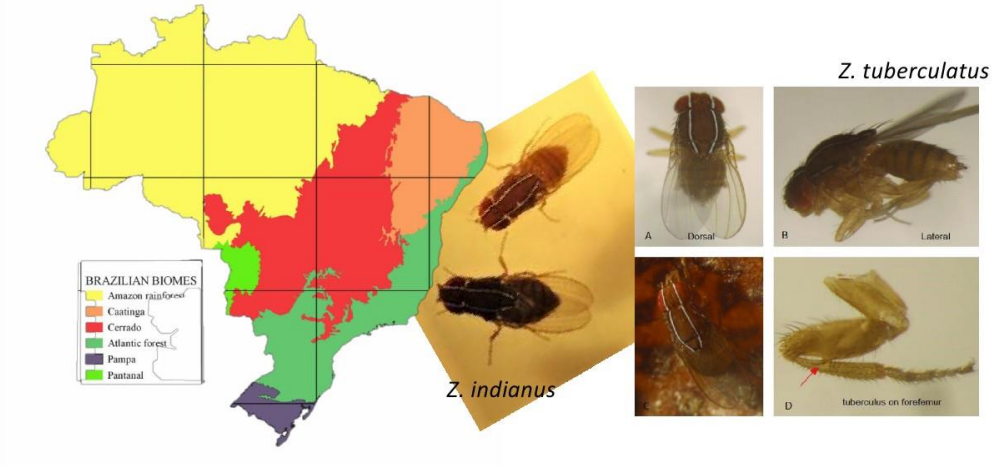
- Genetics (Master e PhD)
- Biosciences (Pos-Doctoral)

I´ve been studying *Zaprionus indianus* since 2000, soon after of their first record in Brazil (1999)

From 2023, we have started studies with *Z. tuberculatus.*

Structure of the talk:

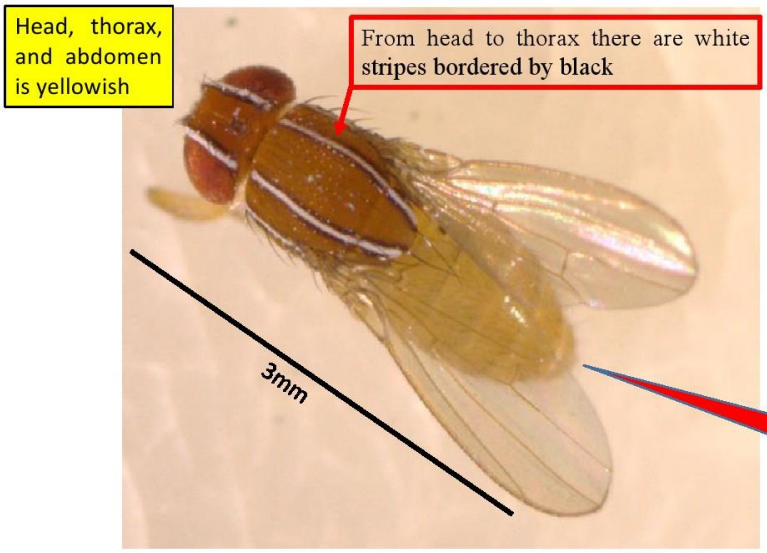
- 1) Introduction
- 2) Bioinvasion throughout Brazil: ecological and adaptation processes
- 3) *Zaprionus tuberculatus* in Neotropical region



Structure of the talk:

•1) Introduction

Introduction – Morphology and Taxonomy



Animalia
Arthropoda
Insecta
Diptera
Schizophora
Drosophilidade
Zaprionus
Zaprionus indianus

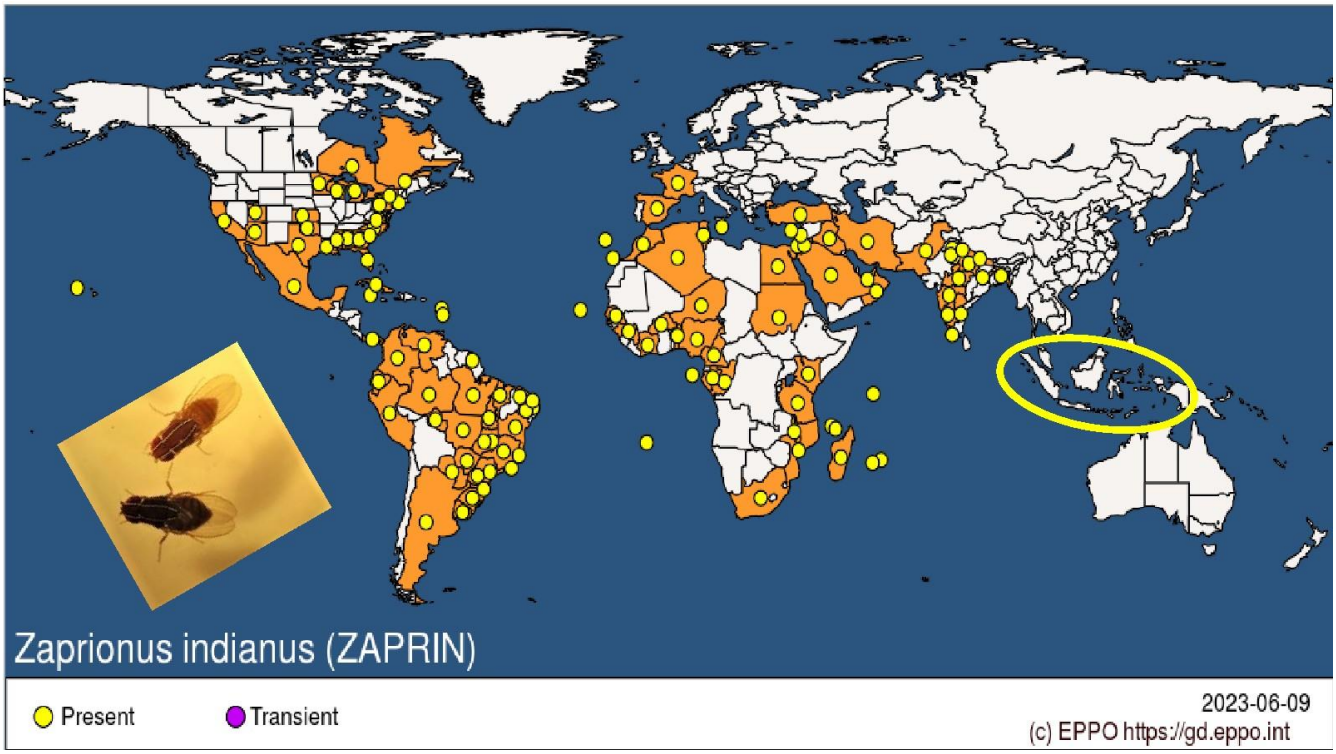
Did you know this fly species before today?

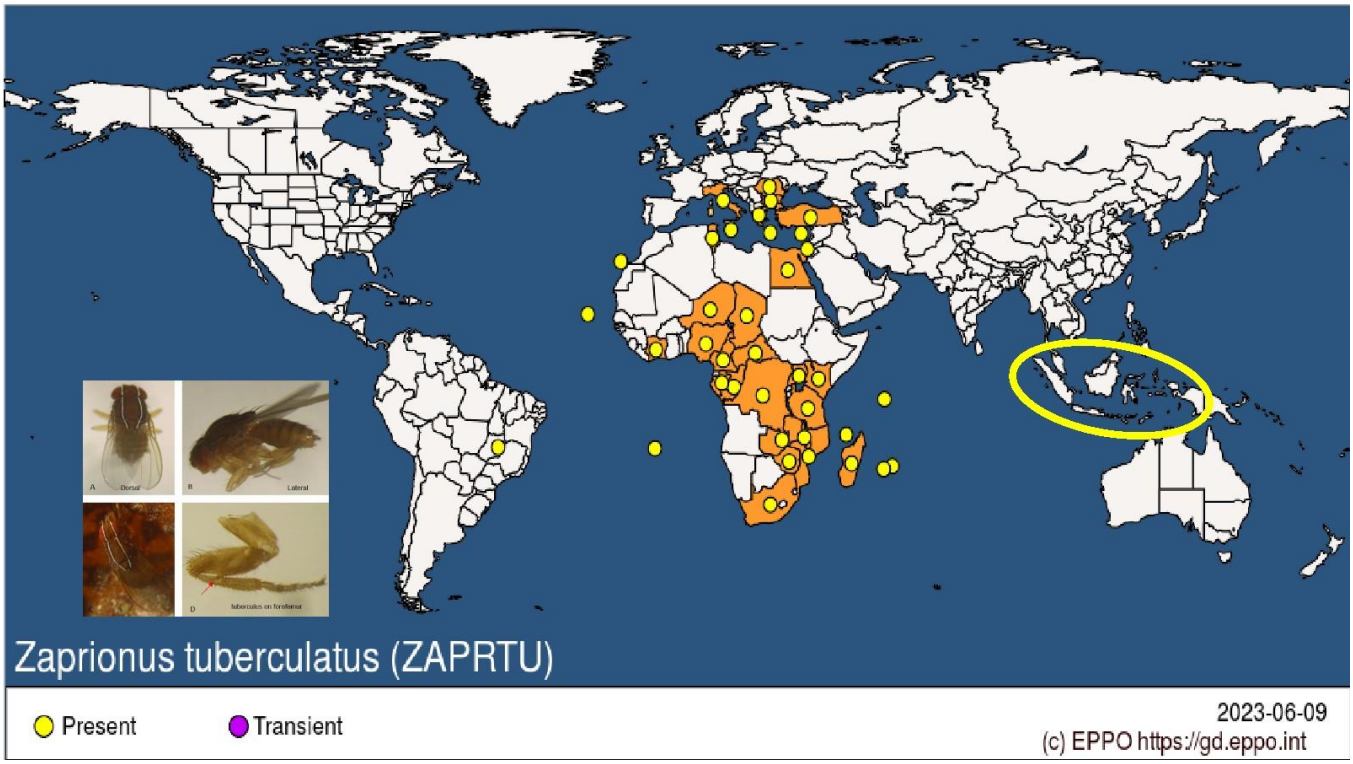
Gupta, 1970

Introduction – Morphology and Taxonomy

Animalia
Arthropoda
Insecta
Diptera
Schizophora
Drosophilidade
Zaprionus
Zaprionus tuberculatus

Gupta, 1970


Zaprionus indianus (ZAPRIN)
Present
Transient
2023-06-09
(c) EPPO https://gd.eppo.int


Zaprionus tuberculatus (ZAPRTU)
Present
Transient
2023-06-09
(c) EPPO https://gd.eppo.int

Structure of the talk:

•2) Bioinvasion throughout Brazil: ecological and adaptation process

Genetics and Molecular Biology, 35, 2, 395-406 (2012)
Copyright © 2012, Sociedade Brasileira de Genética. Printed in Brazil
www.sbg.org.br

Review Article

Taxonomic and evolutionary analysis of *Zaprionus indianus* and its colonization of Palearctic and Neotropical regions

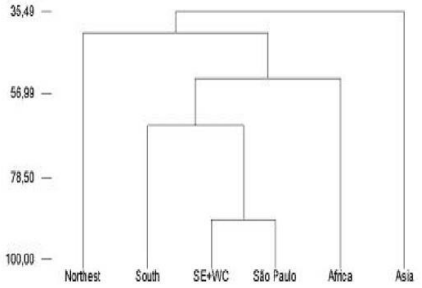
Leliane Silva Commar[1], Luis Gustavo da Conceição Galego[2], Carlos Roberto Ceron[3] and Claudia Marcia Aparecida Carareto[1]

Figure 1 - Migration routes for *Z. indianus* involved in its dispersal throughout the world, based on studies cited in the text. The process that occurred in Brazil is highlighted.

Vilela (1999) and Commar *et al.* (2012)

Analysis of the drosophilid *Zaprionus indianus* introduction in Brazil: contribution of esterase loci polymorphisms.

Galego, Luís Gustavo C., and Claudia Márcia A. Carareto. UNESP – São Paulo State University, Rua Cristóvão Colombo, São José do Rio Preto - São Paulo – Brasil; e-mail: carareto@ibilce.unesp.br.



-After the arrival, *Z. indianus* has spread over the State of São Paulo by highway transportation and from there to the whole country, mainly as a result of fruit commerce.

-After its introduction, *Z. indianus* rapidly spread over the southeastern, southern, and mid-western regions, only reaching the northern and north-eastern regions later on.

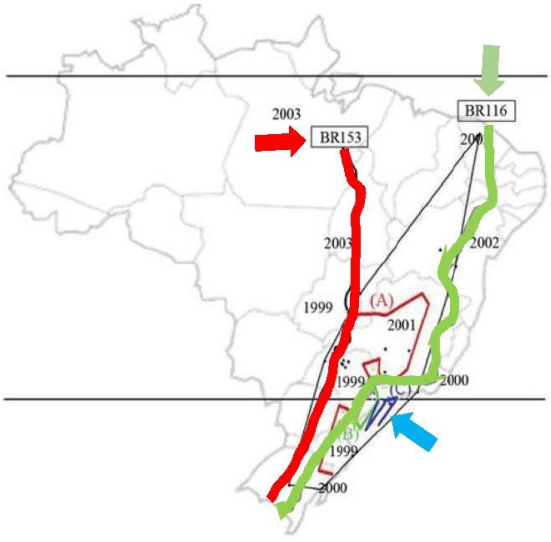
Genetics and Molecular Biology, 33, 4, 767-773 (2010)
Copyright © 2010, Sociedade Brasileira de Genética. Printed in Brazil
www.sbg.org.br

Research Article

Scenario of the spread of the invasive species *Zaprionus indianus* Gupta, 1970 (Diptera, Drosophilidae) in Brazil

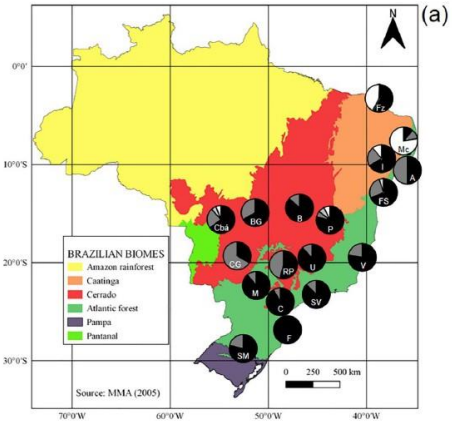
Luís Gustavo da Conceição Galego and Claudia Marcia Aparecida Carareto

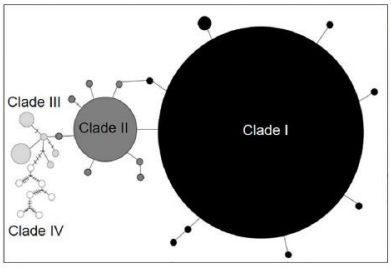
Z. indianus, after first arriving in São Paulo state, spread throughout the country, probably together with the transportation of commercial fruits by way of the two main Brazilian freeways, **BR 153**, to the south and the surrounding countryside, and the **BR 116** along the coast and throughout the north-east.



Networking haplotype (Est6-like)

-There are 4 clades to *Z. indianus* Est-6 like DNA sequences;
-The clades 1 and 2 are widely distributed;
-Clades 3 and 4 are more restricted, and they were detected only in populations from **Pantanal** and **Caatinga** (two Biomes from Brazil)





Galego and Carareto, in preparation

Population size

Z. indianus showed the highest frequencies compared to other drosophilids during the seasons with the highest mean temperatures, but the frequency consistently dropped during autumn and winter to increase again in the spring.

Santos et al., 2005

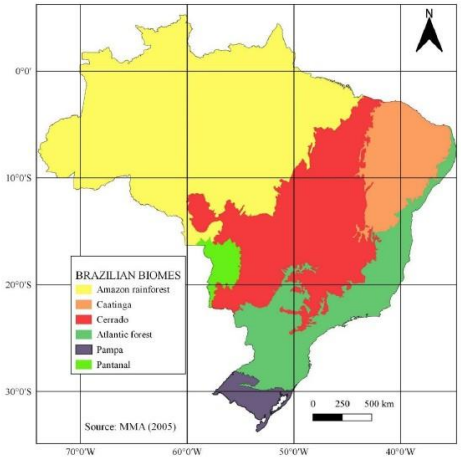
Demography on Brazilian Biomes

Variation in the abundance of *Z. indianus* among Brazilian biomes:

a) The abundance of *Z. indianus* in the **cerrado** and **riverine forests** is greater in the cerrado during rainy periods;

b) *Z. indianus* is the most abundant species in the urbanized environment;

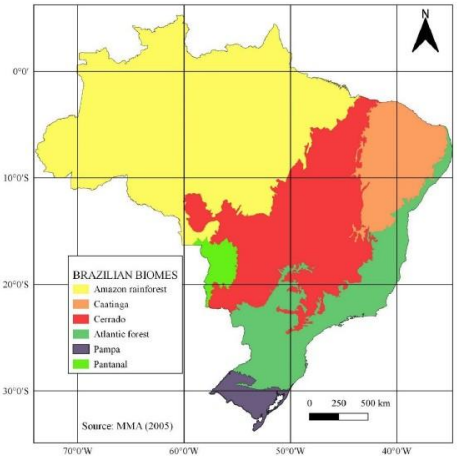
c) In mangrove forests was higher than in the **Atlantic rain forest** but **lower than in the cerrado or in urban environments;**



Tidon *et al.* (2003); Ferreira and Tidon (2005); Tidon *et al.*, (2003); Commar *et al.*, 2012.

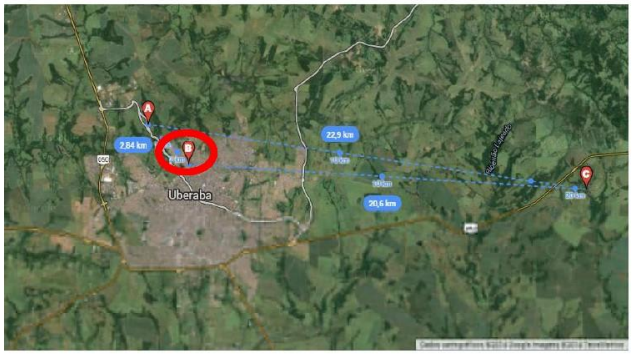
Demography on Brazilian Biomes

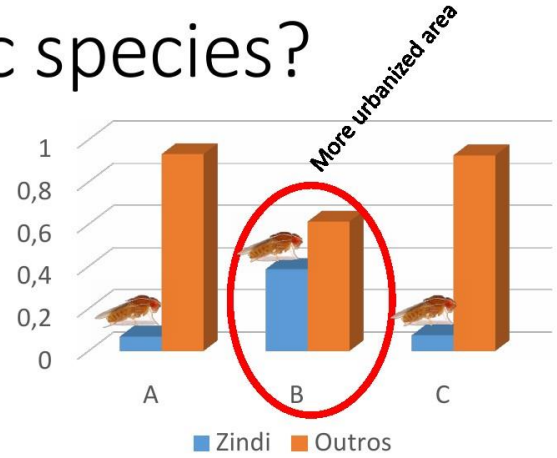
Cerrado > **Caatinga** > **Pampa** > **Pantanal** > **Atlantic rain forest**



Tidon *et al.* (2003); Ferreira and Tidon (2005); Tidon *et al.*, (2003); Commar *et al.*, 2012.

Is it a synurbic species?





Several studies indicate that together with other introduced Drosophilidae, *Z. indianus* could be useful as an **indicator of disturbed areas**.

Ferreira and Tidon (2005); Rodrigues and Galego, in preparation.

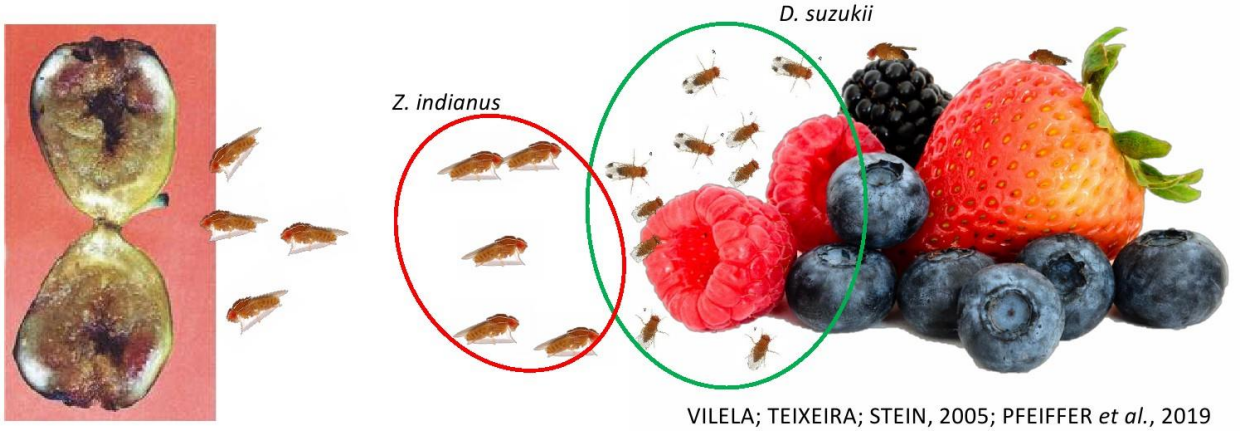
Niche occupation

- -It is a polyphagous species and it was detected in more than 80 different species of plants

LACHAISE; TSACAS, 1983; GOTTSCHALK, 2008

Niche occupation

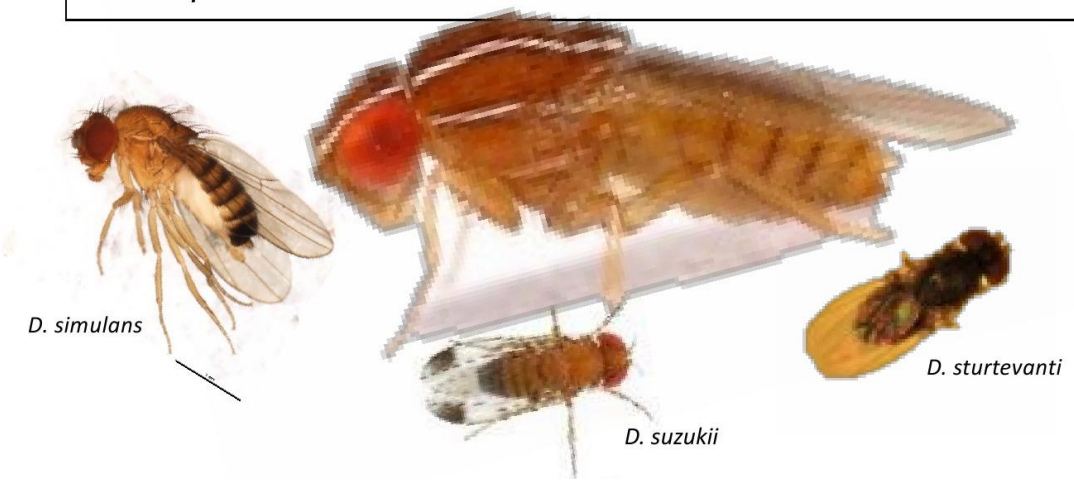
Z. indianus is considered a potential secondary pest in soft fruits and it damaged fig culture in Brazil during their introduction.



VILELA; TEIXEIRA; STEIN, 2005; PFEIFFER *et al.*, 2019

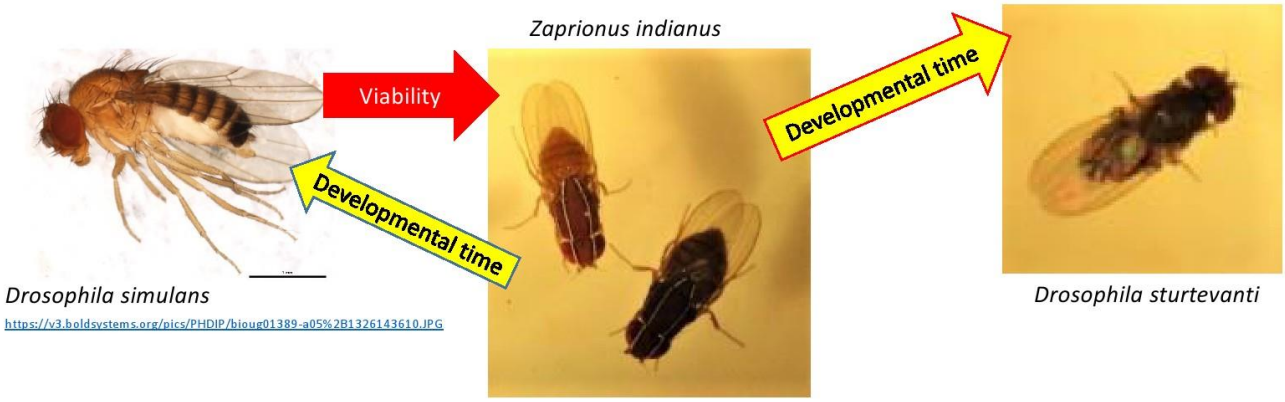
Niche occupation

- *Z. indianus* showed competitive advantage against other species of *Drosophila* with which shares niches.



INTRASPECIFIC AND INTERSPECIFIC PRE-ADULT COMPETITION ON THE NEOTROPICAL REGION COLONIZER *ZAPRIONUS INDIANUS* (DIPTERA: DROSOPHILIDAE) UNDER LABORATORY CONDITIONS [1]

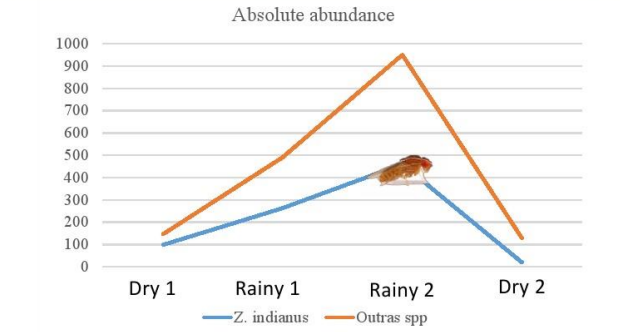
LUÍS GUSTAVO DA CONCEIÇÃO GALEGO [2]; CLAUDIA MARCIA APARECIDA CARARETO [2]

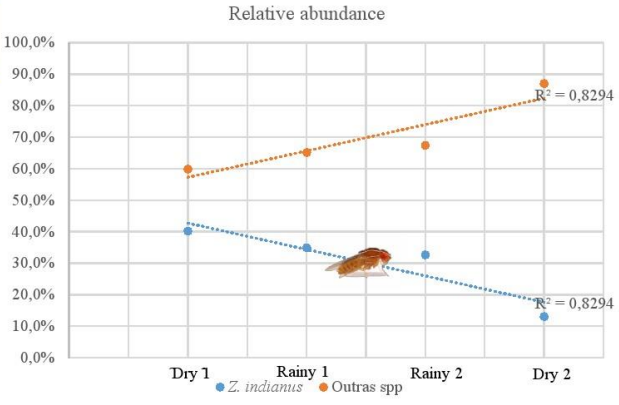


Niche occupation

Seasonal variation in demography, morphometry, and genetics in Cerrado population due to pressures caused by rain distribution and competition during the year.

Greater intraspecific competition in dry seasons and interspecific in rainy ones.





POSSARI; GALEGO, in preparation.

Niche occupation

Seasonal variation in demography, morphometry, and genetics in Cerrado population due to pressures caused by rain distribution and competition during the year.

Dry season

Bigger

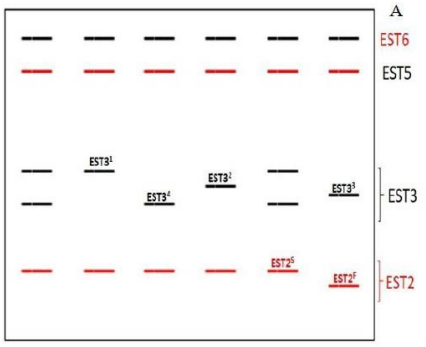
Rainy season

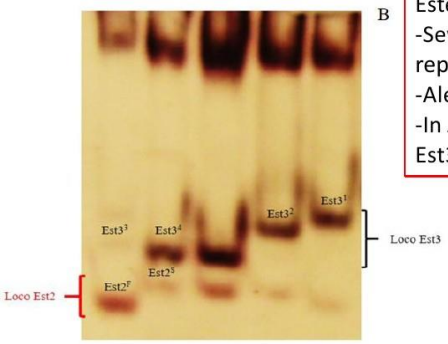
Smaller

POSSARI; GALEGO, in preparation

Niche occupation

Seasonal variation in demography, morphometry, and genetics in Cerrado population due to pressures caused by rain distribution and competition during the year.



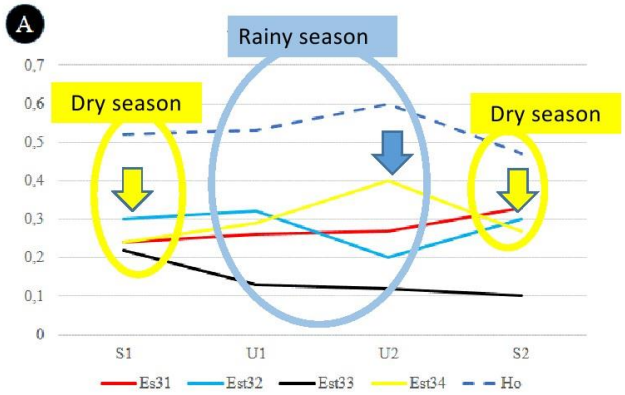


Esterases (enzymes):
-Several biological functions (feed, reproduction, development)
-Alelle polymorphisms
-In *Z. indianus* => Two loci:
Est3 (4 alelles) and Est2 (2 alelles)

Galego, Ceron and Carareto, 2006

Niche occupation

Seasonal variation in demography, morphometry, and genetics in Cerrado population due to pressures caused by rain distribution and competition during the year.



Est2 loci (Esterases)

-Greater frequency of $Est3^2$ allele in the dry season and the $Est3^4$ in the rainy one;

-No significant variation for heterozygosity

POSSARI; GALEGO, in preparation.

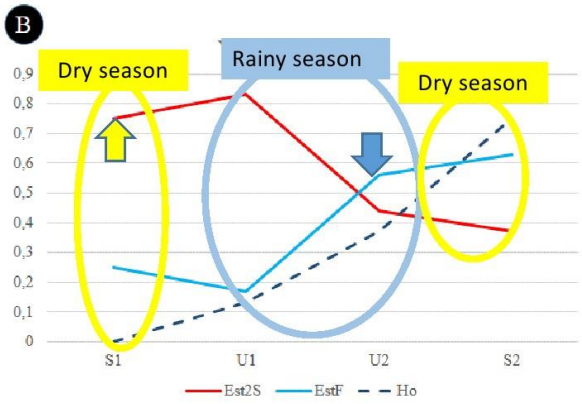
Niche occupation

Seasonal variation in demography, morphometry, and genetics in Cerrado population due to pressures caused by rain distribution and competition during the year.

Est2 loci (Esterases)

-Greater frequency of $Est2^S$ allele in the dry season and the $Est2^F$ in the rainy one;

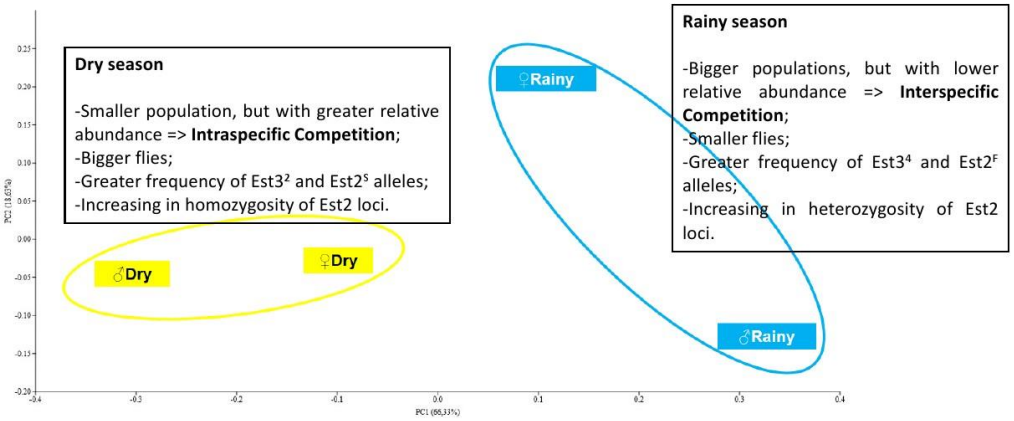
-Increased heterozygosity during rainy seasons



POSSARI; GALEGO, in preparation

Niche occupation

Seasonal variation in demography, morphometry, and genetics in Cerrado population due to pressures caused by rain distribution and competition during the year.

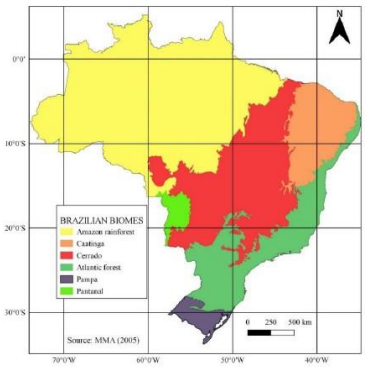


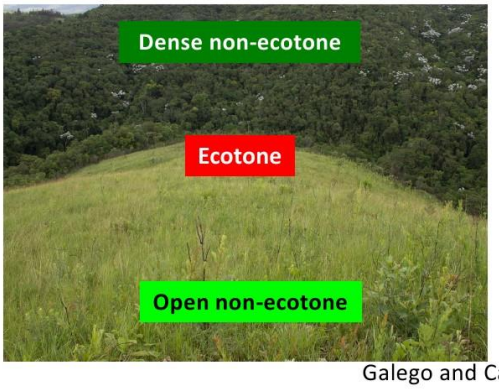
Demography
+
Morphometry
+
Genetics

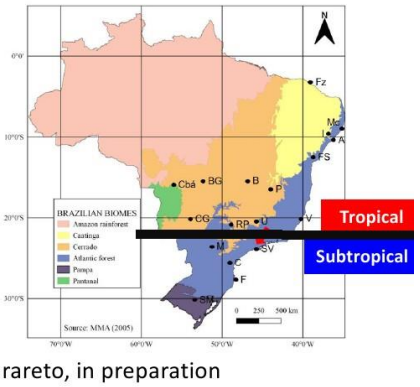
POSSARI; GALEGO, in preparation

Niche occupation

- Genetic structuring in population from biomes (Cerrado and Atlantic forest) and ecotones, or from different climatic zones (Tropical or subtropical)



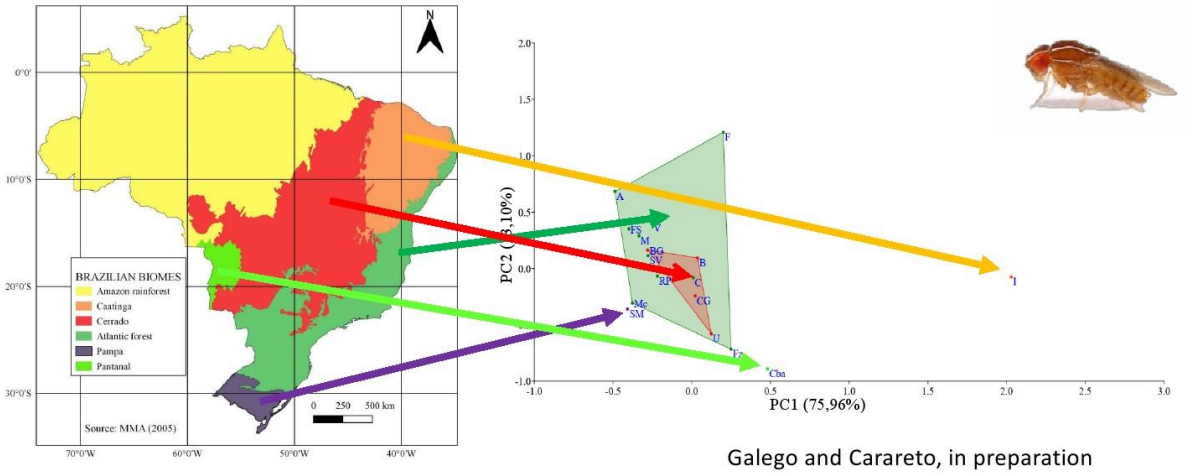




Galego and Carareto, in preparation

Niche ocupation - Biomes

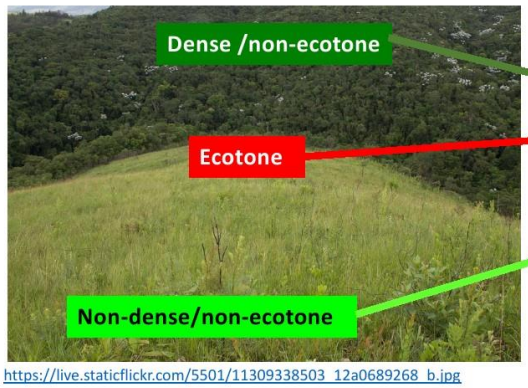
- Genetic structuring in population from biomes (Cerrado and Atlantic forest) and ecotones, or from different climatic zones (Tropical or subtropical)



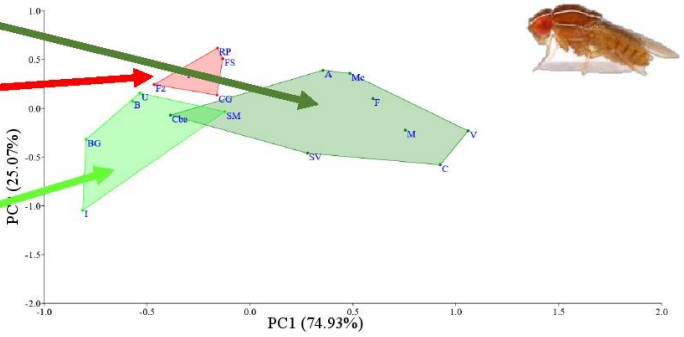
Galego and Carareto, in preparation

Niche occupation – Ecotones/Non Ecotones (Vegetation)

- Genetic structuring in population from biomes (Cerrado and Atlantic forest) and ecotones, or from different climatic zones (Tropical or subtropical)



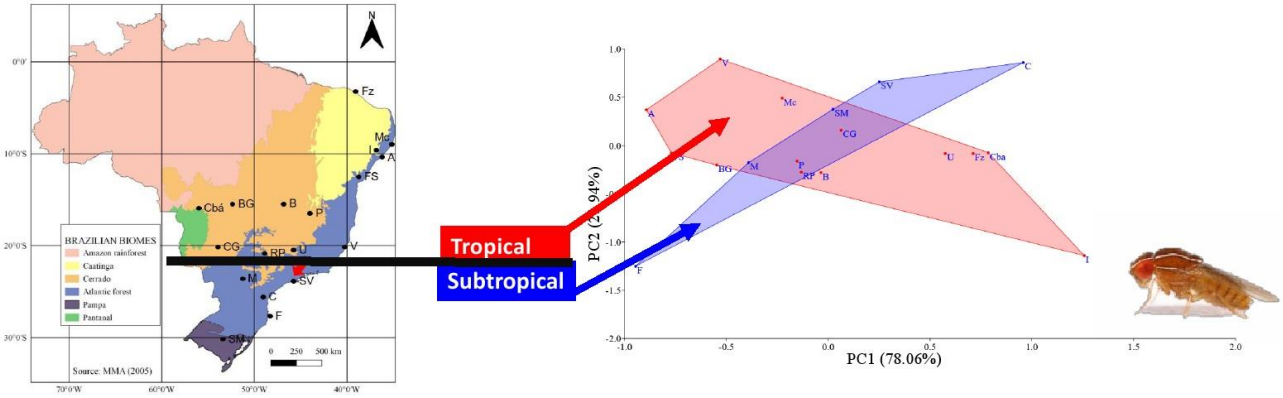
https://live.staticflickr.com/5501/11309338503_12a0689268_b.jpg



Galego and Carareto, in preparation

Niche occupation – Climatic Zone

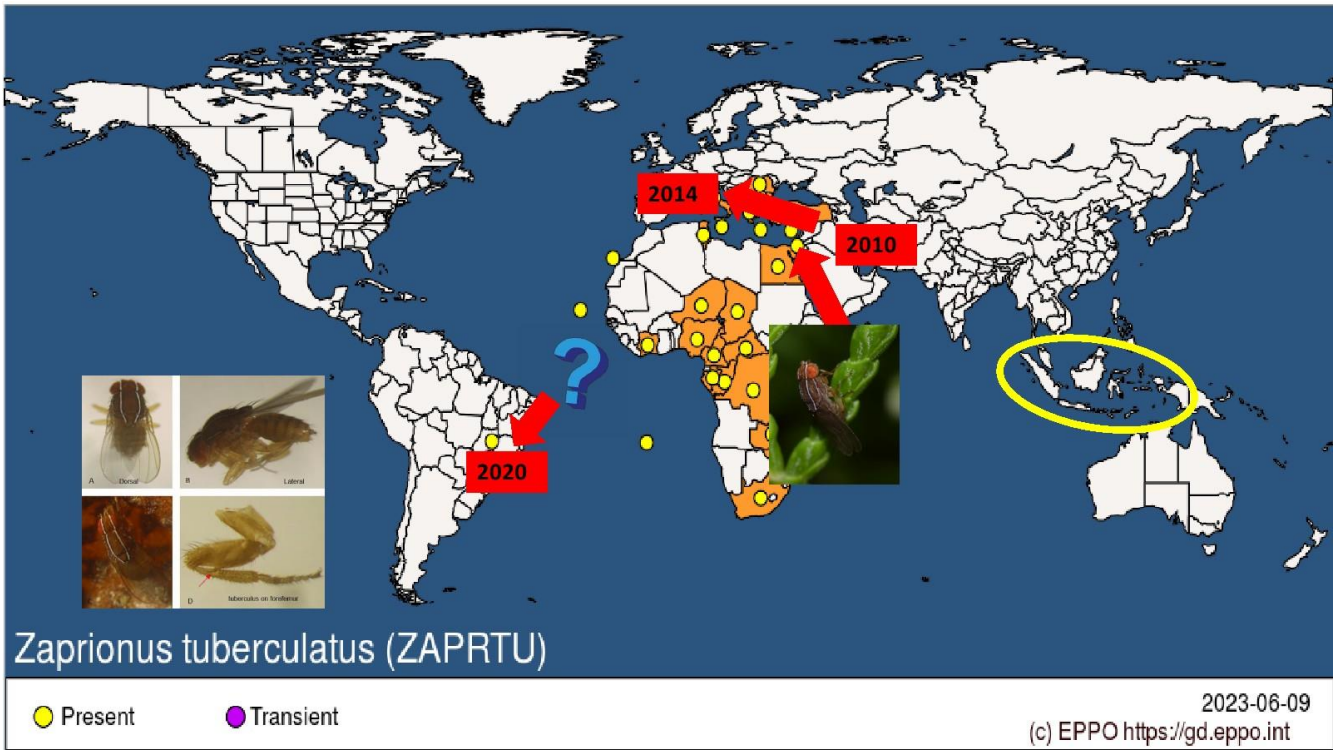
- Genetic structuring in population from biomes (Cerrado and Atlantic forest) and ecotones, or from different climatic zones (Tropical or subtropical)



Galego and Carareto, in preparation

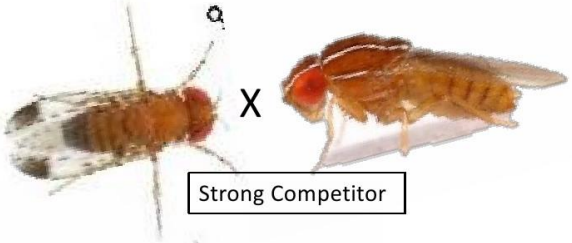
Structure of the talk:

- 3) *Zaprionus tuberculatus* in Neotropical region



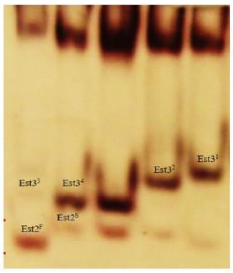
Summing Up

- *What makes Zaprionus indianus a successful colonizing species?*



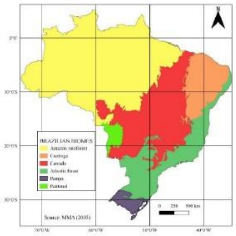
Strong Competitor

Phenotipic plasticity



Genetic variation

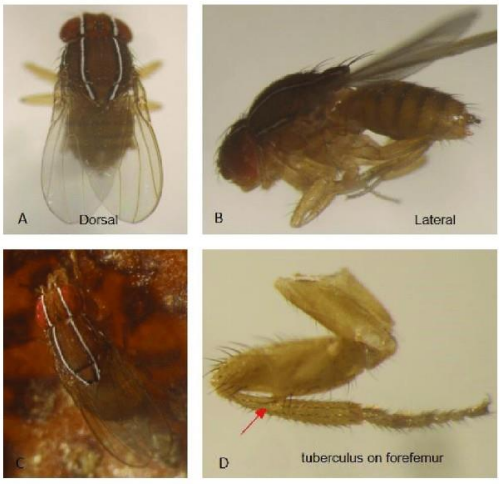
Polyphagous species



Diversity of biomes occupied

Summing Up

- *What about Zaprionus tuberculatus?*



- **Terima kasih!**

- E-mail:
Luis.galego@uftm.edu.br

REFERENCES:

BERNARDI, D.; ANDREAZZA, M.; BOTTON, C. A.; BARONIO & NAVA, D. E.
Susceptibility and interactions of *Drosophila suzukii* and *Zaprionus indianus* (Diptera: Drosophilidae) in Damaging Strawberry. Neotrop**. Entomol**., v. 46, p. 1–7, 2017.

CAVALCANTI, F. A. G. S.; RIBEIRO, L. B.; MARINS, G.; TONELLI, G. S. S. S.; BÁO, S. N.;
YASSIN, A.; TIDON, R. Geographic Expansion of an Invasive Fly: First Record of *Zaprionus tuberculatus* (Diptera: Drosophilidae) in the Americas. **Annals of the Entomological Society of America**, v. 115, p. 267–274, 2022.

COMMAR, L. S.: GALEGO, L. G. C.; CERON, C. R. & CARARETO, C. M. A. Taxonomic and
evolutionary analysis of *Zaprionus indianus* and its colonization of Palearctic and Neotropical regions. **Genet. Mol. Biol**., v. 35, p. 395–406, 2012.

COUTINHO-SILVA, R.D.; MONTES, M.A.; OLIVEIRA, G.F.; CARVALHO-NETO, F.G.;
RHODE, C.; GARCIA, A.C.L. Effects of seasonality on drosophilids (Insect, Diptera) in the northern part of the Atlantic Forest, Brazil. **Bulletin of Entomological Resaearch,** p. 1-11, 2017.

FERREIRA, L. B.; TIDON, R. Colonizing potential of Drosophilidae (Insecta, Diptera) in environments with different grades of urbanization. **Biodiversity And Conservation**, [S.L.], v. 14, n. 8, p. 1809-1821, jul. 2005.

GALEGO, L. G. C.; CARARETO, C. M. A. Effects of intraspecific and interspecific pre-adult competition on the neotropical region colonizer fly *Zaprionus indianus* (Diptera: Drosophilidae). **Bragantia**, v. 64, p. 249-255, 2005.

GALEGO, L. G. C; CARRETO, C. M. A. Analysis of the drosophilid Zaprionus indianus introduction in Brazil: contribution of esterase loci polymorphisms. **Dros. Inf. Serv**. 2007. 90 p.79-84, 2007.

GALEGO, L.G.C.; CARARETO, C.M.A. Scenario for the spreading of the invasive species Zaprionus indianus Gupta, 1970 (Diptera: Drosophilidae) throughout Brazil. **Genetics and Molecular Biology,** v. 33, p. 767-773, 2010a.

GALEGO, L. G. C.; CARARETO, C. M. A.. Variation at the Est3 locus and its adaptability to organophosphorous compounds in Zaprionusindianus populations. **Entomologia Experimentalis et Applicata**, v. 134, p. 94-105, 2010b.

LACHAISE, D.; TSACAS, L. Breeding-sites in Tropical African Drosophilids. In: ASHBURNER, M.; CARSON, H.L.; THOMPSON JR, J.N. **The genetics and biology of *Drosophila.*** 3rd ed. London: Academic Press, 1983. p. 221-332.

LAVAGNINO, N. J.; IMBERTI, M.; ORTIZ, V. E.; FLAIBANI, N.; FANARA, J.J. Contrating
levels of genotype by environment interaction for life history and morphological traits in invasive populations of *Zaprionus indianus* (Diptera: Drosophilidae). **Insect Science**, v. 27, p. 1090-1100, 2020.

MARKOW, T.A.; HANNA, G.; RIESGO-ESCOVAR, J.R.; TELLEZ-GARCIA, A.A.; RICHMOND, M.P.; YEPIZ, N.O.N.; LACLETTE, M.R.L.; CARPINTEYRO-PONCE, J.;
PFEILER, E. Population genetics and recent colonization history of the invasive drosophilid
Zaprionus indianus in Mexico and Central America. **Biol. Invasions**, v.16**,** p. 2427-2434, 2014.

PFEIFFER, D.; SHRADER, M.; WAHLS, J.; WILLBRAND, B.; SANDUM, I.; VAN DER
LINDE, K.; LAUB, C. A.; MAYS, R. & DAY, E. African fig fly (Diptera: Drosophilidae): Biology, expansion of geographic range, and its potential status as soft fruit pest. **Journal of Integrated Pest Management**, v. 10, p. 1-8, 2019.

RENKENA, J.M, MILLER, M, FRASER, H, LEGARÉ, J.P.H, HALLETT, R.H. First records of
Zaprionus indianus Gupta (Diptera: Drosophilidae) from commercial fruit fields in Ontario and Quebec, Canada. Journal of the Entomological Society of Ontario, v. 144, p. 125-130, 2013.

TIDON, R.; LEITE, D.F.; LEÃO, B.F.D. Impact of the colonization of *Zaprionus indianus* (Diptera: Drosophilidae) in different ecosystems of the Neotropical Region: 2 years after the invasion. **Biol. Cons.,** v. 112, p. 299-305, 2003.

VAN DER LINDE, Kim; Gary J. Steck, Ken Hibbard, Jeffrey S. Birdsley, Linette M. Alonso, and David Houle· First record of *Zaprionus indianus* (Diptera: Drosophilidae), a peste species on commercial fruits from Pananma and the Unites States. **Florida Entomologist**, v. 89, n. 3, p.402- 404, set. 2006.

VILELA, C.R. Is Zaprionus indianus Gupta, 1970 (Diptera: Drosophilidae) currently colonizing the Neotropical region? **Dros. Inf. Serv**, v. 82, p. 37-39, 1999.

VILELA, C.R.; TEIXEIRA, E.P.; STEIN, C.P. Mosca-africana-do-figo, *Zaprionus indianu*s (Diptera: Drosophilidae). In: **Histórico e impactos das pragas introduzidas no Brasil.** Editora Holos, São Paulo, p. 48-52, 2001.

VAN DER LINDE, K**.** *Zaprionus indianus*: species identification and taxonomic position. **Dros. Inf. Serv.,** v. 93, p. 95–98, 2010.

YASSIN, A. Molecular and morphometrical revision of the *Zaprionus tuberculatus* species subgroup (Diptera: Drosophilidae), with descriptions of two cryptic species. **Ann. Entomol. Soc. Am.,** v. 101, p. 978–988, 2008.

YASSIN, A.; DAVID, J. R. Revision of the Afrotropical species of *Zaprionus* (Diptera, Drosophilidae), with descriptions of two new species and notes on internal reproductive structures and immature stages. **ZooKeys**, v. 51, p. 33–72, 2010.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Emerging Innovations In Natural Science Education

(Haniza Hanim binti Mohd Zain, PhD. Assoc Professor)
Universiti Pendidikan Sultan Idris Malaysia

ABSTRACT

This presentation explores the emerging innovations in natural science education, highlighting their potential to revolutionize teaching and learning in the field. We focuses on a few key areas of innovation; virtual and augmented reality (VR/AR), citizen science, 3D printing and artificial intelligence. These innovations offer immersive experiences, engage students in authentic scientific research, promote critical thinking and problem-solving skills, and provide access to vast scientific resources. By incorporating these innovations into natural science education, educators can create dynamic and effective learning environments that prepare students for the challenges of a rapidly advancing scientific landscape.

UMS Universitas Muhammadiyah Surakarta

Metagenomic studies and their applications

Dr. Triastuti Rahayu, S.Si., M.Si
Biology Education Study Program
Faculty of Teacher Training and Education,
Universitas Muhammadiyah Surakarta, Indonesia
Email : tr124@ums.ac.id

WHAT IS METAGENOME ?

UMS Universitas Muhammadiyah Surakarta

A metagenome is comprised of all the genetic elements of the host and all those of all the microorganisms (microbiome) that live in or on that host.

Metagenomics is defined as the direct genetic analysis of genomes contained with an environmental sample.

Metagenomic analysis is commonly used to investigate complex microbial communities (MICROBIOME) sampled directly from the environment, without culturing or isolating a single organism.

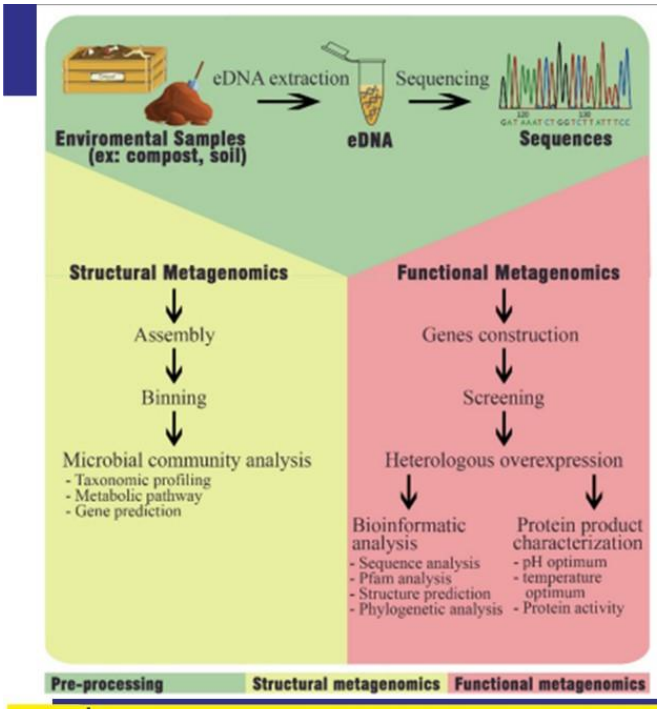


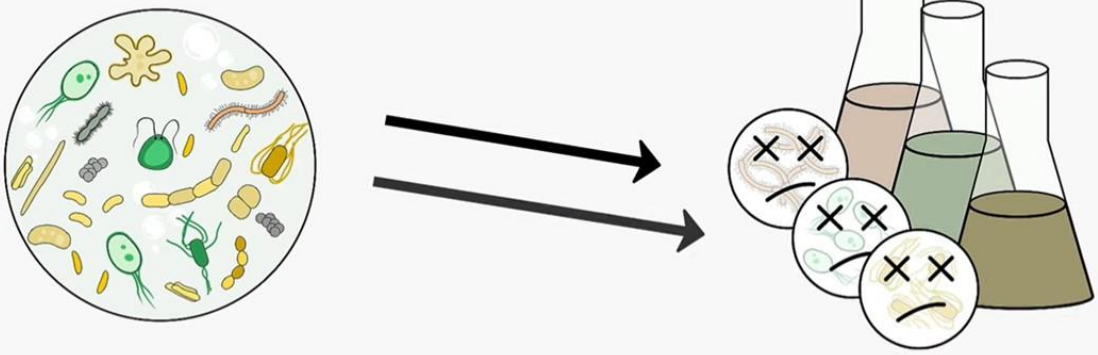
Fig. Framework for metagenomics with two primary studies, structural and functional metagenomics

Prayogo et al. Journal of Genetic Engineering and Biotechnology (2020) 18:39
https://doi.org/10.1186/s43141-020-00043-9
Journal of Genetic Engineering and Biotechnology
REVIEW Open Access

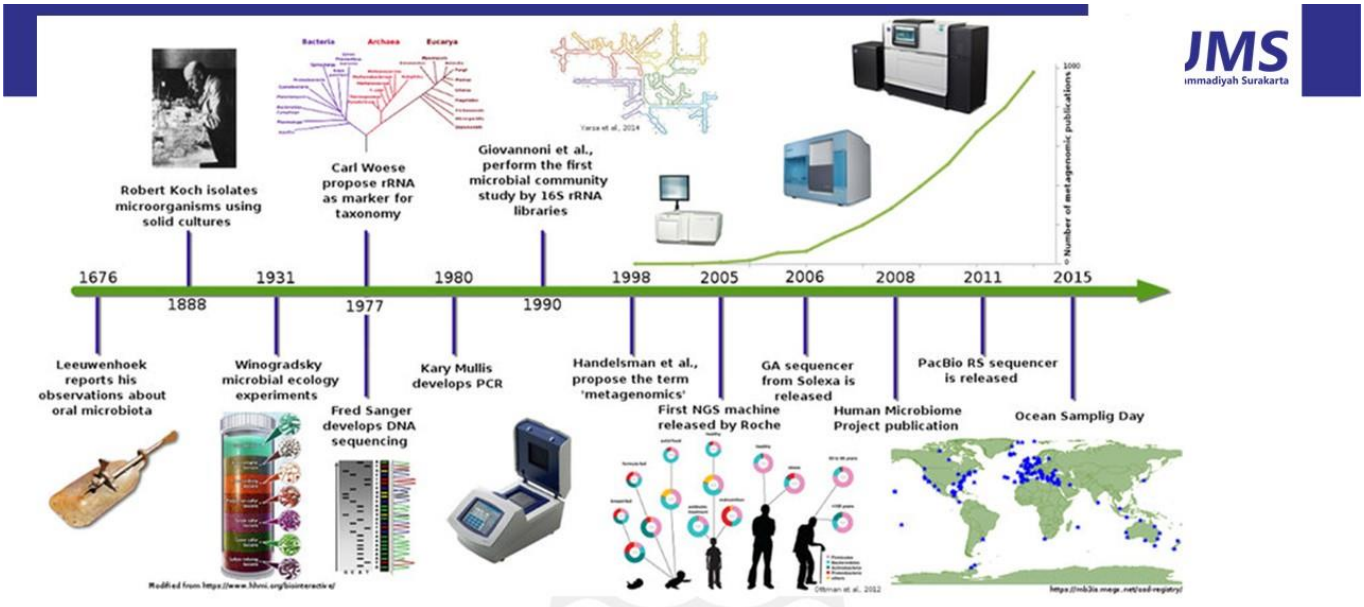
Metagenomic applications in exploration and development of novel enzymes from nature: a review

Fitra Adi Prayogo[1*], Anto Budiharjo[2,3*], Hermin Pancasakti Kusumaningrum[1], Wijanarka Wijanarka[2], Agung Suprihadi[2] and Nurhayati Nurhayati[2]

Why do we study the metagenome?

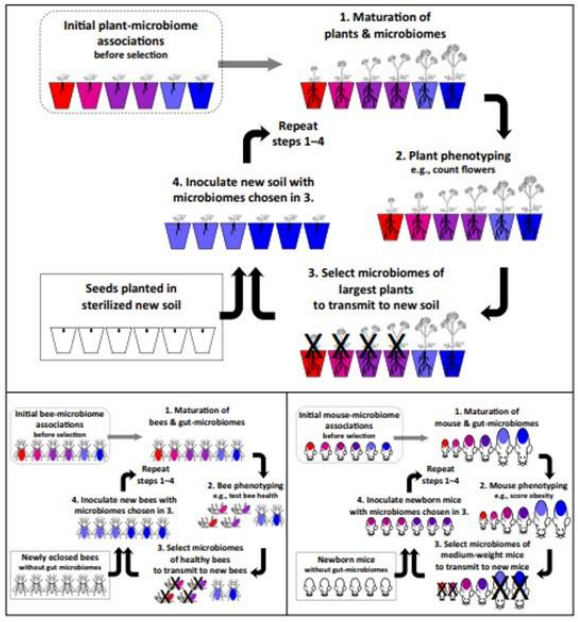


Only approximately 1% of the community of microbes can be cultivated in artificial media.



Metagenomics timeline and milestones. Timeline showing advances in microbial communities studies from Leeuwenhoek to NGS (Ottman et al., 2012; Yarza et al., 2014).

Host-Mediated Engineering of Microbiomes in Animal and Plant Hosts.



Trends in Microbiology
CellPress

Review

Engineering Microbiomes to Improve Plant and Animal Health

U.G. Mueller,[1,2,*] and J.L. Sachs[3,4]

Figure 1. One-sided artificial selection on microbiomes in the plant rhizosphere (top), honeybee gut (left), and mouse gut (right). Different microbiomes are shown in different colors. In one-sided selection experiments, the host is kept genetically homogeneous and cannot evolve between selection cycles because uninfected hosts are taken each generation from nonevolving stock (bottom left in each panel). At the start of each experiment (top left in each panel), microbiomes differ in community composition between hosts; host–microbiome associations are allowed to mature (Step 1), then are phenotyped for the trait used as a direct target for indirect selection on microbiomes (Step 2), then microbiomes are chosen for transmission to the next generation of hosts (Steps 3 and 4). The selection regimes in the plant and honeybee panels are identical in that the most extreme host phenotypes are chosen to identify microbiomes for propagation (microbiomes from the largest plant or the healthiest bee are propagated), but the regime in the mouse panel propagates microbiomes from hosts of intermediate host phenotypes (i.e., selecting against gut microbiomes from extreme lean and extreme obese mice). Drawings by C-C. Fang.

Researchs using the metagenomic approach

1

UMS Universitas Muhammadiyah Surakarta

AGRICULTURE AND NATURAL RESOURCES

Journal homepage: http://anres.kasetsart.org

Research article

Exploration of core endophytic bacteria from different organs of diploid *Musa balbisiana* and triploid *Musa acuminata*

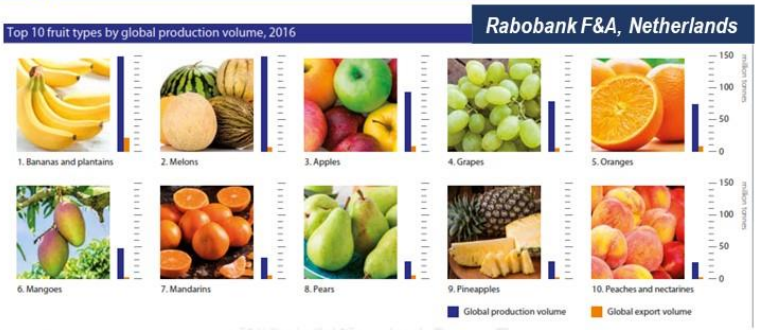
Triastuti Rahayu[a,e,†], Yekti Asih Purwestri[b,†], Siti Subandiyah[c,†], Ahmad Suparmin[d,†], Donny Widianto[d,*]

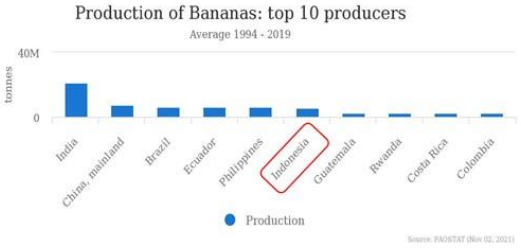
Aims : this study determined the core endophytic bacteria in the Kluthuk and Ambon cultivars

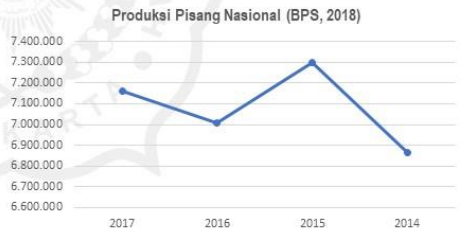
Goal : this report should be valuable for further development of banana resistance through endophytic bacterial amendment based on clear results

Banana production

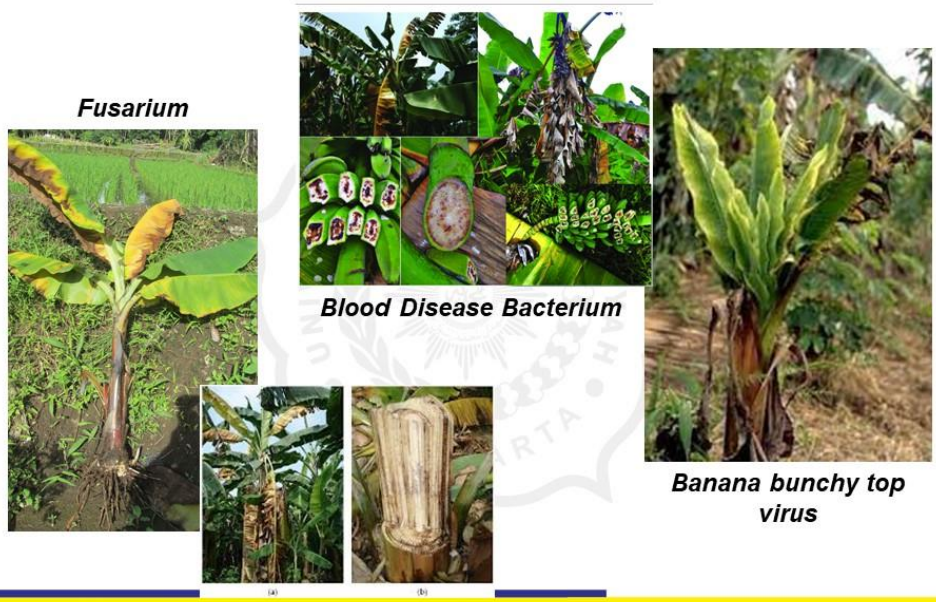
UMS Universitas Muhammadiyah Surakarta



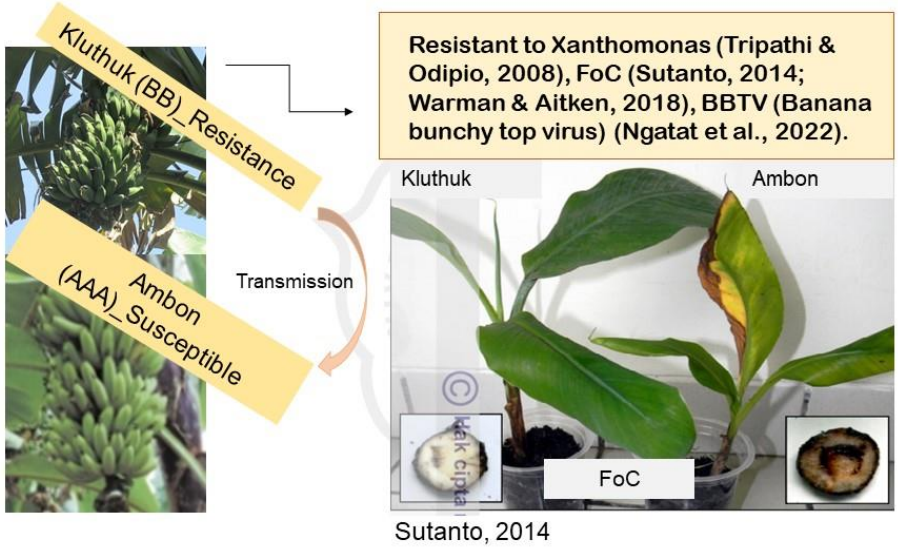




Diseases of banana plants



BANANA PLANT MODEL



Sutanto, 2014

Result

Kluthuk

Ambon

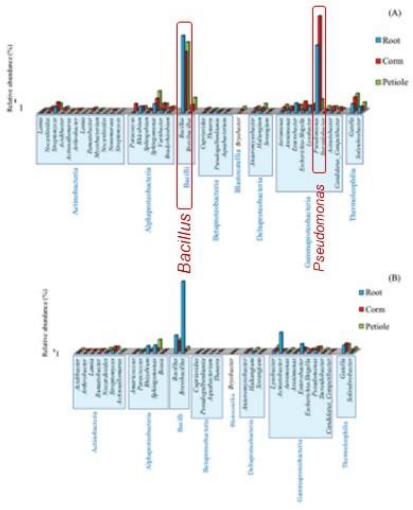
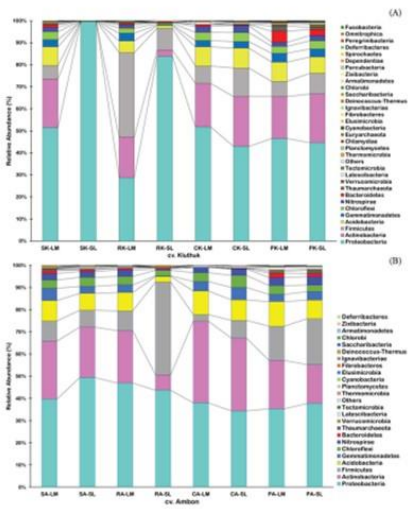


Fig. 5 C
cultivars



3 Relative abundance at phylum level of banana cultivars:
luthuk; (B) Ambon, where x axis label codes are defined in Table S1

Researchs using the metagenomic approach

2

Metagenomic study in the cemetery

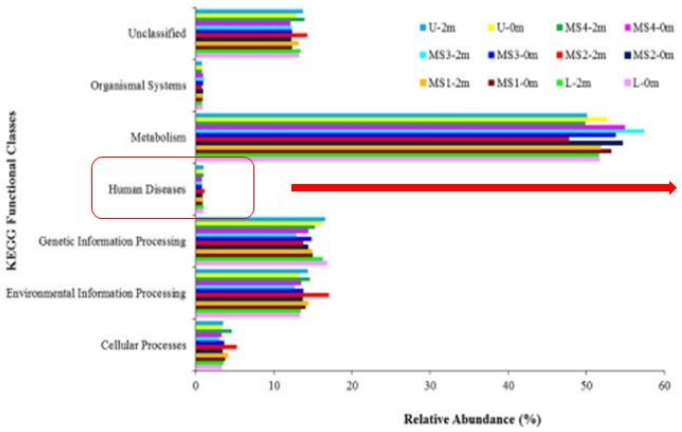


Fig. 8. General predicted functional categories of bacterial populations obtained from different cemeteries based on KEGG (Level 1).

Microbial life beyond the grave: *16S rRNA* gene-based metagenomic analysis of bacteria diversity and their functional profiles in cemetery environments

Akebe Luther King Abia [a,*,1], Arghavan Alisoltani [b,1], Eunice Ubomba-Jaswa [c,d,1], Matthys Alois Dippenaar [e,*,1]

OTUs related to human diseases in cemetery soil (relative abundance; %).

Disease	Maitland cemetery (Cape Town)					
	MS1		MS2		MS3	
	0 m	2 m	0 m	2 m	0 m	2 m
Tuberculosis	0.23	0.22	0.22	0.19	0.22	0.18
Alzheimer's disease	0.12	0.13	0.10	0.17	0.10	0.10
Huntington's disease	0.11	0.14	0.11	0.17	0.10	0.09
Vibrio cholerae pathogenic cycle	0.10	0.11	0.09	0.18	0.10	0.10
Type I diabetes mellitus	0.08	0.07	0.08	0.06	0.08	0.08
Pathways in cancer	0.07	0.08	0.07	0.10	0.07	0.06
Primary immunodeficiency	0.08	0.07	0.08	0.08	0.08	0.08
Parkinson's disease	0.06	0.08	0.05	0.12	0.05	0.04
Amyotrophic lateral sclerosis (ALS)	0.05	0.06	0.05	0.08	0.04	0.08
Type II diabetes mellitus	0.05	0.05	0.05	0.06	0.05	0.05
Pertussis	0.03	0.05	0.02	0.14	0.02	0.04
Epithelial cell signaling in *Helicobacter pylori* infection	0.03	0.04	0.03	0.07	0.03	0.03
Renal cell carcinoma	0.03	0.04	0.03	0.04	0.03	0.03
African trypanosomiasis	0.02	0.03	0.02	0.04	0.02	0.04
Amoebiasis	0.03	0.03	0.03	0.02	0.03	0.01
Prostate cancer	0.02	0.02	0.02	0.03	0.02	0.02
Chagas disease (American trypanosomiasis)	0.02	0.02	0.02	0.03	0.02	0.02
Influenza A	0.02	0.02	0.02	0.02	0.01	0.01
Small cell lung cancer	0.02	0.02	0.02	0.02	0.01	0.01
Viral myocarditis	0.02	0.02	0.02	0.02	0.01	0.01
Toxoplasmosis	0.02	0.02	0.02	0.02	0.01	0.01

Indonesia ??

Bonoloyo Cemetery

Pracimaloyo Cemetery

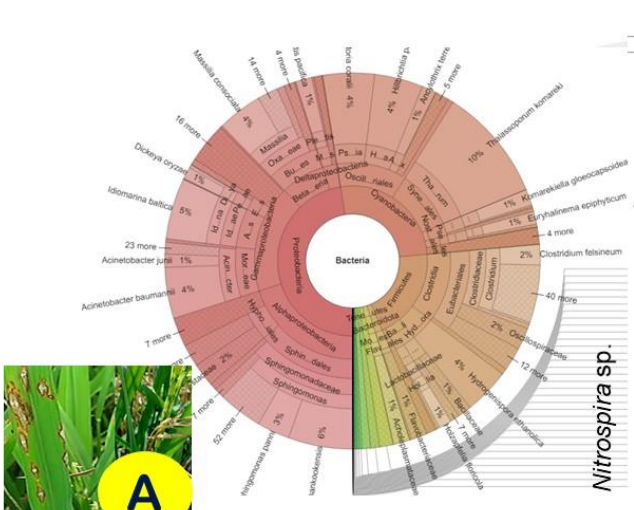
Tax_detail	P12A	P12B	B18A	B18B	B23A	B23B
p__Firmicutes;c__Bacilli;g__Bacillus;	4631	4911	9577	14392	11338	6670
p__Actinobacteriota;c__Actinobacteria;g__Marmoricola;	148	308	132	13206	150	280
p__Actinobacteriota;c__Actinobacteria; g__Nocardioides;	250	1162	344	12789	452	980
p__Proteobacteria;c__Alphaproteobacteria;g__Wolbachia;	0	504	7371	0	597	813
p__Proteobacteria;c__Gammaproteobacteria;g__Buchnera;	0	2528	6658	0	1	6
p__Proteobacteria;c__Gammaproteobacteria;g__Pseudomonas;	3	503	1442	4769	1201	1830
k__Archaea;p__Crenarchaeota;c__Nitrososphaeria;g__Nitrososphaeraceae;	1157	556	81	1045	4709	1346
p__Proteobacteria;c__Gammaproteobacteria;g__Escherichia-Shigella;	20	184	2605	8	115	217
p__Actinobacteriota;c__Actinobacteria;g__Pseudarthrobacter;	72	2233	242	1243	771	2454
p__Actinobacteriota;c__Thermoleophilia;g__Gaiella;	1383	1734	2136	2366	1635	1616
p__Firmicutes;c__Bacilli; g__Pseudobacillus;	263	163	2332	689	405	417
p__Actinobacteriota;c__Actinobacteria;g__Agromyces;	40	407	179	2040	199	297
p__Firmicutes;c__Bacilli; g__Lactobacillus;	0	1243	1963	393	1466	1711
p__Proteobacteria;c__Alphaproteobacteria;g__Asticcacaulis;	1	11	1900	0	4	17
p__Firmicutes;c__Clostridia;g__Romboutsia;	23	1018	1647	47	1150	1387
p__Proteobacteria;c__Gammaproteobacteria;g_Achromobacter;	0	0	1615	1	10	3
p__Proteobacteria;c__Alphaproteobacteria;g__Sphingomonas;	325	795	578	1174	587	1608
p__Proteobacteria;c__Alphaproteobacteria;g__Microvirga;	311	1061	354	379	784	1582
p__Firmicutes;c__Desulfotomaculia;g__Desulfurispora;	2	0	0	1535	0	0
p__Proteobacteria;c__Gammaproteobacteria;g__Pseudoxanthomonas;	2	42	1530	0	81	85
p__Proteobacteria;c__Alphaproteobacteria;g_Devosia;	16	107	572	10	750	1452
p__Verrucomicrobiota;c__Verrucomicrobiae;g__Candidatus_Udaeobacter;	84	113	402	1388	141	102
p__Actinobacteriota;c__Actinobacteria;g__Intrasporangium;	65	395	138	1339	132	403
p__Proteobacteria;c__Alphaproteobacteria;g__Pedomicrobium;	585	251	153	59	1327	623
p__Actinobacteriota;c__Thermoleophilia;g__Solirubrobacter;	198	1204	398	982	414	733
p__Firmicutes;c__Clostridia;g__Sedimentibacter;	0	1160	1	5	0	2
k__Archaea;p__Crenarchaeota;g__Candidatus_Nitrosophaera;	454	255	7	128	1143	532
p__Nitrospirota;c__Nitrospiria;g__Nitrospira;	1134	539	254	269	726	886
p__Firmicutes;c__Bacilli;g__Ammoniphilus;	255	104	297	1059	210	170
p__Proteobacteria;c__Alphaproteobacteria;g__Allorhizobium-Neorhizobium-Pararhizobium-Rhizobium;	29	327	258	8	837	1005
p__Acidobacteriota;c__Vicinamibacteria;g__Vicinamibacteraceae;	952	693	232	946	998	733
p__Actinobacteriota;c__Actinobacteria;g__Microlunatus;	94	548	118	0	568	889
p__Actinobacteriota;c__Actinobacteria;g__Streptomyces;	841	327	142	863	689	740

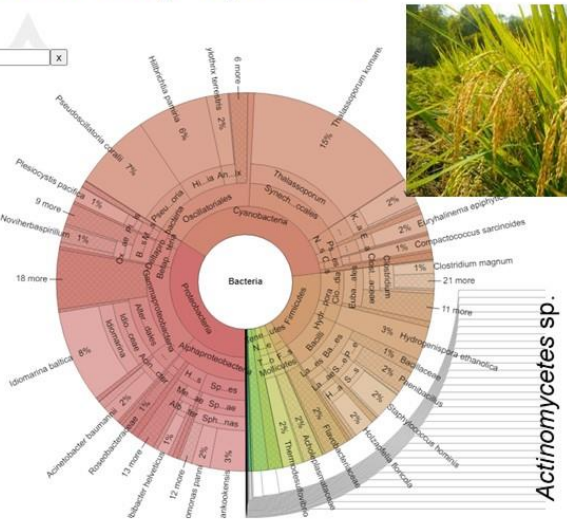
Rahayu et al., 2023 (unpublished)

Researchs using the metagenomic approach

3

Metagenomic study in paddy (Blast desease – A *vs* Healthy - B)



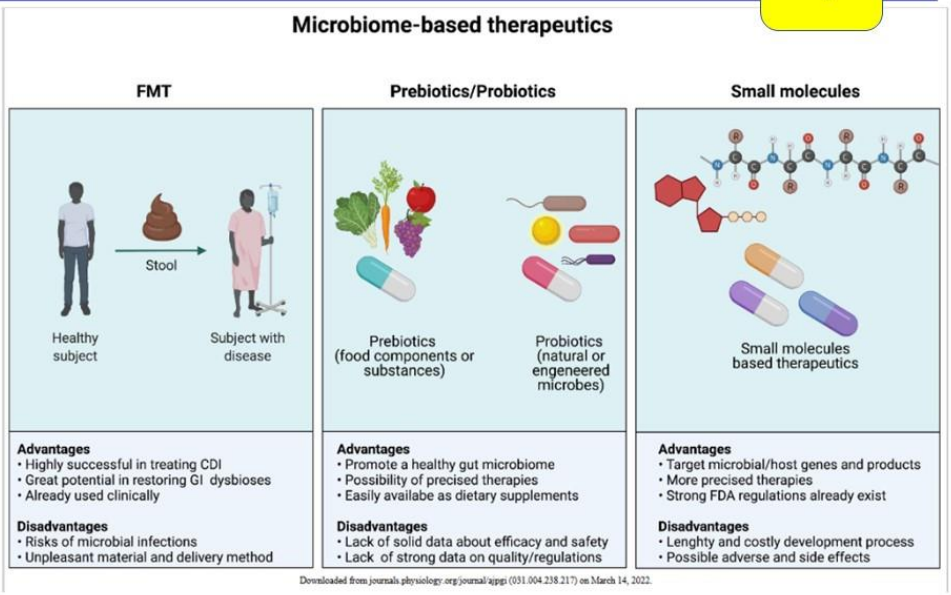


Sidiq et al., 2023, unpublished)

Researchs using the metagenomic approach

4

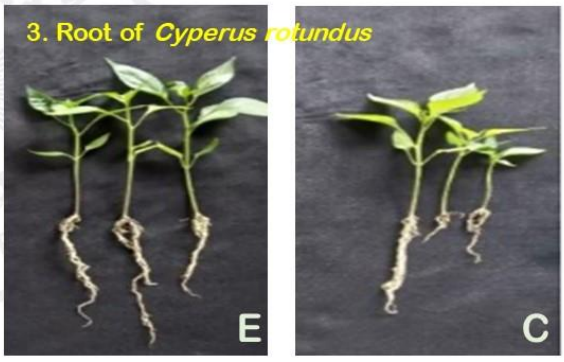
UMS Universitas Muhammadiyah Surakarta



www.ums.ac.id Humanizing ⋆ Liberating ⋆ Transcending 15

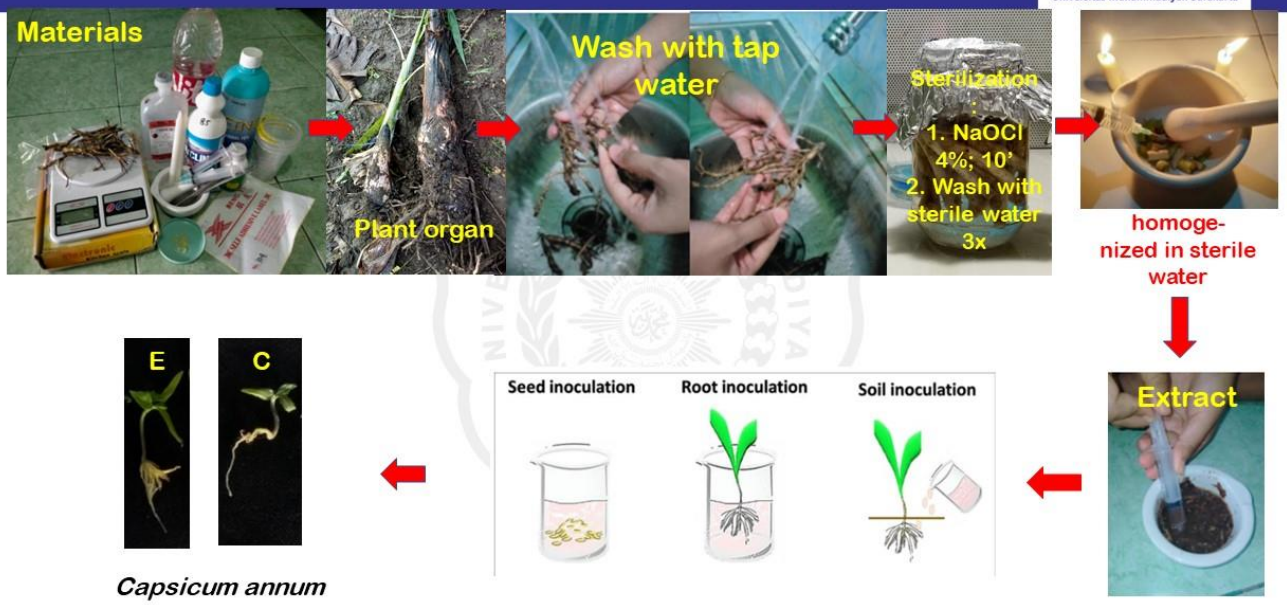
Application → PLANT EXTRACT

UMS Universitas Muhammadiyah Surakarta



www.ums.ac.id Humanizing ⋆ Liberating ⋆ Transcending 16

Procedure



www.ums.ac.id Humanizing * Liberating * Transcending

Summary

- Metagenomic studies are essential to know the communities of microorganisms in nature that are related to their respective functions because the microorganisms that can be grown in artificial media are only about 1%.
- Metagenomic approaches can be applied to several fields such as agriculture, environment, and health.

www.ums.ac.id Humanizing * Liberating * Transcending 18

References

1. Abia ALK, Alisoltani A, Ubomba-Jaswa E, Dippenaar MA. Microbial life beyond the grave: 16S rRNA gene-based metagenomic analysis of bacteria diversity and their functional profiles in cemetery environments. Sci Total Environ. 2019 Mar 10;655:831-841. doi: 10.1016/j.scitotenv.2018.11.302. Epub 2018 Nov 22. PMID: 30481710.
2. Escobar A., de Leon A V., Sanchez-Flores A. 2016. The Road to Metagenomics: From Microbiology to DNA Sequencing Technologies and Bioinformatics. Frontiers in Genetics 6(104):348. DOI: 10.3389/fgene.2015.00348.
3. Lopes M., Dia-Filho M B, & Gurge E S C. 2021. Successful Plant Growth-Promoting Microbes: Inoculation Methods and Abiotic Factors. Front. Sustain. Food Syst., 25 February 2021.Sec. Crop Biology and Sustainability. Volume 5 - 2021 | https://doi.org/10.3389/fsufs.2021.606454
4. Mueller UG, Sachs JL. Engineering Microbiomes to Improve Plant and Animal Health. Trends Microbiol. 2015 Oct;23(10):606-617. doi: 10.1016/j.tim.2015.07.009. Epub 2015 Sep 25. PMID: 26422463.
5. Prayogo, F.A., Budiharjo, A., Kusumaningrum, H.P. *et al.* Metagenomic applications in exploration and development of novel enzymes from nature: a review. *J Genet Eng Biotechnol* **18**, 39 (2020). https://doi.org/10.1186/s43141-020-00043-9
6. Rahayu T, Purwestri Y A. Subandiyah. Suparmin A. & Widianto D. 2021. Exploration of core endophytic bacteria from different organs of diploid Musa balbisiana and triploid Musa acuminate. Agr. Nat. Resour. 55 (2021) 787–797. https://doi.org/10.34044/j.anres.2021.55.5.09.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Development of Android-Based Interactive Teaching Materials Using the Ispring Application with Insight into Sustainable Development

Nurhasnah[1*], Lufri[2], Abdul Razak[3], Festiyed[4], Prima Aswirna[5], Windy Kasmita[6], Wetri Yesmoneca[7]
[1,5,6,7]Department of Tadris IPA Concentration of Physics, Faculty of Tarbiyah and Teacher Training, UIN Imam Bonjol Padang, Jl. Prof. Mahmud Yunus Lubuk Lintah, Kota Padang Sumatera Barat25253, Indonesia.
[2,3,4]Department of Science Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Jl. Prof. Dr. Hamka, Air Tawar Barat, Kota Padang, Sumatera Barat 25131, Indonesia.
[*]Corresponding Author. E-mail address: nurhasnah_tipa@uinib.ac.id

KEYWORDS:
Interactive teaching materials, Sustainable Development, Spring application

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The lack of use of IT-based teaching materials and the low ability of students' scientific literacy in learning science causes the learning objectives to be not achieved in schools. In addition, the use of android among students who are also getting higher can support the learning process if it is used as well as possible. The purpose of this research is to produce Android-based interactive teaching materials using the Ispring application with a sustainable development perspective that is valid and practical to use. This research is a development research with the Plomp three-step development model, namely the preliminary stage, the development stage or the prototype stage and the assessment stage. Based on data analysis, the results of this study produced very valid interactive teaching materials with an average score of 89.22% in terms of material, media and language. Very practical to use by educators and students with an average score of 87.98%. It can be concluded that Android-based interactive teaching material use the Ispring application with an insight into sustainable development with very valid and practical criteria used in science learning.

1. INTRODUCTION

The Sustainable Development Goals (SDGs) replaced the Millennium Development Goals (MDGs) which ended in 2015 within the framework of sustainable development and negotiations and became the standard for sustainable development in countries around the world. Right in 2015, UN members consisting of 195 countries agreed to achieve sustainable development. This makes the world a better place to continue development without harming future generations. This agenda is known as the Sustainable Development Goals (SDGs) or also known as the 2030 Agenda which has 17 goals and 169 targets (Sebestyén et al. 2020). The 2030 sustainable development agenda reflects the urgency to instill the principles of education for sustainable development into all levels of education which has the aim of disseminating competencies that grow people to be able to reflect on what they do, think about their current social, economic and environmental impacts that will be generated in the future that is reviewed from a local and global perspective(Cebrián Bernat et al. 2020).

Education that is integrated with sustainable development is expected to help increase students' awareness of energy-saving attitudes related to environmental conditions and potential. One way that can be done is through the development of teaching materials used in learning. This is one of the principles of sustainable development (Ekantini and Wilujeng 2018). In line with the explanation above, the achievement of sustainable development goals is also related to the development of information and communication technology. In the 21st century, science and technology in various countries have progressed very rapidly (Lee et al. 2011). With this rapid development, the younger generation in this globalization era is required to be able to keep abreast

of information technology developments that are beneficial for developments in various aspects of life, especially in education (Uzunboylu and Aşıksoy 2014). Many strategies have been carried out by the government to meet the demands of the 21st century, one of which is by changing and updating the curriculum used in the learning process in schools.

Organization for Economic Co-operation and Development (OECD) is one of the international organizations involved in developing the world of international education (Schleicher 2016). The OECD regularly organizes the Program for International Student Assessment (PISA) every three years. One of the important aspects assessed from this program is students' scientific literacy skills. Indonesia is one of the countries that routinely participates in the PISA survey. However, the results achieved have never been satisfactory and Indonesia's performance has always been in a position that does not meet standards set internationally and tends to decline (Asyhari 2015). The results of the PISA survey of Indonesian students regarding scientific literacy show that most students in the Republic of Indonesia are at the basic level of scientific literacy 1 and a small proportion of Indonesian students have reached the basic level 2. There are 6 levels in the PISA ranking, so levels 1 and 2 are still considered low (Setiawan et al. 2017).

One way to make teaching and learning activities not boring is to involve technology in these learning activities (Sastrakusumah et al. 2018). Electronic media that students can use have different benefits and characteristics (Smaldino et al. 2004). In this case, the researcher applies the use of Ispring interactive multimedia. Interactive multimedia is an application that can be used to channel messages, stimulate thoughts, emotions, attention, and willingness to learn so that it can control the learning process (Sastrakusumah et al., 2018). Ispring is one of the tools that can convert presentation files to Flash form and SCORM/AICC form used in e-learning. Ispring is not complicated to use and can be easily integrated with PowerPoint (Qomariah and Mistianah 2021). Ispring acts as a powerpoint add-in, making powerpoint files more interesting and interactive, and can be accessed using Android offline anywhere and anytime.

In fact, the teaching materials that teachers use still seem unattractive and a bit boring and there are no teaching materials that are integrated with sustainable development. Based on observations in the field, teachers still tend to teach conventionally and do not utilize technology in learning. Most teachers only rely on handbooks from the government. There is no innovation in the use of teaching materials by teachers, so this method is still considered traditional. Traditional teaching methods are not only inefficient but also a waste of time (Herwinarso et al. 2020). In teaching using this traditional method, time constraints often occur in science classes, and the teacher may miss explaining some concepts in detail. Sometimes, some students cannot follow the material within the allotted time (Herwinarso et al. 2020).

The use of teaching materials that are not optimal is not in accordance with the 2013 curriculum. Learning is carried out to support learning activities using various kinds of teaching materials. One of the suitable teaching materials is Android-based interactive teaching materials. The impact of the underdeveloped use of teaching materials results in students' abilities that are still underdeveloped and limited so there is no better achievement (Reinders and Balcikanli 2011). The lack of development of students' abilities is also caused by the use of more time using smartphones which are not used properly, such as playing games and accessing less useful things, especially in the educational aspect. The research carried out is product development from research that is relevant to this research, namely that carried out by (Manasikana 2017). Based on these problems, the researcher aims to develop an Android-based interactive teaching material using the Ispring application with a sustainable development perspective to support scientific literacy.

The development of this teaching material was developed in accordance with the problems that occur, namely the low ability of scientific literacy and energy-saving attitudes that are still not applied in everyday life by students. The purpose of developing this teaching material is to produce Android-based interactive teaching materials using the Ispring application with a sustainable development perspective that is valid and practical for use by students and teachers. The reference used to develop good teaching materials is that these teaching materials can be used by educators

and students as learning resources. In addition, teaching materials must also be attractive and the appearance can also attract attention and improve students' scientific literacy abilities.

2. MATERIALS AND METHODS

The method used in this study is a research and development method using the Plomp & Nieveen model, (2013). The stages of research and development according to Plomp and Nieveen (2013) are divided into three stages, namely: (1) Preliminary research ; (2) the development or prototyping phase; and (3) the assessment/implementation phase. The three stages are presented in the following figure.

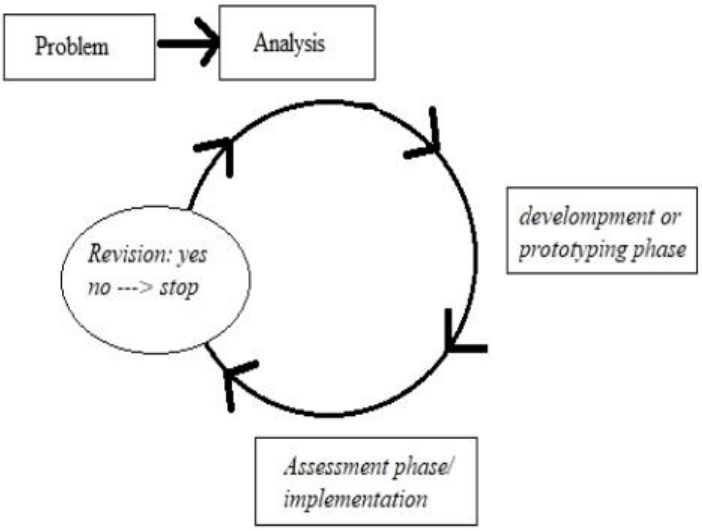
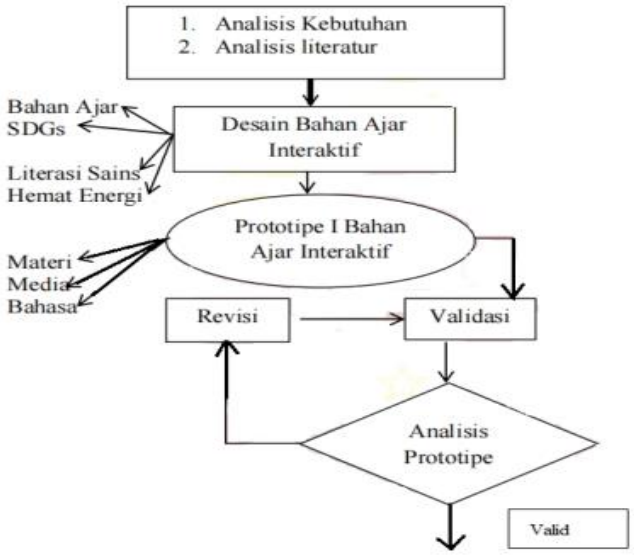
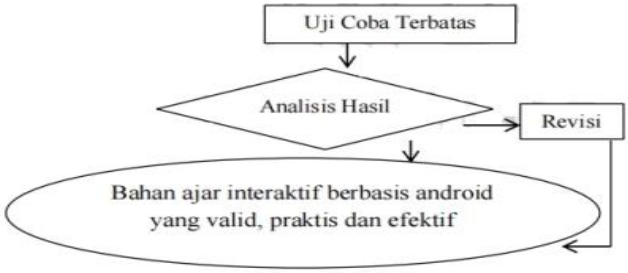


Figure 1. Plomp & Nieveen Development Model, (2013)

Based on the development steps of Plomp and Nieveen (2013), the development procedure in this study can be described in detail as the phases of developing interactive android-based teaching materials with an insight into sustainable development with the Plomp model as follows:

Table 1. The Phases of Developing Interactive Android-Based Teaching Materials with an Insight Into Sustainable Development With The Plomp Model

Stages of Research Activities	**Step** **Plomp & Nieveen Development**
	*PreliminariesResearch*(Preliminary Research) *Prototyping Phase*

Stages of Research Activities	Step Plomp & Nieveen Development
	*Assessment Phase*

This final value indicates the level of validity. The interval for determining these criteria can be seen in **(Table 2.)** follows:

Table 2. Criteria level of validity

No	Score	Criteria
1	81% - 100%	Very Valid
2	61% - 80%	Valid
3	41% - 60%	Valid Enough
4	21% - 40%	Invalid
5	0% - 20%	Invalid

(Sugiyono, 2010)

3. RESULTS AND DISCUSSION

3.1. Preliminary research

Preliminary Research is an initial investigative stage that aims to conduct need and context analysis. The first step taken in this research is Preliminary Research, this activity focuses on gathering information to identify problems. The preliminary research stage is an initial analysis that aims to determine the need for developing Android-based interactive teaching materials (Yustianingsih et al. 2017). researchers collect information about the problems contained in science learning by observing the implementation of learning activities, interviewing science teachers and students in class (Siahaan et al. 2021)

This stage consists of several analyzes, namely:

a. Needs analysis stage (Educators and Students)

At this stage, to collect, analyze and define problems related to the use of learning resources the researcher conducted an interview with Mrs. "A", an integrated science educator at SMPN 3 Solok Selatan. This interview was conducted in person at the residence of Mrs. "A" in Padang Aro, Sangir District, South Solok Regency in July 2021.

Based on the results of interviews conducted with educators, learning is still minimal in terms of the use of technology due to the limited ability of educators in terms of technology. While other factors are due to the need for time and capital to design teaching materials that are in accordance with learning materials, especially interactive teaching materials based on Android. In addition to interviews with educators, to strengthen this research an interview was also conducted with a class VII student at SMPN 3 Solok Selatan. The interview was conducted at the student's residence in Sungai Aro.

Based on the results of the analysis of interviews with students, it can be concluded that most students already have Android, and like learning using technology such as Android. So, one of the teaching materials that can be used is Android-based interactive teaching materials which make it easier for educators in the learning process on temperature and heat, and energy materials. In line with research conducted by Kasmita et al. (2021) who also found that most students use Android and this can have a positive impact if used in

learning. then Android-based learning will maximize the function of technology in the process of understanding science content. Previous research also found that Android-based learning can also improve scientific literacy, conceptual understanding and student learning outcomes (Istighfarini et al. 2022; Manasikana 2017; Nurhamidah et al. 2022; Ramdani et al. 2020).

b. Results of Literature Analysis / Literature Study

This analysis was carried out to find concepts or theoretical foundations that strengthen Android-based Interactive Teaching Materials using the Ispring application with an insight into sustainable development. In this stage, the steps taken are:

1) Curriculum Analysis Stage. The curriculum analysis phase includes core competencies and describes basic competencies into several indicators.
2) Data Analysis Stages. The analysis carried out included identifying what kind of electronic teaching materials were used during online learning during this pandemic, identifying temperature and heat materials and energy materials used in SMP/MTs, as well as the advantages and disadvantages of these interactive android-based teaching materials.
3) Material Analysis Stage. Aims to determine the content and subject matter in accordance with the sustainable development program (SDGs) which can develop students' scientific literacy and energy-saving attitudes. Educators also play a role in the success of the SDGs program, namely the 7th and 15th SDGs programs where everyone supports sustainable development programs by protecting the environment and using renewable energy. Thus, students can apply science learning materials in everyday life.

3.2. Development or prototyping phase ;

This stage is a continuation of the first stage, which aims to produce prototypes of Android-based interactive teaching materials using the Ispring application with a valid sustainable development perspective. The stages in this activity are as follows:

a. Designing Prototypes

The design stage for what is done for Android-based interactive teaching materials using the ispring application with a sustainable development perspective is as follows:

1) Prepare a background design for teaching materials
2) The design of making introductory words, instructions for using teaching materials, as well as the design of making KI, KD, indicators, and learning objectives
3) The design of making the author's bio as an introductory stage before learning begins
4) The design makes matter temperature and heat and matter-energy
5) The design chooses an image that matches the material
6) The design of making learning videos related to the material
7) The design of making sample questions
8) The design makes evaluation questions
9) The design of making a video of the prayer of kafaratul assemblies is a sign of gratitude because learning has been completed.

b. Development of Android-based interactive teaching materials using the ispring application with an insight into sustainable development

1) Product Identity
   Physical form : Electronic Teaching Materials
   Title : Android-Based Interactive Teaching Materials with an Insight into Sustainable Development
2) Android-based display of interactive teaching materials
   The display of interactive teaching materials developed can be seen in the following figure 2.

Figure 2. The appearance of Android-Based Interactive Teaching Materials

3.3. Assessment phase/implementation

The purpose of this stage is to produce interactive teaching materials based on Android using the Ispring application with a sustainable development perspective that is valid and practical. This Android-based interactive teaching material validator consists of 3 lecturers at UIN Imam Bonjol Padang consisting of 1 material expert, 1 media expert and 1 linguist.

a. Content Eligibility
   Indicators for testing the validity of the material/content validity of Android-based interactive teaching materials consist of 12 statements. The lowest score for each statement is 1 and the highest score is 5.
b. Language Eligibility
   Language validity indicators in Android-based interactive teaching materials consist of 4 statements. The lowest score for each language validity statement was 1 and the highest score was 5. The language validity questionnaire was filled out by 1 validator.
c. Media Eligibility
   Android-based interactive teaching material media indicators consist of 15 statements. The lowest score for each statement of media validity is 1 and the highest score is 5. The value of the media validity questionnaire is filled out by 1 validator.

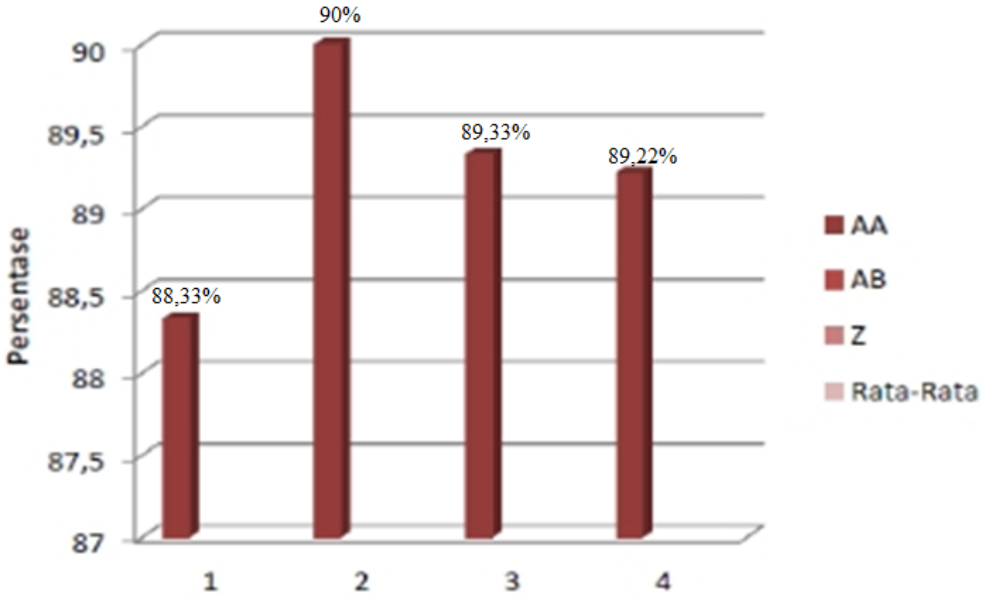


Figure 3. Average Value of Product Validation

Information:
1 Content/Material Validation
2 Language Validation
3 Media Validation
4 Average

If the validation results are at an interval of 81% -100%, it is a very valid category. Judging from the results of the validation analysis by the three validators, the average percentage was 89.22%. So it was revealed that Android-based interactive teaching materials using the Ispring application with an insight into sustainable development are in a very valid category.

Furthermore, a practicality test was carried out using interactive teaching materials based on Android using the Ispring application with an insight into sustainable development for educators and students. As many as 2 science educators and 20 students took this practicality test. The results of the practicality test of educators and students can be seen in the graph below.

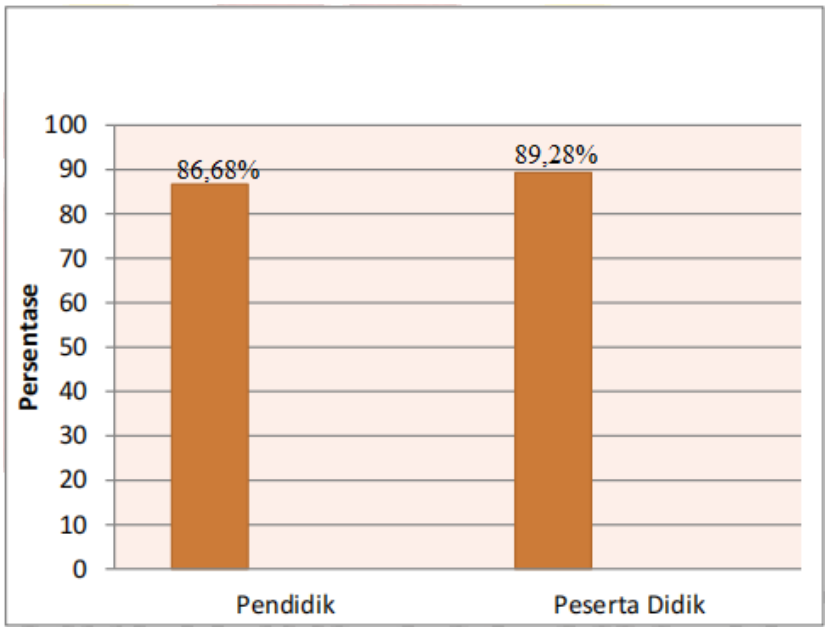


Figure 4. Average Practicality Validation Value

Judging from the results of the analysis of practitioners by educators and students, an average percentage of 87.98% was obtained, it was revealed that Android-based interactive teaching materials used the Ispring application with an insight into sustainable development in a very practical category. This is also supported by several previous studies which also found that the development of teaching materials using ISpring can help students understand science concepts and make learning more interactive (Dasmo et al. 2020; Qomariah and Mistianah 2021; Sari and Ridwan 2020; Sastrakusumah et al. 2018).

4. CONCLUSIONS

Android-based interactive teaching materials using the ispring application with the perspective of sustainable development with very valid, practical, and usable categories. However, this interactive teaching material needs to further see the effectiveness of its use on a larger scale. To be able to see the impact and influence of this interactive teaching material which is more significant for students and educators in learning science.

5. ACKNOWLEDGMENTS

The author would like to express his deepest gratitude to UIN Imam Bonjol Padang and Universitas Negeri Padang (UNP) for the support of this publication. We thank the lecturers at UIN Imam Bonjol and UNP for the suggestions and validation of the products developed in this research.

6. REFERENCES

Asyhari, A. 2015. Profil peningkatan kemampuan literasi sains siswa melalui pembelajaran saintifik. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni* 4(2): 179–191.

Cebrián Bernat, G., Junyent i Pubill, M., and Mulà Pons de Vall, I. 2020. Competencies in Education for Sustainable Development: Emerging Teaching and Research Developments. *Sustainability, 2020, vol. 12, núm. 2, p. 579* MDPI (Multidisciplinary Digital Publishing Institute).

Dasmo, D., Lestari, A. P., and Alamsyah, M. 2020. Peningkatan hasil belajar fisika melalui penerapan media pembelajaran interaktif berbasis ispring suite 9. in: *SINASIS (Seminar Nasional Sains)*.

Ekantini, A., and Wilujeng, I. 2018. The Development of Science Student Worksheet Based on Education for Environmental Sustainable Development to Enhance Scientific Literacy. *Universal Journal of Educational Research* ERIC 6(6): 1339–1347.

Herwinarso, H., Untung, B., Wirjawan, J. V. D., and Pratidhina, E. 2020. Development of android app to assist high school students in learning physics quantities and measurement principles. *TEM Journal* UIKTEN-Association for Information Communication Technology Education and … 9(1): 292–295.

Istighfarini, M. D., Supeno, S., and Ridlo, Z. R. 2022. Pengaruh media aplikasi berbasis android terhadap literasi sains dan hasil belajar IPA siswa SMP. *LENSA (Lentera Sains): Jurnal Pendidikan IPA* 12(1): 61–70.

Kasmita, W., Hamidah, I., and Rochintaniawati, D. 2021. Development of Mobile Media "GeMBul" in Science Learning: The Validity and Reliability Study.

Lee, C., Ki, S., and Choi, J. 2011. Effects of oral curcumin on the pharmacokinetics of intravenous and oral etoposide in rats: possible role of intestinal CYP3A and P-gp inhibition by curcumin. *Biopharmaceutics & drug disposition* Wiley Online Library 32(4): 245–251.

Manasikana, A. 2017. Pengembangan bahan ajar interaktif berbasis android pada materi jurnal penyesuaian dan jurnal koreksi untuk kelas XII akuntansi di SMKN 1 Surabaya. *Jurnal Pendidikan Akuntansi (JPAK)* 5(2).

Nurhamidah, S. D., Sujana, A., and Karlina, D. A. 2022. Pengembangan Media Berbasis Android pada Materi Sistem Tata Surya untuk Meningkatkan Penguasaan Konsep Siswa. *Jurnal Cakrawala Pendas* 8(4): 1318–1329.

Plomp, T., and Nieveen, N. 2013. Educational design research part A: An introduction. *The Netherland: SLO, Enschede*.

Qomariah, I. N., and Mistianah, M. 2021. PENGEMBANGAN MEDIA iSPRING SUITE 8 DENGAN MODEL THINK PADA MATA KULIAH GENETIKA. *Jurnal Pendidikan Biologi* 12(2): 108–113.

Ramdani, A., Jufri, A. W., and Jamaluddin, J. 2020. Pengembangan Media Pembelajaran Berbasis Android pada Masa Pandemi Covid-19 untuk Meningkatkan Literasi Sains Peserta Didik. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran* 6(3): 433–440.

Reinders, H., and Balcikanli, C. 2011. Learning to foster autonomy: The role of teacher education materials. Kanda University of International Studies (KUIS), Chiba, Japan.

Sari, M. P., and Ridwan, R. 2020. Pengembangan Multimedia Interaktif Menggunakan Aplikasi Ispring Suite 9 Pada Pembelajaran IPA Kelas IX Di SMP Negeri 5 Panyabungan. *Jurnal Penelitian Ipteks* 5(2): 216–223.

Sastrakusumah, E. N., Suherman, U., Darmawan, D., and Jamilah, J. 2018. Pengaruh media pembelajaran interaktif berbantuan aplikasi ispring presenter terhadap kemampuan. *Teknologi Pembelajaran* 3(1).

Schleicher, A. 2016. Colombia should improve equity and quality of education. Organisation for Economic Co-operation and Development.

Sebestyén, V., Domokos, E., and Abonyi, J. 2020. Focal points for sustainable development strategies—Text mining-based comparative analysis of voluntary national reviews. *Journal of Environmental Management* Elsevier 263: 110414.

Setiawan, A. R., Utari, S., and Nugraha, M. G. 2017. Mengonstruksi rancangan soal domain kompetensi literasi saintifik siswa smp kelas viii pada topik gerak lurus. *WaPFi (Wahana Pendidikan Fisika)* 2(2): 44–48.

Siahaan, T. M., Sianipar, H. F., Simamora, R., Sijabat, A., and Sinaga, C. V. R. 2021. Pengembangan buku ajar berbasis kooperatif tipe jigsaw untuk meningkatkan kemampuan berpikir kreatif mahasiswa. *Jurnal Basicedu* 5(4): 2496–2503.

Smaldino, S. E., Russell, J. D., Heinich, R., and Molenda, M. 2004. Instructional media and technologies for learning. Upper Saddle River, NJ: Prentice Hall.

Sugiyono, P. D. 2010. Metode penelitian pendidikan. *Pendekatan kuantitatif*.

Uzunboylu, H., and Aşıksoy, G. 2014. Research in physics education: A study of content analysis. *Procedia-Social and Behavioral Sciences* Elsevier 136: 425–437.

Yustianingsih, R., Syarifuddin, H., and Yerizon, Y. 2017. Pengembangan Perangkat Pembelajaran Matematika Berbasis Problem Based Learning (PBL) untuk Meningkatkan Kemampuan Pemecahan Masalah Peserta Didik Kelas VIII. *JNPM (Jurnal Nasional Pendidikan Matematika)* 1(2): 258–274.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Effect of STEM Approach on Students' Critical Thinking Skills

Media Roza[1,*], Minda Azhar[2], Festiyed[2], Prima Aswirna[3], Rika Purnama Sari[4]
[1,3]Tadris Physics Study Program, Universitas Islam Negeri Imam Bonjol Padang, Jl. M. Yunus Lubuk Lintah Padang, 25153, Sumatera Barat, Indonesia
[2]FMIPA, Universitas Negeri Padang, Jalan Prof. Dr. Hamka, Air Tawar Padang, Sumatera Barat, 25132, Sumatera Barat, Indonesia
[4]SMP Islam Terpadu JUARA, Jl Abdul Hamid Hakim, Komp. STAI Imam Bonjol, Kota Padang Panjang, Sumatera Barat, Indonesia
*Corresponding Author. E-mail address: mediaroza@uinib.ac.id

KEYWORDS:
Critical Thinking, Science Learning, STEM Approach

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The influence of the STEM approach has been widely studied. However, a summary of how much influence STEM has on critical thinking skills from these various studies has not been done well. This article examines the impact of the STEM approach on students' capacity for critical thought when studying physics and science. This type of research is quantitative research with meta-analysis methods. Articles from recent four-year publications in national and international journals serve as data sources. Only 16 articles met the criteria for further analysis. This study's method of data analysis involved calculating the effect size to provide a summary effect size. There are four moderator variables analyzed: learning models, teaching materials, subject matter, and education level. Based on the study's findings, it can be said that the STEM approach to fostering students' critical thinking abilities has the largest impact size when used in motion systems courses at the high school level, using media schoology and worksheets for the students. The STEM approach is proven to have a high summary effect size on students' critical thinking skills, with a score of 1.37 (high category).

1. INTRODUCTION

The era of globalization requires qualified, competitive, and adaptive Indonesian human resources in all situations. The best way to be able to compete in a global world is to equip human resources with various 21st-century skills through education. The Partnership for 21st Century Skills states that the competencies needed in the industrial revolution era 4.0 are "The 4 Cs," namely communication, collaboration, critical thinking, and creativity (Lufri et al., 2022; Roza, et al., 2022; Moser, 2017; Mumford & McIntosh, 2017).

Everyone is racing to find innovation by strengthening the quality of education. Competence and high competitiveness in humans will be tips for winning competence in the 4.0 revolution era. Competence in the 21st century era is crucial for students to have in implementing learning to guide them to have creative, innovative abilities, think critically in solving problems, and be communicative (Ananda et al., 2021). As a result, it is reasonable to predict that education in the 4.0 or 21st century age will continue to be important and will serve as a complement to the phenomena of digital penetration in daily life.

Education 4.0 prepares students to directly address digital concerns, where the essence of this phenomenon is the mindset, creativity, and great curiosity of students, so that in the future they can produce graduates who have good quality and skills. Therefore, learning activities in education 4.0 units should be carried out systematically, actively, inspiringly, and fun, and should provide motivation for students to actively participate in providing ideas and creativity and be independent in expressing their talents and interests. To support this, learning must meet at least four principles: student-centeredness, collaboration, integration with real life, and having clear context and goals (Asrizal et al., 2018).

In the fourth industrial revolution, critical thinking abilities are the main emphasis of educational activities (Linh et al., 2019). Critical thinking skills can be formed from several habits, including understanding concepts, classifying, analyzing, collecting, and evaluating information obtained through scientific methods (Siegel, 2013). Whereas the scientific method itself entails observation, formulation of issues, formulation of theories, gathering of information, testing of theories, and formulation of conclusions. If students have fulfilled some of these skill criteria, it can be said that they already have the capacity for critical thought in their learning. In addition, this critical thinking focuses on reflective thinking (Hand et al., 2018), and leads to the analysis of arguments or certain opinions, admit mistakes and bias, and provide conclusions based on the evidence and considerations obtained (Arends & Kilcher, 2010) .

Learning activities should help students enhance their critical thinking abilities by relating what they are learning to real-world context issues. One of the main objectives of education is to help pupils become more adept at critical thinking (Tee et al., 2018), where the development of critical thinking abilities emphasizes the learning process through analysis in order to foster the capacity for clear, logical thought (Higgins, 2014). Of course, to do this effectively and help students develop their critical thinking abilities, educators must play a crucial part in learning activities. However, this ability cannot be maximized in schools. 16 years old, Indonesia is in a position of low science ability level. Besides that, based on PISA (Program for Student Assessment) data for a period of 15 years, Indonesia is still in a low science ability position (OECD, 2016). The results of the study show a similar thing: the average score for critical thinking abilities among students for each indicator is on average below 50% (Hidayanti et al., 2016).

Other evidence that shows the lack of capacity for critical thought in students is shown in several studies, including research in Thailand, where it was found that students' critical thinking skills were still low due to teaching methods that were less varied and the school system (Boa, 2018). In addition, the low critical thinking ability of students is caused by learning that is still teacher-centered, where this condition causes students' critical thinking skills to not be improved (Hairida, 2016). If this condition occurs continuously, students' critical thinking skills cannot develop optimally as expected, and will have an impact on student learning outcomes. Among the subjects that can develop critical thinking skills are science and physics learning.

Studying physics and science is expected to run according to the demands of the current curriculum. However, the fact is that science learning in the field is not as expected, especially with the spread of COVID-19, which requires educators to keep up with changes in technology, learning theory, and changes in educational needs and students (Jowsey et al., 2020). Likewise, physics instruction attempts to educate students to deal with changing situations in life and in a world that is experiencing change (Alistiana, L., Aswirna, P., & Y, A., 2020). Physics learning is usually less desirable, considered difficult, and feared by many students. This condition originates from learning experiences where students find physics learning that only addresses conceptual issues and solves questions with high difficulty through mathematical formulas. Additionally, because of the class's inadequate learning environment, students only participate passively in the learning process (Ananda et al., 2021).

Knowledge and technology that are developing rapidly in the current era are expected to be important factors in supporting the quality of students. Educational challenges also increase with the development of technology (Putriyani & Irawan, 2021). So, based on this, an approach is needed to strengthen pupils' capacity for critical thought, one of which is using the STEM (Science, Technology, Engineering, and Mathematics) learning approach (Onsee & Nuangchalerm, 2019).

STEM approach stands for science, technology, engineering, and mathematics (Estapa & Tank, 2017). The STEM approach is considered to be able to encourage students to develop 21st-century skills (Techakosit & Nilsook, 2018). The STEM learning approach is effectively used in learning because students do not always feel suitable for all conventional learning conditions and environments (Jowsey et al., 2020). If STEM is connected to the environment, it will be able to grow, and students will learn about real-world situations that they encounter every day (Sagala et al., nd). STEM applications can help students plan, construct, and utilize technology well,

improving affective, psychomotor, and cognitive skills. According to certain research findings, STEM can enhance conceptual understanding and critical thinking abilities (Fan & Yu, 2015; Lufri, L., & Asrizal, 2023).

The results of searching for national and international journal articles using Harzing's Publish or Perish application obtained 400 articles related to the effect of the STEM approach on students' capacity for critical thought in learning science and physics. However, from the results of the investigation based on the criteria for the articles needed in this study, 16 research articles were found with various conclusions expressed in relation to the use of learning models, teaching materials or learning media used, materials used, and educational level.

Based on the problems described above, it can be seen that the impact of using the STEM approach has been extensively researched. However, a summary of how much influence STEM has on critical thinking skills from these various studies has not been done well. Therefore, a meta-analysis study is needed to see how much the impact of the STEM approach on students' capacity for critical thoughts. This article aims to analyze the effect of the STEM approach on students' critical thinking skills in learning science and physics based on the four moderator variables; learning models, teaching materials or learning media used, materials used, and educational level.

2. MATERIALS AND METHODS

This kind of research uses a meta-analysis methodology and is quantitative. The meta-analysis aims to determine the relevance of the research topic after the treatment. This study analyzes publications in international and national journals from 2018 to 2021. Literature search using keywords through the Publish or Perish application. After searching, there were more than 400 articles related to the influence of the STEM approach to learning science and physics in junior and senior high schools on students' critical thinking skills. However, after being evaluated, only 16 papers met the requirements for further investigation.

This research was obtained by collecting various research journals from various accurate sources, such as Google Scholar, Scopus, the Directory of Open Access Journals, and others in international, national, and other similar sources, which were then arranged and selected according to the specified criteria. Descriptive statistical analysis techniques used to examine the data acquired for this investigation were the effect size of each article and the summary effect size of the influence of the STEM approach on students' critical thinking abilities. The effect sizes were calculated using the Cohen formula based on the mean, standard deviation, calculated t-value, and sample size (Retnawati, et al., 2018). How to calculate the effect size can be seen in Table 1.

Table 1. The formulas used to calculate the effect size

Statistical Data	Formula
If known, only the mean value of the control group, the mean value of the experimental group, the standard deviation of the control group, and the standard deviation of the experimental group.	$ES(d) = \frac{\bar{X}post_E - \bar{X}post_C}{SD_{within}}$ Where : $SD_{within} = \sqrt{\frac{(n_E-1)SDpost_E^2+(n_C-1)SDpost_C^2}{n_E+n_C-2}}$
For the two groups of independent samples, the mean value and posttest-pretest posttest-pretest standard deviation of the experimental class were identified. and known, the mean value of the posttest-pretest and the standard deviation of the posttest-pretest control group.	$ES(d) = \frac{(\bar{X}post_E - \bar{X}post_E) - (\bar{X}post_C - \bar{X}pre_E)}{SD_{within}}$ Where : $SD_{within} = \sqrt{\frac{(n_E-1)SDpre_E^2+(n_C-1)SDpre_C^2+(n_E-1)SDpost_E^2+(n_C-1)}{2(n_E+n_E-2)}}$

Statistical Data	Formula
For a comparison test of two independent samples, if the number of samples in the control group, the number of samples in the experimental group, and the value of tcount are known	$ES\ (d) = \frac{\bar{X}post_E - \bar{X}post_C}{SD_{within}}$ If the number the number of the control group is the same as the experimental group then: $SD_{within} = \frac{\bar{X}post_E - \bar{X}post_C}{t_h\sqrt{\frac{2}{n}}}$ If the number of the control group is different from the number of the experimental group, then: $SD_{within} = \frac{\bar{X}post_E - \bar{X}post_C}{t_h X \sqrt{\frac{1}{n_E}+\frac{1}{n_C}}}$
For the pretest-posttest contrast design, and if it is known, the average value of posttestE and pretestE	$ES\ (d) = \bar{X}post_E - \bar{X}pre_E$ where: $SD_{within} = \sqrt{\frac{(n_1-1)xS_1^2+(n_2-1)xS_2^2}{n_1+n_2-2}}$
To find the value of variance d	$V_d = \frac{n_E + n_C}{n_E x n_C} + \frac{d^2}{2(n_E + n_C)}$ $Sed = \sqrt{V_d}$
To change d to Hedge's g, use the correction factor (J). The (J)	$J = 1 - \frac{3}{4df-1}$ after: $g = J \times d$ $Vg = J^2 \times V_d$ $Seg = \sqrt{Vg}$

The criteria for determining the effect size are categorized using the reference from Glass can be seen at Table 2.

Table 2. Criteria effects size

No	Effects sizes	Category
1	ES 0.15	Negligible
2	0.15 < ES < 0.40	Low
3	0.40 < ES < 0.75	Medium
4	0.75 < ES < 1.10	High
5	ES > 1.10	Very high

(Modified from Glass, 1976)

The research procedure consists of seven steps: determining the research topic, choosing the type of publication to be collected, collecting the results of the study or literature, recording the

research variables, calculating the effect size for each source or literature, interpreting the report, and making conclusions.

3. RESULTS AND DISCUSSION

The results obtained are a calculation of how much the summary effect influences the STEM Approach on Students' critical thinking abilities based on four the moderator variable is the learning model used, teaching materials or media used, materials and educational levels.

3.1. The effect of the STEM Approach on Students' Critical Thinking Skills

The results of 16 articles that met predetermined criteria regarding the effect of the STEM approach on students' critical thinking ability, found various effect sizes that varied. The effect size of each analyzed article can be seen in Table 3.

Table 3. Effect size of each article

Code Article	d	V_d	SE_d	Category
J01	2.56	0.121	0.348	Very high
J02	3,26	0.086	0.294	Very high
J03	2.44	0.114	0.337	Very high
J04	0.45	0.064	0.253	Medium
J05	3,41	0.194	0.441	Very high
J06	1.05	0.048	0.220	High
J07	0.55	0.065	0.255	Medium
J08	0.80	0.089	0.298	High
J09	4.37	0.036	0.190	Very high
J10	0.21	0.009	0.093	Low
J11	0.60	0.031	0.175	Medium
J12	0.60	0.069	0.262	Medium
J13	0.61	0.056	0.238	Medium
J14	0.51	0.070	0.265	Medium
J15	0.47	0.037	0.192	Medium
J16	0.36	0.041	0.202	Low

where:
d = Cohend's effect size
V_d = Cohend's effect size variance
SE_d = Cohend's standard error effect size

There are 5 articles with a very high effect size, 2 articles in the high category, 7 articles in the medium category, and 2 articles in the low category. Therefore, it is crucial to analyze the overall effect size of the STEM approach's effects on students' capacity for critical thought as well as the moderator factors that have been established, namely learning models, teaching materials or media, subject matter, and level of education.

The use of the STEM approach in learning science and physics in junior and senior high schools is able to improve students' critical thinking skills. As explained by Asigigan and Samur, STEM practice positively improves students' critical thinking skills (Asigigan & Samur, 2021) . The conclusion that STEM practices improve students' critical thinking abilities is supported by a number of research in the literature (Hacioglu & Gulhan, 2021; Mutakinati et al., 2018).

3.2. The Influence of The STEM Approach on Students' Critical Thinking Skills Based on The Learning Model

The description from table 4 explains that the meta-analysis of the use of the STEM approach to students' critical thinking skills based on the learning model used gives an effect with medium,

high, and very high categories. The summary effect size of the influence of the STEM approach using various learning models on students' critical thinking skills can be seen in Table 4.

Table 4. Summary of the effect size of the STEM approach on students' critical thinking skills based on the learning model

Learning model	N	Summary ES	Category	p.s	95% Confidence Interval	
					Lower	Upper
STEM	10	1,087	High	0.000	0.461	1,714
Blended Learning	1	3,237	Very high	0.000	2.665	5.309
PBL	3	0.574	Medium	0.002	0.217	0.932
PJBL	1	1.024	High	0.000	0.603	1.229
Discovery Learning	1	4,357	Very high	0.000	3.985	7.847

If the p-value = 0 < 0.05, then the hypothesis tested using the fixed effect is rejected. So that there is an influence of the STEM approach on students' critical thinking skills in science and physics learning in all learning model analyzed. The highest influence of the STEM approach was found in the discovery learning model with a summary effect size of 4.357, the second highest in the Blended Learning model with a summary effect size of 3.237, the PJBL model in the high category with a summary effect size of 1.024, and so on, followed by the PBL model with a summary effect size of 0.574.

The learning model is a design that is arranged systematically to achieve the goals of learning (Alistiana et al., 2020). STEM learning is effectively combined with Discovery Learning, Blended Learning, and PJBL models because the STEM-based Discovery Learning Model in Biology that is linked to real life is in a good category, thereby increasing the interest and activeness of students and making material easier to remember, as well as ensuring that participants have good concentration during learning (Fadlina et al., 2021).

3.3. The influence of the STEM approach on students' critical thinking skills based on the teaching materials/media used

The results of further research in this research activity are related to the summary effect size analysis of the influence of the STEM approach on learning science and physics through the use of teaching materials or learning media. The summary effect size of the influence of the STEM approach using various teaching materials on students' critical thinking skills can be seen in Table 5.

Table 5. Summary of the effect size of the STEM approach on students' critical thinking skills based on the teaching materials/media used

Teaching Materials	N	Summary ES	Category	p.s	95% Confidence Interval	
					Lower	Upper
Schoology	1	3.237	Very high	0.000	2.665	5.309
Students' worksheets	4	2.637	Very high	0.002	0.931	4.344
PhET	1	0.787	High	0.007	0.212	0.501
Digital Books	1	0.440	Medium	0.079	-0.050	-0.036

The p-value test obtained is smaller than α (0.05), which means that the null hypothesis is rejected when it is tested for schoology or media, student worksheets, and PhET. However, the

results of testing the null hypothesis for digital book media show that the null hypothesis is accepted because the p-value is greater than α (0.05). This means that using instructional materials or media in learning with the STEM approach to students' critical thinking skills has a very significant influence on teaching materials or schoology media, students' worksheets, and PhET. Based on the summary effect size value that has been obtained, the highest summary effect size value is on teaching materials, school media, and students' worksheets. So, using instructional materials or media in learning with the STEM approach to students' critical thinking skills has a very significant influence on teaching materials or schoology, students' worksheets, and PhET.

In the world of education, the teaching and learning process is very dependent on factors that affect the quality of the learning process. The quality of learning can be seen in students' responses to the media or teaching materials used (Izzah et al., 2021). One of them is learning media, or learning aids, which are very important to use to communicate messages from the sender to the recipient so that the learning process can achieve learning objectives effectively by stimulating students' thoughts, feelings, interests, and readiness (Ariska et al., nd).

3.4. The Influence of the STEM Approach on Students' Critical Thinking Skills Based on Subject Matter

In the Summary Effect Sizes in Table 6, which is 4.38, it is presented that the meta-analysis results of the influence of the STEM approach on students' critical thinking ability have different effects ranging from low to very high categories on natural science learning materials and physics in middle and high school. The summary effect size of the influence of the STEM approach using various subject matter on students' critical thinking skills can be seen in Table 6.

Table 6. Summary of the effect size of the STEM approach on students' critical thinking skills based on the subject matter

Subject Matter	N	Summary ES	Category	p.s	95% Confidence Interval	
					Lower	Upper
Sound Wave	1	2.528	Very high	0.000	1.854	-0.036
Light waves	1	2.386	Very high	0.000	0.212	3.520
Light and Optics	1	0.440	Medium	0.079	-0.050	-0.036
Optical	1	0.787	High	0.007	0.212	0.501
Dynamic Fluids	2	1.713	Very high	0.000	1.336	2.09
Static Fluids	2	0.775	High	0.000	0.506	1,043
Motion System	1	4.357	Very high	0.000	3.985	7.847
Ecosystem	1	0.213	Low	0.022	0.031	0.070
Newton's laws	1	0.589	Medium	0.023	0.083	0.229
Electricity (Energy Transformation)	1	0.501	Medium	0.055	-0.010	0.048
Equilibrium	1	0.346	Low	0.078	-0.039	-0.037

The results of testing the null hypothesis on the material sound waves, light waves, optics, dynamic fluids, static fluids, motion systems, ecosystems, and Newton's laws show that the hypothesis was rejected because the p-value test obtained was smaller than the value of α (0.05). However, the results of testing the null hypothesis for the materials light and optics, electricity, and equilibrium show that the null hypothesis is accepted because the p-value test obtained is greater than the value of α (0.05).

This means that the STEM approach influences critical thinking skills in every material except for light and optics, electricity, and equilibrium. Based on the summary effect size value that has been obtained, the highest summary effect size is in motion system material, sound waves, light waves, and fluid dynamics. It may be concluded that the STEM approach to teaching science and physics has a significant positive impact on student's ability to think critically about these four subjects.

The application of the STEM approach is considered to be able to help improve students' critical thinking skills (Khoiriyah, 2018). The characteristics of subjects also influence the success of the STEM approach. Karakoc (2016) argues that when students think critically, they are encouraged to think independently, question hypotheses, analyze and synthesize events, and go further by developing new hypotheses and testing them against facts that occur in real life.

3.5. The Influence of the STEM Approach on Students' Critical Thinking Skills Based on Educational Level

Analysis using the fixed effect model obtained a summary effect size of 0.325 for the effect of the STEM approach on learning science and physics on students' critical thinking skills at the junior high school level, with a 95% confidence interval tested using JASP software ranging from 0.190 to 0.460. The summary effect size of the influence of the STEM approach using various educational level on students' critical thinking skills can be seen in Table 7.

Table 7. Summary of the effect size of the STEM approach on students' critical thinking skills based on the educational level

Educational Level	N	Summary ES	Category	p.s	95% Confidence Interval	
					Lower	Upper
Junior High School	7	0.325	Low	0.000	0.190	0.460
Senior High School	9	2,111	Very high	0.000	1.183	3.038

The results of the analysis using the RE model obtained a summary effect size of 2.111 for the effect of the STEM approach on science and physics learning on students' critical thinking skills at the high school level, with 95% confidence intervals ranging from 1.183 to 3.038. The results of testing the null hypothesis for both levels of education show that the null hypothesis is rejected because the p-value obtained is 0.000, which is smaller than the value of (0.05). It can be concluded that the STEM approach to science learning has a significant influence on students' critical thinking skills at the junior and senior high school levels.

Approaching STEM has a significant impact when applied to high school students. This is because the higher the level of education and the older the person, the more their ability increases. In Bujuri's (2018) research, children aged 11 to 12 years and over are experiencing a formal operational phase, where they are able to think of something that will or may happen and is abstract in nature.

4. CONCLUSIONS

Based on the meta-analysis carried out, it can be stated that there are two research results. First, the summary effect size of the effect of the STEM approach in science and physics learning on students' critical thinking skills is 1.375 in the high category, so the STEM approach in science and physics learning has a significant effect on students' critical thinking abilities. Second, the effect of the STEM approach in science and physics learning on students' critical thinking skills gives the highest summary effect size to the discovery learning model with an effect size of 4.36

in the very high category and to the use of schoology with a summary effect size of 3.24. In the subject matter of motion systems with a summary effect size of 2.56 in the very high category and at the high school level with a summary effect size of 2.11 in the very high category. It can be concluded that the STEM approach has a very high effect on students' critical thinking skills. Educators are required to be able to develop teaching materials or STEM-based learning media to improve critical thinking skills as a support when learning takes place.

5. ACKNOWLEDGMENTS

We are grateful to the lecturers from the Doctoral Program of Science Education of Universitas Negeri Padang and FTK UIN Imam Bonjol Padang in West Sumatra who permitted for the researchers to conduct correctly conducted research and other ideas that aided in this study.

6. REFERENCES

Alistiana, L., Aswirna, P., & Y, A. (2020). analysis of the use of hots-based reciprocal teaching models on students' critical thinking skills in elementary school science material. T*arbiyah al-Awlad* , *10* (2), DOI: 10.15548/alawlad.v10i2.2578

Ananda, MD, Sari, M., & Roza, M. (2021). The Effectiveness of Learning Physics Edutainment with the Help of PhET Media on Students' Logical Thinking Ability. *Natural Science: Research Journal of Science and Science Education* , *7* (2), 103–110. DOI: 10.15548/nsc.v7i2.2478

Arends, D., & Kilcher, A. (2010). *Teaching for student learning: Becoming an accomplished teacher* . Routledge.

Ariska, D., Asril, Z., & Aswirna, P. (nd). (2021). Development of Higher Order Thinking Skills (Hots) Assessment Assisted by the Lectora Inspire Application on Students' Critical Thinking and Creative Thinking Ability. *Student Smart Journal* , *3* (111–125), 15.

Asigigan, S. İ., & Samur, Y. (2021). The Effect of Gamified STEM Practices on Students' Intrinsic Motivation, Critical Thinking Disposition Levels, and Perception of Problem-Solving Skills. *International Journal of Education in Mathematics, Science and Technology* , *9* (2), 332–352. DOI: 10.46328/ijemst.1157

Asrizal, A., Amran, A., Ananda, A., & Festiyed, F. (2018). *Effectiveness of adaptive contextual learning model of integrated science by integrating digital age literacy on grade VIII students* . *335* (1), 012067. DOI: 10.1088/1757-899X/335/1/012067

Boa, EA (2018). The development and validation of the Blended Socratic Method of Teaching (BSMT): An instructional model to enhance critical thinking skills of undergraduate business students. *Kasetsart Journal of Social Sciences*, 9. DOI: 10.1016/j.kjss.2018.01.001

Bujuri, DA (2018). Analysis of cognitive development of elementary age children and its implications for teaching and learning activities. *LITERACY (Journal of Education)* , *9* (1), 37–50.

Estapa, AT, & Tank, KM (2017). Supporting integrated STEM in the elementary classroom: A professional development approach centered on an engineering design challenge. *International Journal of STEM Education* , *4* (1), 6. DOI: 10.1186/s40594-017-0058-3

Fadlina, F., Artika, W., Khairil, K., Nurmaliah, C., & Abdullah, A. (2021). Application of the STEM-Based Discovery Learning Model in Motion Systems Material to Improve Critical Thinking Skills. *Indonesian Journal of Science Education* , *9* (1), 99–107.

Fan, S.-C. and K.-C. Yu. (2015). How an integrative STEM curriculum can benefifit students in engineering design practices. I*nt J Technol Des Edu*c, 1-23.

Hacioglu, Y., & Gulhan, F. (2021). The Effects of STEM Education on the Students' Critical Thinking Skills and STEM Perceptions. *Journal of Education in Science, Environment and Health* , *7* (2), 139–155.

Hairida, H. (2016). The effectiveness of using inquiry based natural science modules with authentic assessment to improve the critical thinking and inquiry skills of junior high school students. *Indonesian Journal of Science Education* , *5* (2), 209–215.

Hand, B., Shelley, MC, Laugerman, M., Fostvedt, L., & Therrien, W. (2018). Improving critical thinking growth for disadvantaged groups within elementary school science: A randomized controlled trial using the Science Writing Heuristic approach. *Science Education* , *102* (4), 693–710. DOI: 10.1002/sce.21341

Hidayanti, D., As'ari, A., & Daniel C, T. (2016). *Analysis of critical thinking skills of grade IX junior high school students on congruence material* .

Higgins, S. (2014). Critical thinking for 21st-century education: A cyber-tooth curriculum? *PROSPECTS* , *44* (4), 559–574. DOI: 10.1007/s11125-014-9323-0

Izzah, N., Asrizal, A., & Festiyed, F. (2021). Meta-Analysis of Effect Size Effect of STEM-Based Science and Physics Teaching Materials on Student Learning Outcomes. *Journal of Physics Education* , *9* (1), 114–130. DOI: 10.24127/jpf.v9i1.3495

Jowsey, T., Foster, G., Cooper-Ioelu, P., & Jacobs, S. (2020). Blended learning via distance in pre-registration nursing education: A scoping review. *Nurse Education in Practice* , *44* , 102775. DOI: 10.1016/j.nepr.2020.102775

Kapila, V., & Iskander, M. (2014). Lessons learned from conducting a K-12 project to revitalize achievement by using instrumentation in Science Education. *Journal of STEM Education*, 15(1).

Karakoc, M. (2016). The significance of critical thinking ability in terms of education. *International Journal of Humanities and Social Science* , *6* (7), 81–84.

Khoiriyah, N. (2018). *Implementation of the STEM learning approach to improve high school students' critical thinking skills in sound wave material*.

Linh, NQ, Duc, NM, & Yuenyong, C. (2019). Developing critical thinking of students through STEM educational orientation program in Vietnam. *Journal of Physics: Conference Series* , *1340* , 012025. DOI: 10.1088/1742-6596/1340/1/012025

Lufri, L., Andromeda, A., & Mufit, F. (2022). Science Teacher's Perception of Digital Technology-Based Learning in the 21st Century. *Jurnal Pendidikan Progresif, 12*(1), 281–293. DOI: 10.23960/jpp.v12.i1.202222

Lufri, L., & Asrizal, (2023). A. Meta-Analysis The Effect of STEM Integrated Problem Based Learning Model on Science Learning Outcomes. *Jurnal Pendidikan Matematika dan IPA*, 14(1), 16-32. DOI: 10.26418/jpmipa.v14i1.51678

Moser, D. (2017). Driving 21st century learning. *Journal for Research and Education, Special Issue*, 115–125.

Mumford, M. D., & McIntosh, T. (2017). Creative thinking processes: The past and the future. *The Journal of Creative Behavior*, *51*(4), 317–322. DOI: 10.1002/jocb.197

Mutakinati, L., Anwari, I., & Kumano, Y. (2018). Analysis of students' critical thinking skills of middle school through stem education project-based learning. *Indonesian Journal of Science Education* , *7* (1), 54–65. DOI: 10.15294/jpii.v7i1.10495

OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education* . OECD. DOI: 10.1787/9789264266490-en

Onsee, P., & Nuangchalerm, P. (2019). Developing Critical Thinking of Grade 10 Students through Inquiry-Based STEM Learning. *Journal of Science Research and Learning* , *5* (2), 132–141. DOI: 10.30870/jppi.v5i2.5486

Putriyani, AE, & Irawan, E. (2021). Analysis of Rational Thinking Ability in Asynchronous Online Learning with STEM Approach. *Natural Science: Research Journal of Science and Science Education* , *7* (2), 125–137.DOI: 10.15548/nsc.v7i2.2903

Retnawati, H., Apino, E., Djidu, H., & Anazifa, RD (2018). *Introduction to meta analysis* . Parama Publishing.

Roza, M., Festiyed, Asrizal, & Desnitad. (2022). The Analysis of Effect Size of the PBL Model on Science Competence of High School Students. *Jurnal Pendidikan Sains,* 10(2), 12–24. DOI: https://doi.org/10.26714/jps.10.2.2022.12-24

Sagala, R., Umam, R., Thahir, A., Saregar, A., & Wardani, I. (nd). (2019). *The Effectiveness of STEM-Based on Gender Differences: The Impact of Physics Concept Understanding* . 9. DOI: 10.12973/eu-jer.8.3.753

Siegel, H. (2013). *Educating Reason* . Routledge.

Techakosit, S., & Nilsook, P. (2018). The Development of STEM Literacy Using the Learning Process of Scientific Imagineering through AR. *International Journal of Emerging Technologies in Learning (IJET)* , *13* (01), 230. DOI: 10.3991/ijet.v13i01.7664

Tee, KN, Leong, KE, & Abdul Rahim, SS (2018). The Mediating Effects of Critical Thinking Skills on Motivation Factors for Mathematical Reasoning Ability. *The Asia-Pacific Education Researcher* , *27* (5), 373–382. DOI: 10.1007/s40299-018-0396-z

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Inventory of Montane Zone Weeds in the Selo Tourism Area, Boyolali Regency, Central Java

Nila Permatasari[1], Santhyami[1,2]*
[1]Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
[2]Environmental Study Centre, Universitas Muhammadiyah Surakarta, Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Correspondence Author, E-mail address: san915@ums.ac.id

KEYWORDS:
Weeds
The tourist area
Montane
Vegetation
Ecosystems

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The weed is a plant that develops in undesirable areas and harms surrounding plants. Nonetheless, this herb can be used as a source of organic material, as a soil coating to prevent erosion, and as a traditional medicine. Weed growth can vary depending on the weed's characteristics and environmental conditions. The Selo region is a verdant tourist destination in the montane zone's highlands. The land clearing caused a change in the area's vegetation. This study seeks to determine the Montane zone's weed vegetation varieties, composition, and structure. It is also connected to the release of land in Selo as a tourist area. This form of research is conducted at three different altitudes (1.600m asl, 1.700m asl, dan 1.800m asl). The intercept-point and exploration method is used, as well as data analysis involving the determination of summed dominance ratio (SDR) values and diversity index analysis. Consequently, there are variations in the composition and dominance of herbaceous vegetation at each height. There are 27 species of vegetation, with Imperata cylindrica (SDR 55.67% and 27.73% at 1.600m asl and 1.800m asl, respectively) dominating at 1.600m asl and 1.800m asl, and Ageratina riparia (SDR 20.86%) dominating at 1.700m asl. The highest diversity of grass species at the altitude of 1.800 m asl (H' 2,17). The highest sorensen's similarity index is at altitudes of 1.600 m asl and 1.700 m asl (SSI 52,17%). The ecosystem conditions influenced by abiotic factors and the management of ecosystems impact the diversity and uniformity of grass species in the mountainous region of the Selo Tourist Area.

1. INTRODUCTION

The weed is all plants that thrive in an area the farmer does not want them to, so their presence can harm other plants or the tree plant (Oksari, 2017). Due to competition for nutrients, water, light, and other essential development elements, weeds can be detrimental to the growth and yield of plants in agriculture (Faisal, et al., 2011). However, weeds can be used as a source of organic material, soil coating to prevent erosion, and as constituents in traditional medicines (Hasan, 2019). Competition between weeds and plants is affected by the type and density of weeds, horticultural culture, plant varieties, fertilization, soil conditions, and climate (Tantra & Santosa, 2016). The risky characteristic of weed, namely that it can germinate and grow in conditions of low light and water, that its seeds do not die or go dormant when the environment is less conducive for its growth, and that its vegetative growth and development are rapid (Widaryanto & Zaini, 2021). The stems are generally triangular, occasionally spherical, and typically not loose; the leaves are arranged in three rows and lack leaf languages (ligula) (Nugraha, 2023).

Montane zone is situated between 1.500 and 2.400 m asl (Rozak, 2016). The zone is characterized by dense vegetation, decreasing stem diameter, and abundant wood-dwelling mollusks and nails. This area has a variety of trees that are decreasing in number. The vegetation

formation above is becoming increasingly open, allowing more sunlight to enter the forest and increasing the presence of weed and weed (Anesta, 2020). Different climates can cause differences in the species and population's vegetation in response to differences in height (Budi, 2018). Weed growth varies based on the weed's characteristics or constitution, environmental conditions, treatment, and environmental adaptability (Andalusia, 2018). Research on weed species is required to understand the distinctions in type, dominance, density, and distribution of weeds in the montane zone. In addition, more research needs to be conducted on vegetation in the tropical montane zone.

Selo area is a Mount Merapi Montane region municipality in Boyolali district, Central Java Province. It is situated on the foothills of Mounts Merapi and Merbabu (Suyana, 2020). Where the topography of Selo's territory ranges from 1.600 to 1.800 m asl. The region offers a variety of tourist destinations with breathtaking natural scenery. The creation of a tourist destination necessitates a large amount of land for its management in order for the land to serve its purpose. The opening of land by humans can alter the structure of previously extant plant life (Blegur, 2022). During land preparation, vegetation control is typically accomplished by soil processing. This causes a change or transition in the plant life in an area, including the growth of weeds.

As a foundation for using and conserving biodiversity and other natural resources, vegetation data is indispensable. These vegetation data are used for scientific purposes and a variety of practical applications, such as forest harvesting, land use, soil protection, water management, mining, etc (Julianto, Putri, and Safi'i, 2020). Selo is one of the tourist destinations close to Mount Merapi, which transforms this region into the high plains. In addition, the region is rich in vegetation, with weed being one of the lesser-known species. Where inventory research has been limited and information on the types of weed in the area to be studied is unavailable, it is necessary to gather data on the types of cereal in the Selo Area. This research is required to identify the zone montane weeds type, particularly in the tropics. In addition, understanding the type of weed vegetation is essential for determining the success of a society's weed control efforts. The land opening causes a shift in the region's vegetation, so it is necessary to update the vegetation data of the weeds zone of the Selo Tourism Area's montane. Therefore, this study aims to identify the weed varieties, composition, and structure of the montane weed zone in the Selo Tourism Area, Boyolali, Central Java.

2. MATERIALS AND METHODS

Sampling Location and Sampling

Observational investigation on the inventory of montane zone weeds in the Selo Tourism Area, Boyolali Prefecture, Central Java at coordinates -7.512369°,110.453935° (1.600m asl), -7.515583°,110,453307 (1.700m asl), and -7.519806°,110452495 (1.800m asl), sampling is conducted. The region's topography consists of highlands in mountainous regions with altitudes between 1.600m asl and 1.800m asl and brown lithosol and grey regosol soil types. This region has a climate of type C, which is sufficiently moist to support agricultural endeavors. This region's average temperature and humidity range from 24-28°C and 75-90%, respectively. In the monsoon season, precipitation ranges from 0 to 256 mm^3, whereas in the dry season, it ranges from 277 to 439 mm^3. The air pressure is between 1.008,80 and 1.011,00 mb, and the wind speed is between 6,90 and 11,00 kph. In the interim, the solar eclipse was between 61 and 86%.

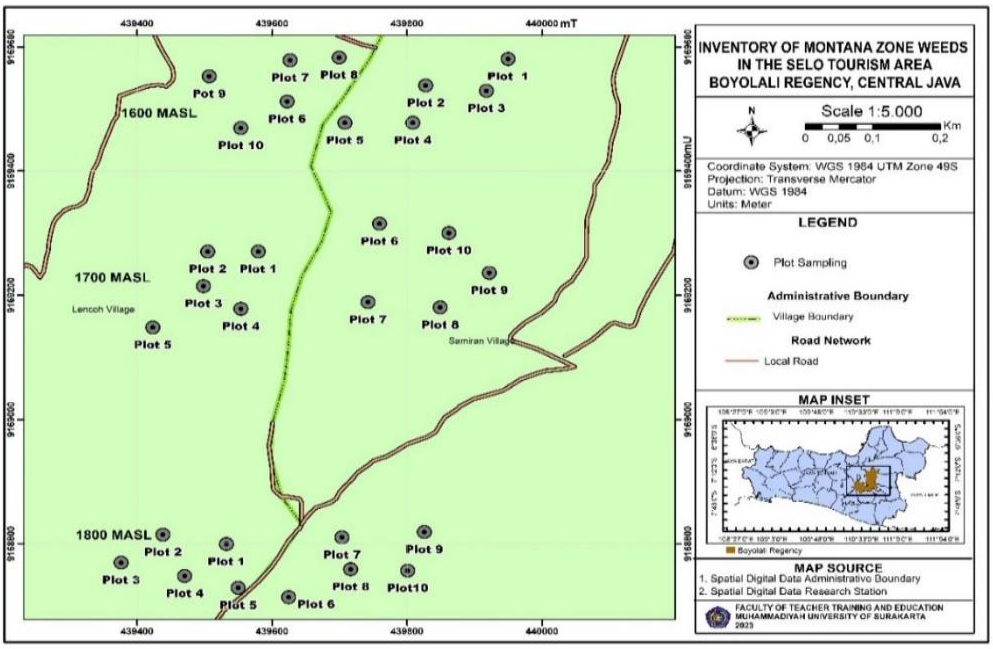


Figure 1. Map and location of research

The study was conducted at three distinct altitudes: 1.600 m asl, 1.700 m asl, and 1.800 m asl. Intercep-point and exploration are the methodologies used. According to Firmansyah et al. (2020), plot placement is conducted using a technique based on the large quantity of weed vegetation. Sampling each plot's weed vegetation using 100cm x 100cm squares (Kartawinata & Abdulhadi, 2016). Roll meters, rafia rope, wooden rods, and small square meter sampling instruments for vegetation are utilized for plotting. The thermohygrometer, altimeter, and soil tester are the instruments that are used to determine environmental conditions. Cutter, plastic bags, cameras, sprayers, petri containers, lups, and writing instruments are employed for plant sampling. Where weed vegetation at various altitudes of the montane zone area (1.600m asl, 1.700m asl, and 1.8000m asl) in the Selo Tourism Area, Boyolali Prefecture, Central Java was utilized for this study.

Figure 2. Sampling tools square meters (1m x 1m)

Herbarium Specimen Collection and Identification

Herbarium collections by gathering specimens of all vegetation species discovered. Thus, the results of the herbarium were identified at the Muhammadiyah University of Surakarta's Biological Laboratory. Identification and nomenclature are accomplished through desk research utilizing the books Flora (Steenis, C.G. G.J., 2013) and Flora of Java (C.A. Backer, R.C. Bakhuizen Van Den Berg, 1963).

Data Analysis

Summed Dominance Ratio (SDR) values are calculated based on Cox (1967) and Mueller-Dombois and Ellenberg's (1974), i.e., the SDR values are derived from the calculation of the Relative Species Density (RD), the Dominance of a Species (RDo), and the Frequency of Reference of a Species (RF), and the Important Value (IV). We also calculated the species diversity index (Shannon & Wiener, 1963) and sorensen's similarity index (Mueller-Dumbois & Ellenberg, 1974).

3. RESULTS AND DISCUSSION

The structure and composition of the weed species found in the ecosystem of the montane zone in the Selo Tourist Area consists of 27 species from 11 families identified during the investigation at three altitude points (1.600m asl, 1.700m asl and 1.800m asl). At an altitude of 1.600m asl, 9 species of vegetation from 3 families were discovered; at 1.700m asl, 14 species from 7 families; and at 1.800m asl, 17 species from 7 families. Asteraceae, Poaceae, Balsaminaceae, Onagraceae, Cyperaceae, Polygalaceae, Urticaceae, Marsileaceae, Umbelliferae, Caryophyllaceae, and Melastomataceae are families of herb species discovered there.

The classification of wheat based on its morphology yields two categories of weed: Large leaf and narrow leaf grass. Large leafy weed is a weed whose blade breadth exceeds half its length. The leaf shapes are oblong, round, triangular, long, round, or kidney-shaped (Tosang, 2019). Typically, the return of the leaves of this group, i.e., the stitching, is dominated by the typical Dicotyledoneae plant group. The narrow-leafed weed is one in which the leaf length and width are tiny or narrow. The shape of the foliage is tapered, linear, needle-like, and elongated. This group's leaf returns are typically straight or linear and dominated by Monocotyledoneae (Firmansyah, 2017). At three different altitudes, it is determined that weedes with broad leaves are the most prevalent (Figure 3). The abundance of broad-leaved weeds makes them the predominant vegetation in the ecosystem, and they can inhibit the growth of weeds. This is due to the fact that seeds are used to cultivate the majority of weed foliage. At the time of soil processing, the seeds in the soil are extracted and germinated if water and light requirements are met (Putra et al., 2018). In addition, broad-leaved weeds are more resistant to heat, water, and light than weeds, stitching, and spotting weeds (Ramlan et al., 2019). Therefore, weeds with broad leaves tend to be more adaptable than narrow ones (Suryanto et al., 2017).

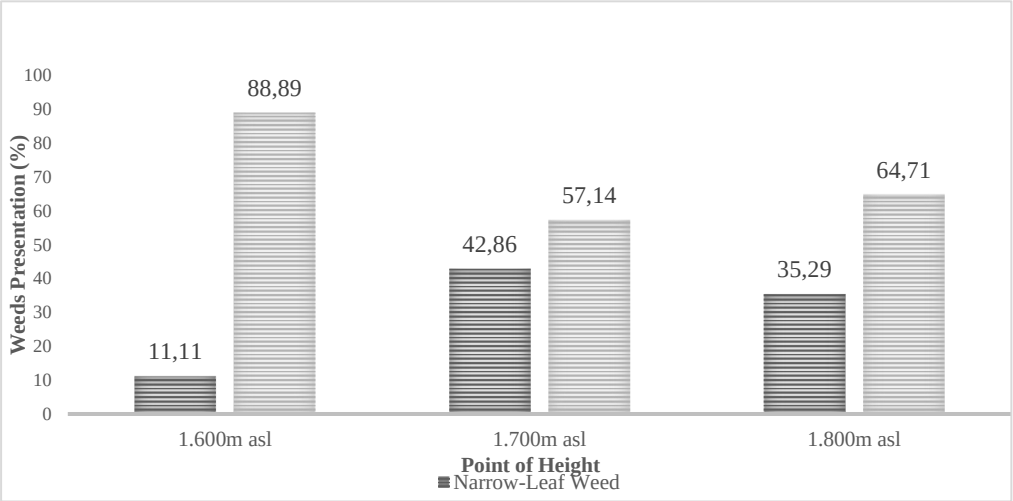


Figure 3. Three-dimensional visualization of the number of large leaf and narrow leaf weed types

The importance of each variety of weed can be used to determine the dominant type of weed in an ecosystem. The variety of weeds that grows in the Selo Tourist Area's montane zone has significant value differences. At 1.600 m asl and 1.800m asl, *Imperata cylindrica* has the highest

significant value and summed dominance ratio (SDR) value (Tables 1 and 3), whereas, at 1.700m asl, *Ageratina riparia* has the highest significant value and Summed Dominance Ratio (S DR) value (Table 2). Where, according to the results of calculations, species *Imperata cylindria* (SDR 55.67%), *Tridax procumbens* (SDS 12.3%), and *Ageratina riparia* (SDR 8.89%) dominate at an altitude of 1.600m asl. At an altitude of 1.700m asl, *Ageratina riparia* (SDR 20.86%), *Pennisetum purpureum* (SDR 18,8%), and *Imperata cylindria* (SDR 18.36%) were found to be the dominant species. At an altitude of 1.800m asl, it was determined that *Imperata cylindria* (SDR 27.73%), *Ageratina riparia* (SDR 17.46%), and *Cyperus odoratus* (SDR 9.68%) predominated. This indicates that *Imperata cylindrica* and *Ageratina riparia* dominate the ecosystem of the Selo Tourist Area's montane zone.

Table 1. Important Value (IV) and Summed Dominance Ratio (SDR) of weed montane zone vegetation at 1.600m asl altitude, in The Tourist Area of Selo, Boyolali, Central Java

No	Name of Species	RD (%)	RF (%)	RDo (%)	IV (%)	SDR (%)
1.	*Imperata cylindrica* Beauv	64.29	31.25	71.45	167	55.67
2.	*Tridax procumbens* L.	13.14	12.5	11.26	36.9	12.3
3.	*Ageratina riparia* (Regel) King & H. Rob.	9.06	9.37	8.51	26.94	8.98
4.	*Bidens tripartita* L.	4.44	9.37	4.52	18.34	6.11
5.	*Ageratum conyzoides* L.	1.59	12.5	1.68	15.78	5.26
6.	*Artemisia vulgaris* L.	4.44	9.37	0.89	14.7	4.9
7.	*Cosmos caudatus* H.B.K	1.95	6.25	0.79	9.002	3
8.	*Crassocephalum crepidioides* (Benth.)	0.71	6.25	0.79	7.76	2.59
9.	*Impatiens platypelata*	0.36	3.12	0.08	3.57	1.19
	Total	100	100	100	300	100

Table 2. Important Value (IV) and Summed Dominance Ratio (SDR) of weed montane zone vegetation at 1.700m asl altitude, in The Tourist Area of Selo, Boyolali, Central Java.

No	**Name of species**	**RD (%)**	**RF (%)**	**RDo (%)**	**IV (%)**	**SDR(%)**
1.	*Ageratina riparia*	28.07	15.22	19.29	62.57	20.86
2.	*Pennisetum purpureum*	17.68	15.22	23.5	56.4	18.8
3.	*Imperata cylindrica* Beauv	15.03	13	27.07	55.14	18.38
4.	*Artharaxon hispidus*	13.15	6.52	10.21	29.88	9.96
5.	*Parietaria judaica* L.	9.39	6.52	4.13	20.05	6.68
6.	*Ludwigia palustris* (L.) Elliot	7.51	2.17	3.4	13.09	4.36
7.	*Crassocephalum crepidioides*	1.88	6.52	4.05	12.45	4.15
8.	*Cyperatus cyperoides*	1.22	8.69	1.13	11.05	3.68
9.	*Tridax procumbens* L.	2.43	4.35	3.57	10.34	3.45
10.	*Cyperatus odoratus*	1.22	6.52	0.57	8.3	2.77
11.	*Polygala paniculata*	1.1	4.35	1.29	6.75	2.25
12.	*Solidago canadensis* var. lepida L.	0.33	4.35	0.24	4.92	1.64
13.	*Ageratum conyzoides*	0.22	4.35	0.32	4.89	1.63

14.	*Impatiens platypelata*	0.77	2.17	1.22	4.16	1.39
	Total	100	100	100	300	100

Table 3. Important Value (IV) and Summed Dominance Ratio (SDR) of weed montane zone vegetation at 1.800m asl altitude, in The Tourist Area of Selo, Boyolali, Central Java

No	Name of Species	RD (%)	RF (%)	RDo (%)	IV (%)	SDR (%)
1.	*Imperata cylindrica* Beauv	24.93	15,.22	43.1	83.2	27.73
2.	*Ageratina riparia* (Regel) King & H. Rob.	26.6	8.7	17.1	52.37	17.46
3.	*Cyperus odoratus* L.	9.9	6.52	12.62	29.04	9.68
4.	*Parthenium hysterophorus* L.	3.73	15.22	2.14	21.1	7.03
5.	*Eclipta prostrata*	9.25	4.35	6.83	20.43	6.81
6.	*Drymaria cordata* Willd	6.04	4.35	3.1	13.48	4.5
7.	*Centella asiatica* Urb.	3.21	6.52	1.75	11.48	3.83
8.	*Arthraxon hispidus* (Thunb.) Makino	4.11	4.35	1.99	10.44	3.48
9.	*Conyza sumatresis*	1.16	6.52	1.51	9.19	3.06
10.	*Tridax procumbens* L.	3.6	2.17	3.1	8.87	2.96
11.	*Marsilea crenata*	2.7	4.35	0.87	7.92	2.64
12.	*Eleusine indica* Gaertn	0.77	4.35	1.91	7.03	2.34
13.	*Briza minor*	1.16	4.35	1.27	6.78	2.26
14.	*Crassocephalum crepidioides* (Benth.)	1.54	4.35	0.71	6.61	2.2
15.	*Ageratum conyzoides* L.	0.64	4.35	1.35	6.34	2.11
16.	*Gamochaeta purpurea (*L.) Cabrera	0.39	2.17	0.4	2.96	0.99
17.	*Melastoma candidum*	0.26	2.17	0.32	2.75	0.92
	Total	100	100	100	300	100

Important value and value of high Summed Dominance Ratio *Imperata cylindrica* are attributable to the weed's ability to survive in extreme conditions, allowing it to develop to nearly any height on the territory. *Imperata cylindrica* can proliferate wildly in various soil types, particularly on unused and infertile soils with few migrants (Subagia et al., 2021). *Impera cylindrica* is aggressive and invasive because its primary organ is a crust. This is consistent with Sayfulloh's study (2020), which has been categorized as one of the most invasive plants, particularly in tropical and subtropical regions of the world (Invasive Species Specialist Group, 2008) due to its capacity to grow rapidly on formerly processed soils such as gardens, open land for buildings, and roadside. Because it grows in the forest, *Ageratina riparia* also governs the ecosystem of the Montane Zone in the Selo Area. This plant thrives in a subtropical climate between 975 and 1.706 m asl. This plant is dominant because it is a member of a group of invasive species yuliare capable of rapid growth, particularly in tropical regions (Perianto, 2019). In addition, this plant can thrive anywhere, particularly in wet environments, such as open forests and lawns with heavy precipitation (Respitosari & Pujiastuti, 2022).

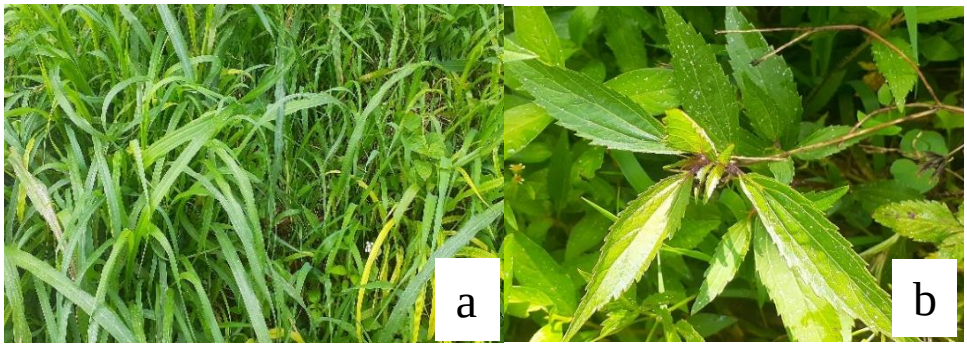


Figure 4. *Imperata cylindrica* (a) dan *Ageratina riparia* (b)

It has been stated that the diversity of grass species with H'<1 includes low, 1 < H' <3 includes medium, and H' >3 includes high. The result of the level of diversity of weed species at three points of altitude in the Selo Tourist Area's montane zone is medium, with the highest Shannon-Wiener diversity index (H') at 1.800m asl and the lowest diversity index at 1.600m asl (Table 4). The diversity values of the grain varieties obtained indicate that differences in ecosystem conditions significantly impact the diversity of grain species because if the ecological environment is not conducive to growth, the weed weeds will go dormant. However, if the ecosystem environment is conducive to flora, then the weed propagules will germinate and develop into weed vegetation, which can cause problems for the primary plants (Setiawan & Sarjiyah, 2021). In addition to the conditions of ecosystems, weed species diversity is also affected by ecosystem management.

Table 4. Type diversity index (H') vegetation weeds zona montane on Selo, Boyolali, Central Java Tourist Areas

Point of Height (m asl)	H’
1.600	1.24 (Medium)
1.700	2.02 (Medium)
1.800	2.17 (Medium)

The condition of the ecosystem in the Selo Tourism Area's montane zone can be determined by measuring the abiotic factor. Differences in height, soil pH, atmospheric pressure, light intensity, temperature, and humidity exist between the ecosystems of three altitude locations (Table 5). The weed's development can be affected by the weed's height. The investigation by Sintayehu (2019) indicates that weed can grow well up to 2.400m asl. There is a highest diversity of vegetation species at higher elevations than at lower elevations. Among the three altitude locations, the type diversity index is at an altitude of 1.800m asl highest compared to 1.600m asl. These differences in height impact the diversity of weedes because they result in variations in climate conditions, such as temperature and humidity, which influence weed growth (Nurnasari & Djumali, 2010).

The measurements of abiotic factors revealed a highly significant correlation between the intensity of light at three different altitudes and abiotic factors (Table 5). The relationship between light intensity and the ecophysiological processes of plants is close. The intensity of light has a significant impact on the efficacy of photosynthesis in plants. Adaptation of shadow plants and heat-resistant plants to the intensity of light results in efficient photosynthesis, allowing both types of plants to survive and produce abundantly (Yustiningsih, 2019). *Imperata cylindrica* plants are C4 plants; these plants require a high intensity of sunlight for photosynthesis and thrive on open ground (Fujiyanto, 2015). Therefore, *Imperata cylindrica* is found near all elevations. The *Ageratina* riparia plant is a C3 plant, so it is typically found in frigid climates and can photosynthesize more efficiently than a C4 plant at 25°C. In addition, a higher tree cover at 1.800m asl than at other heights influenced the diversity of the herbicides discovered.

In addition to the abiotic factors described previously, using herbicides and managing the mountain ecosystem in the Selo Tourism Area are human-controllable factors that can influence the diversity of weed species. Observations indicate that local communities at an altitude of 1.600m asl tend to employ herbicides as weed degradants, thereby reducing the diversity of weeds at that altitude. This is due to herbicidal properties that inhibit or destroy certain types of weeds without harming the crops (Yuliana & Ami, 2020). Furthermore, vegetation is also routinely carved at the height of 1.600m asl, unlike at 1.700m asl and 1.800m asl. Thus, the diversity of vegetation species at an altitude of 1.800m asl is highest than at other research sites.

It has been stated that grass similarity rates >75% are incredibly high, 50%-75% are high, 25%-50% are low, and 25% are deficient. Following the differences in the presence of grass species as measured by the Sorensen diversity index (Table 6), the diversity indices at an elevation of 1,600m dpl and 1,700m dple was 52.17 percent. corresponds to the mean as indicated by the index value. However, the diversity index at altitudes of 1.600 m asl and 1.800 m asl was low at 38.46%, and the diversity index at altitudes of 1.700 m asl and 1.800 m asl was also low at 45.16%. This is due to a variety of ecosystem conditions, including altitude, air temperature, soil pH, and air humidity. At altitudes of 1.600m asl and 1.800m asl, there is a slight variation in weed species due to differences in abiotic factors; consequently, the varieties of weeds that grow at these altitudes are quite distinct from one another. This is evidenced by the morphology of weed at an altitude of 1.600m asl, which tends to be more broad-leafed than weed at 1.800m asl. This weed leaf morphology is related to the light intensity and tree cover at each altitude, where the light intensity at an altitude of 1.600m asl is highest than at altitudes of 1.700m asl and 1.800m asl.

Table 5. Montane zone abiotic factors in Selo, Boyolali, Central Java

Abiotic Factors	Point of Height		
	1.600m asl	**1.700m asl**	**1.800m asl**
Temperature of air (°C)	28.7	20.6	21.3
Humidity of the air (%)	57	94	73
pH of soil	6	5,5	6
The atmospheric pressure (atm)	835.4	825.3	815.6
The intensity of light (Cd)	18200	11460	2180

Table 6. Sorensen's Similarity Index (SSI) vegetation weeds montane zone in Selo, Boyolali, Central Java Tourist Areas

Point of Height	SSI (%)
1.600m asl and 1.700m asl	52,17 (High)
1.600m asl and 1.800m asl	38,46 (Low)
1.700m asl and 1.800m asl	45,16 (Low)

According to the vegetation data of the mountain weeds zone in the Selo Tourism Area, the composition of the region's weeds is highly diverse. This research's conclusions can be utilized as a supplement material for biodiversity-related education in schools. For further research, students can use these accounts as references for future research. For the community to provide information about the various vegetation of the plant weed zone Montana in the Selo Tourism Area, it can take advantage of the types of weeds that exist (potential use) and know the weed control techniques in the montane zone.

4. CONCLUSIONS

In research related to the inventory of montane zones, disparities in composition and dominance of weed vegetation at each height (1.600m asl, 1.700m asl, and 1.800m asl) were discovered in the Selo Tourist Area. The quantity of weeds at each ecosystem height varies, with a total of 27 weeds belonging to 11 families. The vegetation species *Imperata cylindrica* and *Ageratina riparia* are the most prevalent. The diversity of vegetation species in the mountainous zone ecosystem of the Tourist Area at an altitude of 1.800 m asl is highest than at altitudes of 1.700 m asl and 1.600 m asl. At an altitude of 1.600m asl and a height of 1.700m asl, the sorensen's similarity index of vegetation species in the ecosystem is high. The conditions of the ecosystem are influenced by abiotic factors and the management of ecosystems impacts the diversity and uniformity of weed species in the mountainous region of the Selo Tourist Area. Where the research is limited to a certain height (1.600-1.800m asl), it is necessary to conduct additional inventory at higher montana heights (>1.800 m asl) in order to increase the data on montane weeds vegetation. The data on this region's vegetation must be continuously updated because this region is becoming a tourist destination, necessitating advanced research.

5. ACKNOWLEDGMENTS

The author expresses gratitude to the relevant parties who have contributed to the completion of this article, in particular to Universitas Muhammadiyah Surakarta Biological Laboratory, which has provided tools and locations to aid the author's research, and to the manager of the New Selo tourist area, who has granted permission to research the inventory of montane zone weeds.

6. REFERENCES

Andalusia, S. N. (2018). Inventarisasi Gulma Pada Tanaman Jagung (Zea Mays L.) di Dataran Rendah dan Dataran Tinggi (Doctoral Dissertation, Universitas Brawijaya).

Anesta, A. F., Fatman, A. F., & Sugandi, M. (2020). Zonasi Distribusi Tanaman Hutan di Taman Nasional Gunung Semeru Berdasarkan Integrasi Nilai Indeks Vegetasi dan Digital Elevation Model. Jurnal Geosains dan Remote Sensing 1(2): 64-70. DOI: 10.23960/jgrs.2020.v1i2.30

Blegur, W. A., & Binsasi, R. (2022). Ancaman Spesies Invasif di Hutan Produksi Oinbit Kabupaten Timor Tengah Utara. Syntax Idea 4(1): 228-239. DOI: 10.46799/syntax-idea.v4i1.1739

Budi, G. P. (2018). Analisis Vegetasi dan Penentuan Dominansi Gulma pada Pertanaman Jagung di Beberapa Ketinggian Tempat. Agritech: Jurnal Fakultas Pertanian Universitas Muhammadiyah Purwokerto 20(1): 13-18. DOI: 10.30595/ agritech.v20i1.3417

Faisal, R., Siregar, E. B. M., & Anna, N. (2011). Inventarisasi Gulma pada Tegakan Tanaman Muda Eucalyptus Spp (Weed Inventory On Stand Of Young Eucalyptus spp.). Peronema Forestry Science Journal 2(2): 44-49.

Firmansyah, A. P. (2017). Pengantar Pelindungan Tanaman. Makassar : Penerbit CV. INTI MEDIATAMA.

Firmansyah, N., Khusrizal, Handayani, R. S., Maisura, & Baidhawi. (2020). Dominansi Gulma Invasif pada Beberapa Tipe Pemanfaatan Lahan di Kecamatan Sawang Kabupaten Aceh Utara. Jurnal Agrium 17(2): 144–148. DOI: 10.29103/agrium.v17i2.2926

Fujiyanto, Z., Prihastanti, E., & Haryanti, S. (2015). Karakteristik Kondisi Lingkungan, Jumlah Stomata, Morfometri, Alang-Alang yang Tumbuh di Daerah Padang Terbuka di Kabupaten Blora dan Ungaran. Buletin Anatomi dan Fisiologi 23(2): 48-53. DOI: 10.14710/baf.v23i2.10011

Hasan, I. S. (2019). Hijauan Pakan Tropik. Bogor: PT Penerbit IPB Press.

Imaniasita, V., Liana, T., & Pamungkas, D. S. (2020). Identifikasi Keragaman dan Dominansi Gulma pada Lahan Pertanaman Kedelai. Agrotechnology Research Journal 4(1): 11–16. DOI: 10.20961/agrotechresj.v4i1.36449

Kartawinata, K., & Abdulhadi, R. (2016). Ekologi Vegetasi Tujuan dan Metode. Jakarta : LIPI Press.

Nugraha, E., Noertjahyani, N., & Parlinah, L. (2023). Pengaruh Konsentrasi Pgpr (Plant Growth Promoting Rhizobacteria) terhadap Pertumbuhan dan Hasil Tanaman Kangkung (Ipomoea Reptans Poir) Varietas Bika. OrchidAgro 3(1): 12-19. DOI: 10.35138/orchidagro.v3i1.513

Nurnasari, E., & Djumali. (2010). Effect of Altitude Conditions on the Production and Quality of Temanggung Tobacco. Buletin Tanaman Tembakau, Serat & Minyak Industri 2(2): 45–59. DOI: 10.14203/beritabiologi.v13i1.648

Perianto, L. H., Soejono, A. T., & Astuti, Y. T. M. (2019). Komposisi Gulma pada Lahan Kelapa Sawit (Elaeis guineensis Jacq.) pada Tanaman Belum Menghasilkan dan Tanaman Menghasilkan di KP2 Ungaran. Jurnal Agromast 1(2): 1-16.

Putra, F. P., Yudono, P., & Waluyo, D. S. (2018). Perubahan Komposisi Gulma pada Sistem Tumpangsari Padi Gogo dengan Kedelai di Lahan Pasir Pantai. Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy) 46(1): 33-39. DOI: 10.24831/jai.v46i1.17093

Ramlan, D. N., Riry, J., & Tanasale, V. L. (2019). Inventarisasi Jenis Gulma di Areal Perkebunan Karet (Hevea brasiliensis) Pada Ketinggian Tempat yang Berbeda di Negeri Liang Kecamatan Teluk Elpaputih Kabupaten Maluku Tengah. Jurnal Budidaya Pertanian 15(2): 80–91. DOI: 10.30598/jbdp.2019.15.2.80

Respitosari, N. G. M., & Pujiastuti, P. (2022). Kekayaan Jenis Tumbuhan Herba Angiospermae di Taman Hutan Raya Raden Soerjo Sub Wilayah Mojokerto. Jurnal Aaintifika 18(2): 13-13.

Rozak, A. H., Astutik, S., Mutaqien, Z., Widyatmoko, D., & Sulistyawati, E. (2016). Kekayaan jenis pohon di hutan Taman Nasional Gunung Gede Pangrango, Jawa Barat. Jurnal Penelitian Hutan dan Konservasi Alam 13(1): 1-14. DOI: 10.20886/jphka.2016.13.1.1-14

Sayfulloh, A., Riniarti, M., & Santoso, T. (2020). Jenis-Jenis Tumbuhan Asing Invasif di Resort Sukaraja Atas, Taman Nasional Bukit Barisan Selatan (Invasive Alien Species Plants in Sukaraja Atas Resort, Bukit Barisan Selatan National Park). Jurnal Sylva Lestari 8(1): 109-120. DOI: 10.23960/jsl18109-120

Setiawan, A. N., & Sarjiyah. (2021). Keanekaragaman dan Kelimpahan Gulma pada Tumpangsari Jagung Manis dengan Kacangan. Bioeksperimen 7(2): 1443–153. DOI: 10.23917/bioeksperimen.v7i2.10814

Sintayehu, A. (2019). African Journal of Agricultural Research Weed Flora Survey in Field Crops of Northwestern Ethiopia. African Journal of Agricultural 14(16): 749–758. DOI: 10.5897/AJAR2019.13947

Subagia, I. N., Suwantana, I. G., Sudiana, I. G. N., Surada, I. M., I Nyoman Rema, Tirta, I. M. D., Adnyana, P. E. S., Giri, I. P. A. A., & · I. M. P. A. (2021). Tanaman Upakara. Bali : Nilacakra.

Suryanto, P., Tohari, Sulistyaningsih, E., Putra, E. T. S., Kastono, D., & Alam, T. (2017). Estimation of Critical Period for Weed Control in Soybean on Agroforestry System with Kayu Putih. Asian Journal of Crop Science 9(3): 82–91. DOI: 10.22146/ipas.17700

Suyana, J. (2020). Profil Desa Wisata Samiran di Lereng Merbabu-Merapi Kecamatan Selo Kabupaten Boyolali Propinsi Jawa Tengah. SEMAR (Jurnal Ilmu Pengetahuan, Teknologi, dan Seni bagi Masyarakat) 9(1): 27-35. DOI: 10.20961/semar.v9i1.42015

Tantra, A. W., & Santosa, E. (2016). Manajemen Gulma di Kebun Kelapa Sawit Bangun Bandar: Analisis Vegetasi Dan Seedbank Gulma. Buletin Agrohorti 4(2): 138-143. DOI: 10.29244/agrob.v4i2.15012

Tosang, R. (2019). Inventarisasi Jenis-Jenis Gulma Berdaun Lebar pada Lahan Tanaman Jagung Zea Mays L. di Desa Samangki Kecamatan Simbang Kabupaten Maros (Doctoral Dissertation, Universitas Hasanuddin).

Widaryanto, E., & Zaini, A. H. (2021). Teknologi Pengendalian Gulma. Malang: Universitas Brawijaya Press.

Yuliana, A. I., & Ami, M. S. (2020). Analisis Vegetasi dan Potensi Pemanfaatan Gulma Lahan Persawahan. Jombang: LPPM Universitas KH. A. Wahab Hasbullah.

Yustiningsih, M. (2019). Intensitas Cahaya dan Efisiensi Fotosintesis pada Tanaman Naungan dan Tanaman Terpapar Cahaya Langsung. BIO-EDU: Jurnal Pendidikan Biologi 4(2): 44-49. DOI: 10.32938/jbe.v4i2.385

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Development of Problem-Based HOTS (Higher Order Thinking Skill) Question Instruments on Class VIII Pressure Material

Rina Irawati*, Sukarmin, Sri Yamtinah
Science Education Department, Faculty of Teacher Training and Education, Universitas Sebelas Maret. Jalan Ir. Sutami 36 Kentingan, Jebres, Surakarta, 57126, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: irinairawatii@student.uns.ac.id

KEYWORDS:
Aiken
Development
HOTS
Instruments
Pressure

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The HOTS question instrument is important in learning. Through HOTS students are trained to learn things at a higher level, think critically in receiving information, think creatively in problem solving, and make the right decisions in complex situations. These various abilities are certainly needed in the face of changing life dynamics. This situation requires us to continue to adapt, so the ability of HOTS is very important to be developed as an effort to improve the ability to think at a higher level and prepare ourselves to face problems in life. This makes the author interested in developing a problem-based HOTS problem instrument on pressure material. This research uses R&D techniques that refer to Thiagarajan's (1974) 3-D procedural model. The instrument consists of 10 description questions that refer to 5 indicators, namely: analyzing; Evaluate; Created; Troubleshooting; and critical thinking skills. The instrument was validated by 7 experts with the validity analysis technique Aiken (1950). The results of the analysis obtained: suitability of the question with bloom's taxonomy (88%), suitability of the question with the answer (86%), feasibility of language (85%); and the feasibility of presenting the question (84%). This proves that all aspects of the instrument are declared valid because $V_{count} > V_{table}$ Aiken, V_{table} Aiken 75%, so it is concluded that this instrument is declared valid and feasible to be used to test the higher-order thinking skills of learners.

1. INTRODUCTION

The teaching and learning process that has been carried out between teachers and students can be measured for success through the provision of learning evaluation, which is an assessment or measurement of the ability of students, (Permatasari, A, 2014). Teachers in assessing learning outcomes require assessment instruments in the form of questions (Dewi, 2016). An instrument is a tool that can be used to assess how well learners have learned certain skills (Desilva 2020; Septiani et al, 2022).

Making question instruments certainly adjusts to the learning indicators that have been set based on learning objectives. Learning applied in Indonesia has several goals that must be achieved, these goals include: (1) critical thinking and problem solving, (2) communication and collaboration skills, (3) creativity and innovation, (4) technology and communication literacy, (5) contextual learning. (6) media and information literacy, (Gradini, 2019). Based on the goals that must be achieved, it can be seen that higher-order thinking is one of the important points that must be developed in students and there needs to be measurement at the end of each lesson. This is supported by a survey conducted by an expert in the United States regarding the needs in the world of work. The survey shows that critical thinking skills are at the top, then new mastery of information, the ability to think collaboratively and innovatively, (Angraini, 2019).

Based on the learning objectives to be achieved, the assessment instrument of student learning outcomes must be adjusted, by means of questions given must be based on HOTS (Higher Order Thinking Skill). Lewis and Smith (1993) state that higher-order thinking skills (HOTS) include critical thinking, creative thinking, problem solving, and decision making. Meanwhile, according to Anderson and Krathwohl (2001) the cognitive process of HOTS includes analyzing (analyzing) or C4 equivalents in Bloom's Taxonomy, evaluating (evaluating) or C5 equivalents in Bloom's Taxonomy, and creating (creating) or C4 equivalents in Bloom's Taxonomy. So the author took 5 indicators in the assessment of higher-order thinking skills on pressure material and its application in life for class VII. HOTS indicators are: analyze (C4); evaluate (C5); create (C6); Troubleshooting; critical thinking skills. Based on the opinions of experts, it can be concluded that the HOTS problem instrument is not just a problem that relies on memorization skills for students, but measurement using HOTS questions is more about how students think about a certain situation that is packaged in the form of a problem so that students must analyze, evaluate, create, think critically, or have to find solutions to solve problems well.

2. METHODS

The type of research used in this research is Research and Development (R&D) which means research and development. R&D research is used to produce certain products and test the effectiveness of these products (Sugiyono, 2014: 407). This R&D study has three stages: definition, design, and development, which refers to Thiagarajan's (1974) 3-D procedural model.

2.1. Define Stage

At the defining stage, the author defines the needs in the field by collecting various information through questionnaires that are distributed online in various schools in Surakarta. Junior high school science teachers fill in the obstacles faced through the google form provided by the researcher. In addition, respondents also revealed the desired product developments in the future so that learning can be maximized in the pandemic era by utilizing various existing technologies to improve students' higher-order thinking skills (HOTS).

2.2. Design Stage

At this design stage, it is hoped that the resulting question instrument can measure the higher-order thinking skills of students after learning science class VIII pressure material. Here are some stages of design carried out by researchers:

2.2.1. Test preparation

Test instruments that fall into the HOTS (Higher Order Thinking Skill) category are questions that accompany students in thinking according to Bloom's taxonomy, namely C4 analysis, C5 evaluation, and creating C6, Anderson and Krathwohl (2001). In addition, Lewis and Smith (1993) add that higher order thinking skills (HOTS) include critical thinking and problem solving. Therefore, the author in compiling an evaluation test instrument includes 5 indicators, namely C4 to C6, critical thinking, and problem solving. The preparation of questions is equipped with matrices, grids, and the results of the analysis of learning objectives on pressure material and its benefits in the daily life of grade VIII junior high school.

2.2.2. Format selection

After the stage of determining the type of HOTS question based on the needs analysis, the researcher determines a good and appropriate format. The author designs the questions attractively in the form of pictures so that students can imagine according to the application in their daily lives. The number of questions developed is 10 points by taking into account the indicators that have been set as a benchmark for students' higher-order thinking skills (HOTS). Preparation pays attention to the layout, size, and clarity of the image so that the problem can be understood appropriately by students.

2.2.3. Early Desai

The instruments that have been made by researchers then assess their feasibility by validators who are experts in the fields of language, ISIS feasibility, and presentation feasibility. After going through reviews and assessments from experts, the author received a lot of suggestions and input so that the question instrument was revised to be better according to the advice of experts. The results of the revision of the HOTS (Higher Order Thinking Skill) question instrument become Prototype 1 which is ready to be used as a measuring tool for evaluating the learning outcomes of grade VIII students on pressure material and its application in everyday life.

2.3. Develop Stage

This development stage aims to produce prototypes or products that have been developed and then validated and input by validators, lecturers, experts, and practitioners. At the development stage, this is in the form of expert appraisal, which is to assess the validity of the prototype that has been developed using a validation questionnaire. Expert validation was carried out by 2 expert lecturers and 6 practitioners. Expert lecturers are lecturers of S2 Science Education at Sebelas Maret University, practitioners consist of 6 including: 2 science teachers of SMP Negeri 26 Surakarta; 3 science teachers of Al Abidin Islamic Junior High School Surakarta; and 1 teacher Indonesian Al Abidin Islamic High School Surakarta. Each practitioner was chosen by the researcher because he has experience in teaching for approximately 10 years.

On the validity of the researcher used the analytical technique provided by Aiken. In 1985, Aiken proposed the concept of content validity in more detail. There are three levels that determine the quality of the validity of the content, namely sensual E, useful but not essential (G), and not necessary (T). In this study the author used the V Aiken foumulation written by (Azwar, 2012, p. 113; Aiken, 1985, p. 133) with the following formulation:

$$V = \frac{\sum(ri - lo)}{[n\ (c - 1)]}$$

Information:
r = number given by the appraiser
lo = lowest validity assessment number
c = highest validity assessment number
n = number of experts & practitioners performing
assessments i = integers from 1,2,3 to n
The validity classification range corresponds to the following table 1.

Table 1. Range of Validity Categorization

Quality	Score Range	Category
E	4 Score 5	Worth using without revision
G	Score 3	Worth using with revisions as suggested
T	1 Score 2	Not worth using

The results of the question instrument are said to be valid and feasible to be used as a measure of students' higher-order thinking skills (HOTS) when the results $V_{count} > V_{table}$ aiken.

3. RESULTS AND DISCUSSION

The HOTS (Higher Order Thinking Skill) question instrument that has been made by researchers is then tested for feasibility and validity to experts. The aspects assessed are the content aspect (the suitability of the question with the answer and the suitability of the question with Bloom's taxonomy), the language aspect, and the presentation aspect. Researchers use Aiken analysis techniques. For the results of the validator assessment of the content aspect of the HOTS question instrument product, the pressure material and its application in life for grade VIII junior high school can be seen in table 2 (suitability of the question with bloom's taxonomy) and table 3 (suitability of the question with the answer).

Table 2. The results of the validation of HOTS instrument products in the aspect of conformity of questions with Taxonomy Bloom

Question Point	V Aiken	Information
1	0.91	Valid
2	0.88	Valid
3	0.88	Valid
4	0.94	Valid
5	0.81	Valid
6	0.91	Valid
7	0.81	Valid
8	0.91	Valid
9	0.88	Valid
10	0.91	Valid
Average	0.88	
Percentage	88%	

Based on the calculation results, it was found that question items number 1 to 10 were all above the Aiken index of 0.75 so that an average of 0.88 or 88% of the conformity of the questions with Bloom's taxonomy was obtained from C4, C5, C6, critical thinking, and problem solving. When $V_{count} > V_{table}$ or $0.88 > 0.75$ then it can be stated that the instrument is valid and feasible to be used as a measure of higher-order thinking skills.

Table 3. The results of the validation of the HOTS instrument are aspects of the suitability of the answer questions with the questions

Question Point	V Aiken	Information
1	0.78	Valid
2	0.78	Valid
3	0.94	Valid
4	0.91	Valid
5	0.88	Valid
6	0.88	Valid
7	0.78	Valid
8	0.91	Valid
9	0.86	Valid
10	0.88	Valid
Average	0.86	
Percentage	86%	

Based on the calculation results, it was found that question items number 1 to 10 were all above the Aiken index of 0.75 so that an average of 0.87 or 87% of the match with the answers was obtained. When $V_{count} > V_{table}$ or 0.87 > 0.75 then it can be stated that the instrument is valid and suitable for use as a measurement of higher order thinking skills (HOTS).

After the feasibility of the content, the validator also assesses the HOTS question instrument of class VIII material about pressure and its application in life in terms of language. The following results of expert validators can be seen in table 4.

Table 4. The results of the validation of HOTS questions from the language aspect

Question Point	V Aiken	Information
1	0. 81	Valid
2	0.78	Valid
3	0.91	Valid
4	0.84	Valid
5	0.91	Valid
6	0.88	Valid
7	0.84	Valid
8	0.88	Valid
9	0.81	Valid
10	0.88	Valid
Average	0.85	
Percentage	85%	

Based on the calculation results, it was found that question items number 1 to 10 were all above the Aiken index of 0.75 so that an average of 0.85 or 85% of the feasibility of the language used in the question was obtained. When $V_{count} > V_{table}$ or 0.85 > 0.75 then it can be stated that the instrument is valid and suitable for use as a measurement of higher order thinking skills (HOTS).

The last and no less important aspect in the validation process is the feasibility test of the questions in terms of presentation. Both font size, image selection, image clarity, image placement and so on related to the presentation of question instruments. These results can be seen in table 5 as follows.

Table 5. The results of the validation of the HOTS question from the aspect of material presentation

Question Point	V Aiken	Information
1	0. 84	Valid
2	0.88	Valid
3	0.88	Valid
4	0.81	Valid
5	0.88	Valid
6	0.81	Valid
7	0.88	Valid
8	0.78	Valid
9	0.84	Valid
10	0.85	Valid
Average	0.84	
Percentage	84%	

Based on the calculation results, it was found that question items number 1 to 10 were all above the Aiken index of 0.75 so that an average of 0.84 or 84% of the feasibility of the language used in the question was obtained. When $V_{count} > V_{table}$ or 0.84 > 0.75 then it can be stated that the instrument is valid and suitable for use as a measurement of higher order thinking skills (HOTS).

4. CONCLUSIONS

From this study, it can be concluded that the level of validity or feasibility achieved by the HOTS question instrument in learning science pressure material and its application in everyday life for class VIII is declared valid and feasible to be used as a measure of students' higher-order thinking skills. This is evidenced by the results of V aiken analysis, the suitability of the question with bloom's taxonomy (88%), the suitability of the question with the answer (86%), the feasibility of the language (85%); and the feasibility of presenting the question (84%). This proves that all aspects of the instrument are declared valid because $V_{count} > V_{table}$ Aiken, V_{table} Aiken 75% or 0.75.

5. REFERENCES

Angraini, G. 2019. Analisis Kemampuan Berpikir Tingkat Tinggi Siswa SMAN Kelas X di Kota Solok pada Konten Biologi. Journal of Education Informatic Technology and Science (JeITS), 114-124.

Azwar, S. 2012. Tes Prestasi Fungsi Pengembangan Pengukuran Prestasi Belajar. Pustaka Pelajar, Yogyakarta.

Bashooir, K. 2018. Validitas dan Reliabilitas Instrumen Asesment Kinerja Literasi Sains Pelajaran Fisika Berbasis STEM. Jurnal Penelitian dan Evaluasi Pendidikan, 219-230.

Budiman, A. 2014. Pengembangan Instrumen Asesmen Higher Order Thinking Skill (HOTS) pada Materi Pelajaran Matematika SMP Kelas VIII Semester 1. Jurnal Riset Pendidikan Matematika, 1(2): 139-151.

Gradini, E. 2019. Menilik Konsep Kemampuan Berpikir Tingkat Tinggi (Higher Order Thinking Skill) dalam Pembelajaran Matematika. Jurnal Numeracy.

Jumrah. 2023. Pengembangan Instrumen Tes Berbasis HOTS dengan Pendekatan Pengukuran Rasch pada Pelajaran Matematika Topik Bangun Ruang untuk Siswa Sekolah Dasar. Jurnal Basicedu, 7(1): 11-27.

Litna, K. 2021. Pengembangan Instrumen Tes Higher Order Thinking Skills (HOTS) Matematika SMA Kelas X. Jurnal_ep, 11(1): 10-20.

Sari, Y. 2019. Meningkatkan Kemampuan Menyusun Soal IPA Berorientasi HOTS bagi Guru Sekolah Dasar Gugus Pandanaran Dabin IV UPTD Semarang Tengah. Indonesian Journal of Community Services, 1(2): 175-183.

Sa'idah, N. 2020. Pengembangan Instrumen Tes Higher Order Thinking Skill (HOTS) Mata Pelajaran Fikih Kelas XI di MA Masalikil Huda Tahunan Jepara. Al-JPI JUrnal Pendidikan Islam, 11(2): 209-220.

Umami, R. 2021. Pengembangan Instrumen Tes untuk Mengukur Higher Order Thinking Skills (HOTS) Berorientasi Programme for International Student Asessment (PISA) pada Peserta Didik. OPEM, 7(1): 57-68.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Characteristics of Herbal Tea Combination Between Butterfly Flower with Mint and Pandan Leaf on Drying Duration Variation

Titik Suryani*, Ria Anisa Rahmasari, Riza Ainun Nisa

Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.

Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia

*Corresponding Author. E-mail address: ts169@ums.ac.id

KEYWORDS:

herbal tea, butterfly flower, mint leaf, pandan leaf, drying duration, antioxidant activity, organoleptic quality

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Herbal tea is a functional bevarage made from leaf or flower. Butterfly flowers contain flavonoids, anthocyanins and flavonol glycosides. Mint leaf contain 1-2% essential oil and 80-90% menthol. Pandan leaf contain 10% essential oil, aromatic compounds 2-acetyl-1 pyrroline, flavonoids. The purpose of this study was to determine the characteristics (antioxidant activity and organoleptic quality) of herbal tea combination between butterfly flowers with mint leaf and pandan leaf on drying duration variations. This research method was an experiment with Completely Randomized Design (CRD), two factors. Factor I: combination of flowers butterfly : mint leaf (6 g : 2 g) and combination of butterfly : pandan leaf (6 g : 2 g). Factor II : drying duration of 90 minutes and 120 minutes The results showed that the highest antioxidant activity was K_1L_1 treatment (combination of butterfly flower: mint leaf with drying duration of 90 minutes) that was 83.147%. The best organoleptic quality of herbal tea in K_1L_1 treatment (combination of butterfly flowers: mint leaf with drying duration of 90 minutes), dark blue color, mint aromatic, not bitter taste, fresh and quite like.

1. INTRODUCTION

Herbal tea is one of the functional bevarage made from leaf or flowers processed as tea making (Yamin, 2017), can improve taste without reducing its taste (Mu'nim, 2008), also can be consumed as a practical drink to maintain health. One type of plant can be used as an ingredient herbal tea is the butterfly flower. Butterfly flowers are indigo blue (purple) with the middle of white color (Putri, 2018), contain antioxidants, Flavonoids (20.07 ± 0.55 mmol/mg flowers), Anthocyanins (5.40 ± 0.23 mmol/mg flowers), Flavonol glycosides (14.66 ± 0.33 mmol/mg flower), Kaempferol glycoside (12.71 ± 0.46 mmol/mg flower), Querserin glycoside (1.92 ± 0.12 mmol/mg flower), and also myricetin glycosides (0.04 ± 0.01 mmol/mg flowers) (Kazuma, 2003). Flavonoids are potential antioxidants, anti-radicals of butterfly flowers (Soeharto, 2004). Antioxidants are compounds that can delay, slow, or inhibit oxidation reactions and can fight free radicals (Agustina, 2017). Free radicals are highly reactive molecules because they have one or more unpaired electrons. Excess free radicals can attack any compound and have implications for the

emergence of various diseases such as heart disease, cancer, arteriosclerosis and symptoms of aging (Kusumowati, 2012).

The flavor of herbal tea enhances the taste due to the loss or reduction of aromatic compounds which are partly composed of volatile alcohols, aldehydes and ketones. Butterfly flower tea does not smell like grass (Jeremy, 2019), therefore, in processing herbal tea, it is necessary to add flavor. The addition of the flavor of butterfly flower tea is mint leaf. Peppermint extract is menthyl acetate produces "minty" aroma and flavor of lemon tea, while pandan leaf (Sukardi, 2009) have a fragrant and fresh aroma due to the essential oil content of mint leaf and fragrant pandan leaf as a flavor of tea bevarage (Wartini, 2015).

Mint leaf (*Mentha piperita*) contain essential oil 1% essential oil, 78% free menthol, 2% menthol mixed with esters, tannins, menthone (21.45%), isomenthone (2.87%), menthofuran (1-17%), carvone, linalool and piperitone oxide (Moghtader, 2013). The most ideal content of mint leaf in herbal tea is 3%, because the higher the percentage of mint content, the spicier it tastes when brewed. The addition of mint leaf to reduce the bitter and astringent taste so that it is fresh and has a distinctive minty flavor (Anggraini, 2014).

Pandan leaf as an ingredients of bevarage and aroma contain tannins, alkaloids, flavonoids, and polyphenols as antioxidant activity, antidiabetic of water extracts, antioxidants of water and methanol extracts, anticancer of ethanol and methanol extracts, and antibacterial of ethanol and ethyl extracts acetate (Prameswari and Widjanarko, 2014). The addition of antioxidants can reduce the level of oxidative stress, therefore slowing the occurrence of premature aging and complications of various diseases. Fragrant pandan leaf have a distinctive aroma of essential oil, consisting of 6–42% sesquiterpene hydrocarbons and 6% monoterpene linalool and 10% aromatic compound form of 2-acetyl-1 pyrroline (Priastomo, 2018). 2-acetyl-1-pyrroline (2-AP) is the largest component of pandan leaf, volatile oils, alcohols, aromatic aldehydes, ketones and esters. Pandan leaf extract can act as a natural antioxidant (Tasia & Widyaningsih, 2014).

The addition of flavor or taste, drying time in the making of herbal tea affects antioxidant activity (Adri,2013). The longer the drying, the lower the levels of flavonoids and phenolics (antioxidant compounds). Drying at high temperatures and for quite long time can reduce antioxidant activity of dry material (Yamin, 2017). The results of the study (Yamin, 2017) state that ketepeng leaf of herbal tea has the highest antioxidant activity at 110 minutes of drying time. The results of Rofiah's research (2018) state the highest antioxidant activity were in tin leaf of herbal tea with drying time of 120 minutes. The longer the drying, the higher the temperature and the lower the antioxidant activity.

The purpose of this study was to determine the characteristics (antioxidant activity and organoleptic quality) of herbal tea combination of butterfly flowers with mint and pandan leaf on drying duration variations.

2. METHODS

This research used experimental method and completely randomized design (CRD), two factors. Factor 1 : combination between butterfly flower and mint leaf K1 (6 g : 2 g) and combination between butterfly flower and pandan leaf K2 (6 g : 2 g), Factor 2 : drying durations of L1 (90 minutes) and L2 (120 minutes), 3 repetitions. The research procedurs included: making herbal tea, drying duration, testing antioxidant activity with the DPPH method and organoleptic quality as well as public acceptance involving 15 panelists. The research data were analyzed descriptively qualitatively and quantitatively.To find out the results of this study, the data analysis used was descriptive qualitative to determine the differences in each treatment. Data collection was carried out using experimental methods, measuring antioxidant activity, organoleptic quality, observation methods, literature methods and research documentation.

3. RESULTS AND DISCUSSION

3.1. Antioxidant Activity

The results of the antioxidant activity herbal tea of the combination between butterfly flower with mint leaf and pandan leaf on variations of drying duration for 90 minutes and 120 minutes at 55°C can be seen in the table below:

Table 3.1. Average Antioxidant Activity of Herbal Tea Combination between butterfly Flower with Mint Leaf and Pandan Leaf on Variations of Drying duration

Treatment	Antioxidant activity (%)
K_1L_1 (butturfly flower : mint leaf) + drying duration 90’	83,147**
K_2L_1(butterfly flower : pandan leaf)+ drying duration 90’	60,589
K_1L_2 (butterfly flower : mint leaf)+ drying duration 120’	78,664
K_2L_2(butterfly flower :pandan leaf)+ drying duration 120’	59,473*

Explanation: * the lowet of Antioxidant activity terendah, ** the highest of Antioxidant activity

Table 3.1 showed that the highest antioxidant activity was in the K_1L_1 treatment (butterfly flower : Mint leaf) + 90 minutes drying duration of 83.147%, while the lowest antioxidant activity was in the K_2L_2 treatment (butterfly flower: Pandan leaf) + 120 minutes drying duration of 59.473%. This showed that the variations of drying duration provide different antioxidant activity.

The longer the drying, the less the antioxidant activity, because the longer the drying, the antioxidant compounds will be damaged so that it will affect the antioxidant activity. This is supported by research (Rusnayanti, 2018) stated that antioxidant activity will decrease if the drying temperature and drying time are higher, because the higher the temperature and drying duration result in secondary metabolite compounds that act as antioxidants being damaged. In accordance with Yamin's research (2017), showed that drying Chinese ketepeng leaf at 55°C with a drying duration of 110 minutes provided the highest antioxidant activity of 43.79 µg/ml (IC50 µg/ml unit) compared to 130 minutes of drying that was 60 .18µg/ml. The IC50 value is inversely proportional to the ability of the compound to act as an antioxidant. The smaller the IC50 value, the greater the antioxidant activity.

This was supported by Andesa research (2020) stated that the antioxidant activity of herbal tea of butterfly flowers and basil leaf at 90 minutes of drying duration was higher than 120 minutes of drying duration. There was the highest antioxidant activity of the herbal combination between butterfly flowers and mint leaf. According to Cahyaningsih research (2019) stated that butterfly flowers have antioxidant activity with an IC50 value of 87.86 ppm. Specifically, an antioxidant is categorized as very strong if the IC50 value is less than 50 ppm,however it is strong if the IC50 is 50-100 ppm,and moderate if the IC50 is 100-150 ppm, and an antioxidant is categorized as weak if the IC50 is 150-200 ppm. The smaller the IC50 value means the stronger the antioxidant activity. This shows that the greater the ratio of the composition of the butterfly flower, the higher the antioxidant activity. This was confirmed by Rohmadianto's research (2009) stated that antioxidant activity was concentration of corn-rosella hair 55:45 with a drying duration of 2.5 hours was 90.63%, while the lowest antioxidant activity was concentration of corn hair : rosella (85:15)at drying time 1.5 hours is 63.15%. The reason for the high antioxidant activity is due to the high concentration of rosella. The higher the concentration of rosella, the higher the antioxidant activity. This is because rosella contains flavonoid compounds and anthocyanin pigments which act as antioxidants.

Variation of drying duration gives different antioxidant activity. The longer the drying, the lower the antioxidant activity. This is because the longer the drying time, the antioxidant compounds will be damaged so that it will affect the antioxidant activity. Strengthened by Hartiati's research (2009) states that raw materials that through the drying process, the antioxidant activity produced is smaller, this is due to damage or degradation of the gossyperin, antiocyanin and glucoside hibiscin compounds in rosella damaged during the drying process. The longer the drying process. it will increase the damage to the antioxidant constituent compounds. In accordance with Yamin's research (2017) showed that drying Chinese ketepeng leaf at 55°C with

drying time of 110 minutes provided the highest antioxidant activity of 43.79 µg/ml (IC50 µg/ml unit) compared to 130 minutes of drying that 60 .18µg/ml. The IC50 value is inversely proportional to the ability of the compound to act as an antioxidant. The smaller the IC50 value, the greater the antioxidant activity. This is supported by Andesa research (2020) that the activity of herbal tea of butterfly flowers and basil leaf at 90 minutes of drying duration has higher antioxidant activity than 120 minutes of drying duration.

3.2. Organoleptic Quality and Acceptance

The results of organoleptic quality are presented in the table below:

Table 3.2. Organoleptic Quality of Herbal Tea Combination betweeen butterfly Flower with Mint Leaf and Pandan Leaf on Variation of Drying Duration.

Treatments	Organoleptic quality			Acceptability
	Color	Smell	Flavor	
K_1L_1	Dark blue	Mint specific	Not bitter, fresh	Quite like
K_1L_2	Purplish blue	Mint specific	No bitter, fresh	Quite like
K_2L_1	Dark blue	pandan specific	No bitter, fresh	like
K_2L_2	Purplish blue	Pandan specific	No bitter, fresh	like

Explanation:

K_1L_1 = Butterfly : Mint leaf + 90 minutes of drying duration

K_1L_2 = Butterfly : Mint leaf + 120 minutes of drying duration

K_2L_1 = Butterfly : Pandan leaf + 90 minutes of drying duration

K_2L_2 = Butterfly : Pandan leaf + 120 minutes of drying duration

Table 3.2 showed that the color of the herbal tea combination between butterfly flower and mint leaf was purplish blue and dark blue because the anthocyanin contains 14.66 ± 0.33 nmol/mg flowers (Wiyantoko, 2020). Differences in the color of the tea produced in each sample The combination between butterfly flower and mint leaf of herbal tea showed that the butterfly flower dominates the color of the herbal tea . The more the butterfly flower composition is added, the darker or blue color of the herbal tea will be. This was reinforced by Fizriani's research (2020) stated that the addition of 0.75 gram of butterfly extract, the color of the cendol is blue than the addition of 0.25 gram of butterfly extract, so the more powdered butterfly extract is added to the cendol, the bluer the color of the resulting cendol. The aroma of herbal tea combination between butterfly flowers and mint leaf is specific mint, because mint leaf contain 0.5 - 4% essential oil, 30-55% menthol (Setiawan, 2019). This is in accordance with Kamilia's research (2009) stated that butterfly flowers do not contain essential oils, but are influenced by mint leaf. The taste of

herbal tea can be influenced by the ingredients used. The taste of the herbal tea of combination between butterfly flowers and mint leaf is not bitter and fresh. Butterfly flowers and mint leaf contain tannins which cause an astringent taste (Hussein, 2019 and Manjula, 2013). The low tannin content is covered by the high essential oil content of mint leaf,

The color of the herbal tea is a combination between butterfly flowers and pandan leaf, dark blue and purplish blue, has a distinctive pandan aroma, tastes not bitter and fresh, and like acceptance. The acceptability, color, aroma of the herbal tea is in accordance with SNI 3836 (2013). The difference in the color of the herbal tea indicated that the drying duration and the combination between butterfly flowers and pandan leaf had an effect on the color of the herbal tea. The shorter the drying time and the greater the mixture of butterfly flower and pandan leaf, the resulting darker blue color causes the color of the anthocyanin pigments in the butterfly flower to dissolve in water. Agree with Pratimasari's research (2018) which shows that the color of the syrup with 0.25% butterfly extract shows better color stability compared to 0.5% butterfly extract. The difference of color herbal tea is caused by the quality of vision and sharpness of the panelists. The aroma of herbal tea mixed with butterfly flowers and pandan leaf is typical of pandan produced in accordance with SNI 3836 (2013) the aroma of good tea is typical of tea products. This is in accordance with Faras' research (2014) that pandan leaf contains essential oils and aromatic compounds which are volatile or easily evaporate so that it has a strong distinctive aroma of pandan. Pandan leaf have a distinctive aroma from a derivative of the amino acid phenylalanine, that is 2-acetyl-1pyroline. According to Fabra (2009) 2-acetyl-1pyroline is a component very soluble in water and alcohol, the same as in the combination between butterfly flower and pandan leaf in herbal tea, 2-acetyl-1pyroline is much extracted by water so that the aroma is characteristic of pandan. The taste of the herbal tea, which is combination between butterfly flowers and pandan leaf, is not bitter and is quite fresh or fresh. The butterfly flower is not bitter, however the fresh taste of pandan leaf, the tannin content which is very low in the butterfly flower and pandan leaf produce a taste that is not bitter. The acceptance of the combination between butterfly flower and pandan leaf of herbal tea was liked by the panelists.

4. CONCLUSION

The characteristics of the best herbal tea of combination between butterfly flowers and mint leaf and drying duration of 90 minutes was antioxidant activity of 83.147% and the best organoleptic quality of herbal tea was dark blue color, mint aroma, taste not bitter, fresh and quite like.

5. REFERENCES

Andesa, S. (2017). Effect of Drying Time Variation and Composition Variations of Herbal Tea Combination of Butterfly Pea (Clitoria ternatea L.) on the Content of Secondary Metabolite Compounds as Potential Antioxidants. Unsyiah Journal, 1(1).

Andriani, D., & Murtisiwi, L. (2018). Determination of Total Phenolic Content of Ethanol Extract of Butterfly Pea Flower (Clitoria ternatea L.) Using UV VIS Spectrophotometry. Journal of Pharmacy, 2(1), 32-91.

Andriani, D., & Murtisiwi, L. (2020). Antioxidant Activity Test of 70% Ethanol Extract of Butterfly Pea Flower (Clitoria ternatea L.) From Sleman Region Using the DPPH Method. Indonesian Pharmacy Journal, 17(1), 70-76.

Anggorowati, D., Priandini, G., & Thufail. (2016). Potential of Avocado Leaves (Persea americana miller) As Antioxidant-Rich Herbal Tea. Journal of Innovative Industries, 6(1), 1-7.

Anggriani, L. (2019). Potential of Butterfly Pea Flower Extract (Clitoria Ternatea) As Local Natural Colorant in Various Food Industries. Canrea Journal, 2(2), 32-37.

Angraiyati, D., & Hamzah, F. (2017). Drying Time in Making Pandan Wangi Leaf Herbal Tea (Pandanus amarylifolius Roxb.,) on Antioxidant Activity. Journal of Faperta, 4(1), 1-12.

Anjani, P., Andrianty, S., & Widyaningsih, T. (2015). The Effect of Adding Fragrant Pandan and Cinnamon to Salak Peel Herbal Tea for Diabetics. Journal of Food and Agroindustry, 3(1), 203-214.

Cahyaningsih, E., Sandhi, P., & Santoso, P. (2019). Screening and Phytochemical and Antioxidant Activity Test of Ethanol Extract of Butterfly Pea Flower (Clitoria ternatea L) Using UV-VIS Spectophotometry Method. Medicamento Scientific Journal, 5(1), 51-57.

Dewata, I., Wipradnyadewi, P., & Widarta, I. (2017). Effect of Temperature and Brewing Time on Antioxidant Activity and Sensory Properties of Avocado Leaf Herbal Tea (Persea americana Mill.). ITEPA Journal, 6(2), 30-39.

Djaeni, M., Ariani, N., Hidayat, R., & Utari, F. (2017). Ultrasonic Extraction of Anthocyanins from Rosella (Hibiscus sabdariffa L.) Petals: Review of Antioxidant Activity. Journal of Food Technology Applications, 6(3), 148-151.

Felicia, N., Widarta, I., & Yusasrini, N. (2016). Effect of Leaf Aging and Processing Method on Antioxidant Activity and Sensory Characteristics of Herbal Tea Avocado Leaf Powder (Persea americana Mill.). ITEPA Journal, 5(2), 85-94.

Palimbong, S., & Pariama, A. (2020). Potential of Butterfly Pea Flower Extract (Clitoria ternatea Linn) as a Colorant in Glutinous Tape Products. Journal of Science and Health, 2(3), 228-235.

Pamungkas, D., Retnaningtyas, Y., & Wulandari, L. (2017). Antioxidant Activity Test of the Combination of Methanol Extract of Gadung Mango Leaves (Mangifera indica L. var. gadung) and Pandan Wangi Leaf Ethanol Extract (Pandanus amaryllifolius Roxb.). Journal of Health Library, 5(1), 46-4

Purwaniati, Arif, A., & Yuliantini, A. (2020). Analysis of Total Anthocyanion Levels in Butterfly Pea (Clitoria ternatea) Preparations Using a Differential pH Method Using Visible Spectophotometry. Journal of Pharmagazine, 7(1), 18-23.

Putri, M., & Shofi, M. (2019). Education on the Benefits and Potential of Telang Flower (Clitoria ternatea) as a Health Drink for the Community of Datengan Village, Grogol District, Kediri Regency. Proceedings of Community Service Seminar, 162-166.

Tasia, W., & Widyaningsih, T. (2014). Potential of Black Grass Jelly (Mesona Palustris Bl.), Pandan Leaves (Pandanus Amaryllifolius) and Cinnamon (Cinnamomum burmannii) As Raw Materials for Functional Herbal Drinks. Journal of Food and Agroindustry, 4(2), 128-136.

Wartini, N., Putra, G., & Ina, P. (2015). Absolute Chemical Composition of Pandan Wangi Leaf Essential Oil Curing Treatment. Journal of Food Technology, 2(1), 16-22.

Widarta, I., Permana, I., & Wiadnyani, S. (2018). Study of Withering Time and Temperature of Avocado Leaves in an Effort to Use It as Herbal Tea. Journal of Food Technology Applications, 7(2), 55-61.

Yamin, M., Ayu, D., & Hamzah, F. (2017). Drying Time on Antioxidant Activity and Quality of Chinese Ketepeng Leaf Herbal Tea (Cassia alata L.). Journal of Faperta, 4(2), 1-15.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Preservice Biology Teacher's TPACK Integration into Lesson Planning

Putri Agustina[1*], Lina Agustina[1], Rina Astuti[1], Yesi Chotimah[1], Putri Gayatri Ramadhanty[1], Alanindra Saputra[2]

[1]Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia

[2]Biology Education Department, Faculty of Teacher Training and Education, Sebelas Maret University. Jl. Ir. Sutami 36A, Kentingan, Jebres, Surakarta 57126, Jawa Tengah, Indonesia

[*]Corresponding Author. E-mail address: pa182@ums.ac.id

KEYWORDS:
TPACK,
Lesson planning,
Integration,
Preservice teacher

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

This research was aimed to investigate preservice Biology teacher's performance in integration TPACK into lesson plans. The subjects in this study were preservice biology teacher taking Biology lesson planning and microteaching course. The object of this research was all of lesson plan developing by preservice biology teacher. The aspects of TPACK that were examined for integration of TPACK in the lesson plans included content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), and technological pedagogical and content knowledge (TPACK). TPACK integration data on the lesson plan was obtained through documentation techniques and analyzed using an identification sheet. The result of identification were analyzed descriptively using percentage techniques. The results of the identification show that the integration of TPACK aspects into lesson planning at the microteaching course is: learning objectives of 66.67%, opening activities of 30.77%, core activities of 89.74%, closing activities of 7.69%, student worksheet of 38.46%, and assessment instruments of 12.82%. While the integration at the biology lesson planning course is: learning objectives of 78%, opening activities of 33%, core activities of 89%, closing activities of 22%, student worksheet of 51%, and assessment instruments of 13%.

1. INTRODUCTION

Currently we live in the era of technology. The Industrial Revolution 5.0 refers to technological developments which include artificial intelligence, robotics, Internet of Things (IoT), big data, virtual reality, and other technologies. In this era, learning demands underwent significant changes. The rapid development of technology has had a major impact on the development of life, one of which is education. Aydın Günbatar et al. (2017) said that technology has been integrated in the curriculum and instruction. Teachers have a crucial role in the implementation of technology in classrooms so that they need to be teachers are one of the keys to the successful integration of technology in learning so that teachers should have the essential skills and knowledge needed to carry out effective integration of technology in the teaching and learning process. One of the essential types of knowledge that teachers must have in integrating technology in learning is TPACK.

TPACK is a specialized, highly applied type of knowledge that supports content-based technology integration. It has been characterized as the multiple intersections of teachers' knowledge of curriculum content, general pedagogies, technologies, and contextual influences upon learning. Nurhidayah and Suyanto (2021) TPACK level component that integrates with technology is TPACK which is a combination of technological knowledge, pedagogy, and content. TPACK is an understanding, knowledge, and communication of concept representations using

technology, pedagogical techniques, knowledge of concepts whether difficult or easy to learn and knowledge of how to help and develop students.

The TPACK framework indicates that teachers need to have a deep understanding of technology, pedagogy, and content in learning and be able to manage them. TPACK helps teachers to integrate technology effectively in learning. They learn how to use technology as a tool to support teaching and learning, thereby enhancing the quality of student learning experiences. Teachers with a good understanding of TPACK can choose and use technological tools that are appropriate to learning content and learning objectives (Akhwani 2020).

TPACK integration can increase student involvement in learning. By using the right technology, teachers can create interesting, interactive, and relevant learning experiences for students. Teachers can incorporate technology into their teaching strategies to facilitate student collaboration, exploration, and problem solving, which in turn increases student engagement in the learning process. Through TPACK, teachers can understand and respond to students' needs in using technology. They can identify students' technological preferences and abilities and adapt technology methods and tools to suit students' needs. This helps create relevant and personalized learning for each students (Bwalya and Rutegwa 2023).

TPACK was very important knowledge in preservice teacher education. TPACK helps preservice teacher to develop an understanding of how technology can be used effectively in learning contexts. They learn about technology tools and resources relevant to their teaching materials, and how to use them to facilitate active, student-centered, and engaging learning. Through TPACK, preservice teacher learns to combine pedagogical knowledge with content knowledge and knowledge about how to use technology to meet students' needs. They learn student-centered teaching strategies and leverage technology as a tool to facilitate better understanding, student engagement, and learning differentiation. TPACK encourages student teacher candidates to develop creativity and innovation in their learning designs. With knowledge of technology, they can design learning experiences that are interesting, diverse, and relevant to students' needs. Student teacher candidates can use technology to create interactive learning resources, collaborative projects, or creative activities that encourage students' critical and creative thinking (Sari and Mega 2022).

Aspects of TPACK can be developed in the teaching and learning process if integrated explicitly in the lesson plan. Learning devices occupy an important role in order to achieve success in the learning process. Therefore, all preservice teachers are equipped with the ability to develop learning tools. One of them is by compiling learning tools in the form of lesson plans. The TPACK aspect can be seen from the preparation of the lesson plan, because the lesson plan contains elements of pedagogy, content and technology.

This research was aimed to investigate preservice Biology teacher’s performance in integration TPACK into lesson plans

2. MATERIALS AND METHODS

This research is a descriptive study that aims to describe TPACK integration in lesson planning by preservice biology teacher at the course of biology lesson planning and microteaching in Biology Education Department Faculty of Teacher Training and Education Universitas Muhammadiyah Surakarta. The aspects of TPACK studied in this research were aspects of PCK, TCK, TPK, and TPACK. Subjects of this research were 342 lesson plans developed by preservice biology teacher in the biology lesson planning and microteaching course. Technique of data collection in this research was the documentation namely collecting all lesson plans documents developed by preservice Biology teacher students. This documents then analyzed using an identification sheet to determine the integration of TPACK. Data analysis was performed by qualitative descriptive analysis using percentage techniques.

3. RESULTS AND DISCUSSION

Teaching and learning planning has an important role in determining the success of learning. Learning devices occupy an important role in order to achieve success in the learning process. One of the learning tools is the lesson plan. The integration of TPACK aspects was obtained from the identification results of lesson plan for preservice Biology teacher taking microteaching and Biology lesson planning courses presented in Table 1.

Table 1. TPACK Integration in Lesson Planning by Preservice Biology Teacher

Course	Aspect	Percentage of integration in… (%)					
		Learning outcomes	Learning Activity			Student Worksheet	Assessment
			Opening	Main Activity	Closing		
Microteaching	PCK	97.44	87.18	100	100	92.31	94.87
	TCK	66.67	30.77	89.74	7.69	38.46	12.82
	TPK	66.67	30.77	89.74	7.69	38.46	12.82
	TPACK	66.67	30.77	89.74	7.69	38.46	12.82
Biology Lesson Planning	PCK	83.00	72.00	100.0	71.00	62.00	82.00
	TCK	78.00	33.00	89.00	22.00	51.00	13.00
	TPK	78.00	33.00	89.00	22.00	51.00	13.00
	TPACK	78.00	33.00	89.00	22.00	51.00	13.00

3.1. Preservice Biology Teacher's PCK Integration in Lesson Planning

Pedagogical Content Knowledge (PCK) is a concept used in education to describe a teacher's knowledge and understanding of how to teach a particular subject matter effectively. PCK combines two important aspects, namely knowledge about subject matter (content knowledge) and knowledge about effective teaching strategies (pedagogical knowledge).

Based on Table 1, it is known that the integration of PCK aspects into lesson planning at the microteaching course is: learning objectives of 97.44%, opening activities of 87.18%, core activities of 100%, closing activities of 100%, student worksheet of 92.31%, and assessment instruments of 94.87%. While the integration at the biology lesson planning course is: learning objectives of 83%, opening activities of 72%, core activities of 100%, closing activities of 71%, student worksheet of 62%, and assessment instruments of 82% (**Fig 1**).

In order to improve the quality of learning, it is important to integrate PCK into learning tools. This assists teachers in conveying learning materials effectively, improves student understanding, and facilitates a better overall learning process. By integrating PCK into learning tools, teachers can develop appropriate teaching strategies to deliver material effectively. This helps improve students' understanding and facilitates a better learning process (Sukaesih et al. 2017).

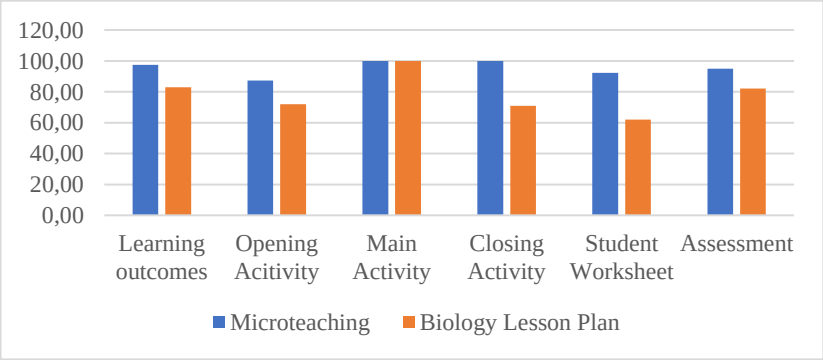


Fig. 1. PCK Integration by Preservice Biology Teacher in Lesson Planning

Every student has a different learning style and needs. With PCK integrated into learning tools, teachers can better identify and respond to individual student needs. They can provide clearer explanations, relevant examples, and adapted learning strategies to help students overcome their learning difficulties. The application of PCK in learning tools requires a deep understanding of learning materials and effective teaching strategies. By paying attention to PCK, teachers are expected to continue to develop themselves in the field of pedagogy and content. This encourages the professional development of teachers and ensures that they continuously improve the quality of their teaching (Shopie Azizah et al. 2021).

3.2. TCK integration in lesson planning

Technological content knowledge (TCK) refers to the knowledge of how technology can create new representations for specific content. It involves the intersection of technological knowledge and content knowledge. It suggests that teachers understand that, by using a specific technology, they can change the way learners practice and understand concepts in a specific content area (Schmidt et al. 2009).

Based on Table 1, it is known that the integration of TCK aspects into lesson planning at the microteaching course is: learning objectives of 66.67%, opening activities of 30.77%, core activities of 89.74%, closing activities of 7.69%, student worksheet of 38.46%, and assessment instruments of 12.82%. While the integration at the biology lesson planning course is: learning objectives of 78%, opening activities of 33%, core activities of 89%, closing activities of 22%, student worksheet of 51%, and assessment instruments of 13% (**Fig 2**).

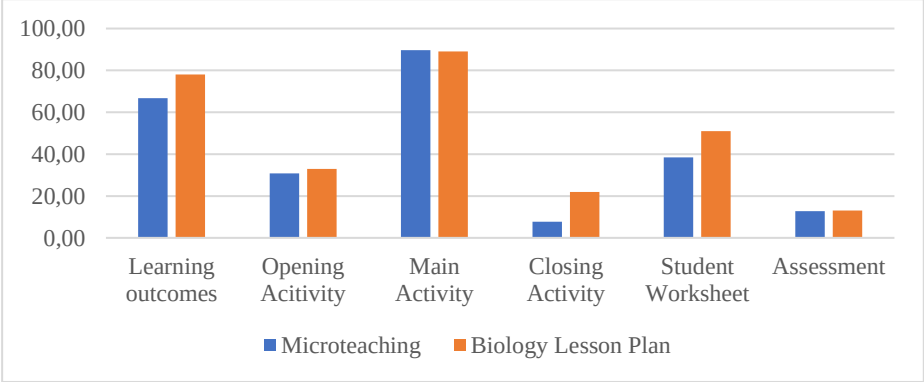


Fig. 2. TCK Integration by Preservice Biology Teacher in Lesson Planning

3.3. TPK integration in lesson planning

According to Schmidt et al (2009) TPK refers to the knowledge of how various technologies can be used in teaching, and to understand that using technology may change the way teachers teach. TPK refers to understanding technology's benefits and limitations as an enhancer of various teaching styles. It pertains to the knowledge of how various technologies can be used in the classroom and the potential for technology to alter how teachers teach (Bwalya and Rutegwa 2023). Based on Table 1, it is known that the integration of TPK aspects into lesson planning at the microteaching course is: learning objectives of 66.67%, opening activities of 30.77%, core activities of 89.74%, closing activities of 7.69%, student worksheet of 38.46%, and assessment instruments of 12.82%. While the integration at the biology lesson planning course is: learning objectives of 78%, opening activities of 33%, core activities of 89%, closing activities of 22%, student worksheet of 51%, and assessment instruments of 13% (**Fig 3**).

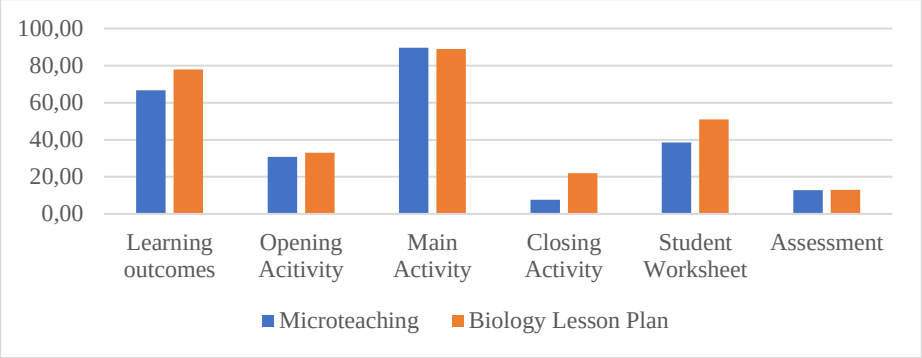


Fig. 3. TPK Integration by Preservice Biology Teacher in Lesson Planning

3.4. TPACK integration in lesson planning

TPACK defined by knowledge of the interaction between content, pedagogy, interrelated technology in the learning process (Akhwani 2020). Based on Table 1, it is known that the integration of TPACK aspects into lesson planning at the microteaching course is: learning objectives of 66.67%, opening activities of 30.77%, core activities of 89.74%, closing activities of 7.69%, student worksheet of 38.46%, and assessment instruments of 12.82%. While the integration at the biology lesson planning course is: learning objectives of 78%, opening activities of 33%, core activities of 89%, closing activities of 22%, student worksheet of 51%, and assessment instruments of 13% (**Fig 4**).

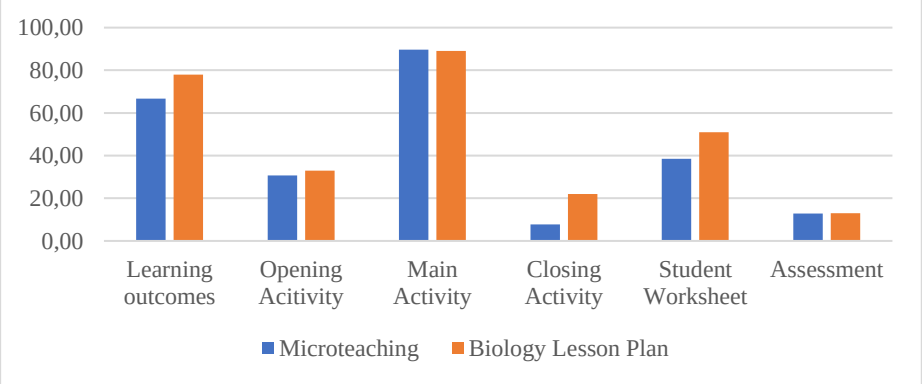


Fig. 4. TPACK Integration by Preservice Biology Teacher in Lesson Planning

TPACK helps teachers to integrate technology effectively in learning. They learn how to use technology as a tool to support teaching and learning, thereby enhancing the quality of student learning experiences. Teachers with a good understanding of TPACK can choose and use technological tools that are appropriate to learning content and learning objectives. Through TPACK, teachers can understand and respond to students' needs in using technology. They can identify students' technological preferences and abilities and adapt technology methods and tools to suit students' needs. This helps create relevant and personalized learning for each student. Overall, TPACK is important for teachers because it helps enhance their ability to integrate technology effectively in learning, increases student engagement, and prepares students for success in an evolving digital world (Chapoo et al. 2014).

It is important for student teacher candidates to integrate TPACK in learning for the following reasons: (1) TPACK integration helps student teacher candidates to design and implement more effective and meaningful learning experiences. They can use technology appropriately in delivering learning content, encouraging student interaction, and creating a relevant and interesting learning environment (Tafli and Atici 2016); (2) The current generation of students grew up in the

digital age and often have access to and familiarity with technology. By integrating TPACK, student teacher candidates can confront this digital trend and connect learning to students' real lives. This helps create greater connectedness and relevance in learning; (3) The use of appropriate technology in learning can increase student engagement and participation. Through TPACK, student teacher candidates can combine interesting and interactive technological tools and resources to activate students in the learning process. Technology can facilitate collaboration, exploration, and experimentation that encourages active student engagement (Güneş and Bahçivan 2016); (4) TPACK integration helps prospective teacher students to equip students with relevant skills to succeed in the digital world. They can teach students about digital literacy, digital ethics, and the ability to use technology as a tool for solving problems, communicating ideas, and working collaboratively. This helps students to be ready to face the demands of an increasingly digital world of work.; and (5) TPACK encourages student teacher candidates to be innovative in their learning approaches. They can use technology as a tool to create learning experiences that are creative, interesting, and in accordance with the needs of students. By utilizing technology effectively, prospective teacher students can present innovative and interesting learning for students.

4. CONCLUSIONS

The integration of PCK aspects into lesson planning at the microteaching course is: learning objectives of 97.44%, opening activities of 87.18%, core activities of 100%, closing activities of 100%, student worksheet of 92.31%, and assessment instruments of 94.87%. While the integration at the biology lesson planning course is: learning objectives of 83%, opening activities of 72%, core activities of 100%, closing activities of 71%, student worksheet of 62%, and assessment instruments of 82%. While the integration of TPK, TCK, and TPACK aspects into lesson planning at the microteaching course is: learning objectives of 66.67%, opening activities of 30.77%, core activities of 89.74%, closing activities of 7.69%, student worksheet of 38.46%, and assessment instruments of 12.82%. While the integration at the biology lesson planning course is: learning objectives of 78%, opening activities of 33%, core activities of 89%, closing activities of 22%, student worksheet of 51%, and assessment instruments of 13%

5. REFERENCES

Akhwani. 2020. Integration of TPACK as a Basic Framework for 21st Century Learning: An Analysis of Professional Teacher Competencies. *Advances in Social Science, Education, and Humanities Research* 508: 291–296. DOI: 10.2991/assehr.k.201214.251

Aydın Günbatar, S., Yerdelen Damar, S., and Boz, Y. 2017. A Closer Examination of TPACK-Self-Efficacy Construct: Modeling Elementary Pre-Service Science Teachers' TPACK-Self Efficacy. *Elementary Education Online* 16(3): 917–934. DOI: 10.17051/ilkonline.2017.330232

Bwalya, A., and Rutegwa, M. 2023. Technological pedagogical content knowledge self-efficacy of pre-service science and mathematics teachers: A comparative study between two Zambian universities. *Eurasia Journal of Mathematics, Science and Technology Education* 19(2): em2222. DOI: 10.29333/ejmste/12845

Chapoo, S., Thathong, K., and Halim, L. 2014. Biology Teacher's Pedagogical Content Knowledge in Thailand: Understanding & Practice. *Procedia - Social and Behavioral Sciences* 116: 442–447. DOI: 10.1016/j.sbspro.2014.01.237

Güneş, E., and Bahçivan, E. 2016. A multiple case study of preservice science teachers' TPACK: Embedded in a comprehensive belief system. *International Journal of Environmental and Science Education* 11(15): 8040–8054.

Nurhidayah, L., and Suyanto, S. 2021. Integrated of Technological Pedagogical and Content Knowledge (TPACK) for Pre-Service Science Teachers: Literature Review. *Proceedings of the 6th International Seminar on Science Education (ISSE 2020)* 541(Isse 2020): 98–106. DOI: 10.2991/assehr.k.210326.014

Sari, W. P., and Mega, I. R. 2022. Prospective Elementary Science Teacher in Developing Lesson Plan through Integration of STEM-Based TPACK. *Jurnal Pendidikan MIPA* 23(4): 1620–1634.

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., and Shin, T. S. 2009. Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Preservice Teachers. *Journal of Research on Technology in Education* 42(2): 123–149.

Shopie Azizah, D., Anjani Putri, D., and Mulhayatiah, D. 2021. Prospective Science Teacher TPACK Skills in Preparing the Lesson Plans. *Jurnal Geliga Sains: Jurnal Pendidikan Fisika* 8(2): 132. DOI: 10.31258/jgs.8.2.132-139

Sukaesih, S., Ridlo, S., and Saptono, S. 2017. Analisis Kemampuan Technological Pedagogical And Content Knowledge (TPACK) Calon Guru Pada Mata Kuliah PP Bio. *Seminar Nasional Pendidikan Sains* 21: 58–64.

Tafli, T., and Atici, T. 2016. The Opinions of Pre- Service Biology Teachers ' About The Context of Teachers ' Skills in Technological Pedagogical Content Knowledge. *European Journal of Education Studies* 2(9): 21–36.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Students' Creative Thingking Ability in view From The Level of Understanding in Waste Management

Syarifah Zahrah*, Rita Retnowati, Rita Istiana
Biology Education Department, Faculty of Teacher Training and Education, Pakuan University.Jl. Pakuan PO Box 452 Bogor 16143 Wets Java, Indonesia
*Corresponding Author. E-mail address: Safanisaputriazzahra25@gmail.com

KEYWORDS:
creative thinking skills, environment, student understanding, managing waste.

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Creative Creative thinking is an important nature in the learning process, the weak ability of students' creative thinking is caused by a static learning process. This study aims to analyze the factors that cause high and low students' creative thinking abilities in terms of their level of understanding and identify other factors that influence creative thinking abilities. The subjects of this study were students of class XI MIPA at SMAN 1 Ciomas, Bogor Regency. The research was conducted in November 2022 – May 2023. The method used in this study was a mixed method with a sequential explanatory research design. The research sample was 123 students, the sampling technique used proportional random sampling technique. Quantitative data analysis techniques use descriptive and inferential analysis or hypothesis testing, namely correlation and regression, and qualitative data analysis techniques include data reduction, data presentation and drawing conclusions. The instrument used for Y and X variables is a multiple choice test instrument and for qualitative use interview guidelines, observation and documentation studies. The results showed that there was a fairly high positive correlation, with an r^2 value of 24.1%, students' creative thinking ability was influenced by understanding and the remaining 75.9% was influenced by internal factors including interests, hobbies and external factors including teacher guidance, environment, and some school activities. such as organization, performing arts, social media. The solution to overcome these problems is to develop learning designs for environmental materials that can increase understanding so that students are better trained to have the ability to think creatively in solving environmental problems. The existence of collaboration between schools in developing learning designs can increase understanding so that students have the ability to think creatively.

1. INTRODUCTION

Thinking is a mental activity that helps in solving problems, making decisions and fulfilling desires. This shows that someone who is solving problems and making decisions is doing thinking activities. Creative thinking has a very important role in the educational process, because students will play a role as a driver of social change.

Creative thinking is a cognitive characteristic of creativity or the process of seeing things from a new perspective forming new concepts from several concepts that have been mastered, creative thinking helps students create new ideas to solve problems from different perspectives, creative thinking skills are also needed to produce innovation new approach involving analysis and intuition, a new component in creative thinking refers to an emphasis on acquiring new insights, new approaches, and new perspectives on understanding things (Pratiwi et al. 2019). It can be assumed that creative thinking is the ability to solve problems by forming new concepts or a process of seeing things from a different perspective in order to form new concepts. Creative thinking has a very important role in the educational process, because students will play a role as

a driver of social change. Creative thinking refers to the concept of mental activity in students which refers to five aspects including fluency, flexibility, originality, detailing, and judging (Tri Agustiana et al. 2020).

Creative education and environmental education are related fields, not all creative efforts are good for the environment. cultivating the ability to think creatively results in good consequences so that it is not ignored in the field of education, several governments around the world have identified the development of the ability to think creatively (Cheng 2019). Several countries have curricula that also focus on the ability to think creatively. The aim of their curriculum is to increase students' ability to think creatively to manage the environment (Putra et al. 2019). With the ability to think creatively students can create ideas and ideas to solve environmental problems, especially waste problems that can damage and pollute, so that the environment looks clean and comfortable.

Waste management requires creativity and the active role of the community in reducing the amount of waste, classifying the types of waste, selecting types of waste that can be reused to meet the needs of the community and the surrounding environment. Several areas in Bogor City have provided waste banks, if one pays attention to their existence they are very effective in reducing the amount of waste and empowering waste to be managed with the aim of protecting the environment (Nasution et al. 2021). Protecting the environment by managing waste is not difficult, everyone can do it, but if everyone is not used to protecting the environment from an early age then it will be difficult to do, so families need to instill awareness in protecting the environment (Çelik and Yüce 2019)

Based on the results of interviews in qualitative research that understanding contributes quite a bit in creating ideas to solve problems, especially environmental problems, there are several inspirations to solve waste problems for example plastic bottle waste that is used as a planting medium, apart from the problem of waste understanding also influences the concepts that will be assembled to make a waste reuse product. Based on the level of understanding that triggers the ability to think creatively, the research aims to analyze the factors that cause the high and low levels of students' creative thinking ability in terms of the level of understanding and identify other factors that influence the ability to think creatively besides understanding.

Understanding in managing waste is the ability of humans to understand and know how to deal with waste problems by looking at various points of view in solving them. Learning at school has an important influence on the level of students' understanding, especially on the introduction of the environment which can provide an overview of good waste management patterns such as the 3Rs, namely: reduce, reuse, and recycle. The (reduce) pattern of reducing waste is that students are expected to reduce the use of materials that are difficult to recycle such as plastic. Patterns (reuse) of reusing waste such as utilizing organic waste left over from food and vegetables as compost. The pattern of (recycle) waste is recycling waste into new items of use value such as packaging waste into various types of bags, flower vases, and others (Purnami 2021).

Waste is a substance that is produced from a production process of human activities, both household, industrial and mining. The more people, the more waste is produced. The presence of waste can have a negative impact on the environment, especially for health, so it is necessary to deal with waste problems. The increase in population makes more and more community settlements, so that it has an impact on the production of waste that is produced, whether it is waste from household activities or other waste (Sunarsih 2014). Waste has a small volume but there will be a lot of waste production because it can be seen from the amount produced by humans every day for a long period of time, this small volume of waste will become a mountain of problems that will cause air, soil and water pollution which will cause global problems (Abdulredha et al. 2017).

There needs to be sufficient understanding and good creative thinking skills in order to be able to deal with waste problems properly and get ideas for waste management so that the environment is better. The level of understanding in waste management is needed to regulate waste management starting from the selection, utilization as well as the destruction of the waste (Wahdah et al. 2020). The ability to think creatively here involves understanding related to experience factors whether students are in difficulty either to generate ideas based on knowledge or understanding they have

or get out of control by doing something without considering the impact. Based on this research, most students can master how to think and consider what needs to be done, this shows that learning outcomes that link understanding with experience can produce good ideas (Mulatti and Treccani 2023).

The low ability of students' creative thinking affects students' concern for the environment, based on school observations that students' creative thinking skills regarding waste management reach an average score of 78 in the moderate category, this is due to the absence of school activities for students to develop their creativity. So that researchers are interested in conducting research on creative thinking analysis in terms of students' understanding of waste management at SMA Negeri 1 Ciomas with the aim of knowing whether there is a relationship between creative thinking abilities and students' understanding of waste management and what factors influence creative thinking abilities besides understanding.

2. MATERIALS AND METHODS

2.1. Methods

The method used is sequential explanatory. The sequential explanatory combination research method is a research method that combines quantitative and qualitative research sequentially (Khairunnisya 2017).

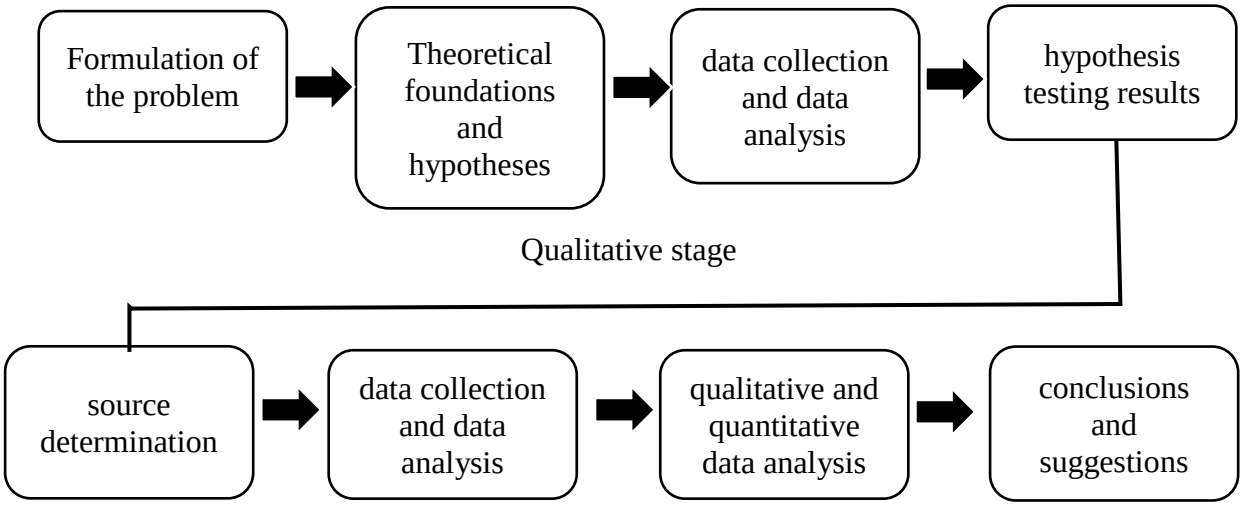


Figure 1. Sequential explanatory design research steps

2.2. Time and research instruments

When the research was conducted in February-March 2023, the instrument used to examine creative thinking skills (Y) and understanding (X) used multiple choice with a variable number (Y) of 25 questions and a variable (X) of 30 questions, variable question indicators (Y) includes (1) Developing knowledge about waste management, (2) Conceptualizing waste management, (3) Knowing current waste management issues, (4) Solving waste management problems in creative and innovative ways, (5) Managing or conserving natural resources so that damage does not occur. Variable indicators (X) include (1) Categorizing recyclable and non-recyclable waste, (2) Distinguishing between organic and inorganic waste, (3) Providing examples of proper waste management, (4) Estimating the impact of indiscriminate waste disposal, (5) Determining products to be made based on waste.

2.3. Data analysis technique

Quantitative data analysis technique uses the estimated error normality test using the Liliefors test and homogeneity test using the Barlett test with the help of Excel 2016 software. If the data is normally distributed and homogeneous, then hypothesis testing is carried out using descriptive

statistics in the form of a simple Pearson Product Moment regression correlation technique using the t test. Qualitative data analysis includes data reduction, data presentation and conclusion.

3. RESULTS AND DISCUSSION

The results of the study are strongly recommended to be presented in tables and figures. The table is made in an open form and given the title above which describes the contents of the table as shown in the example (**Table 1**).

Table 1. Summary of Normality Test Results

group variance	**Price**	**L**	**Conclusion**
regression	X^2count	X^2 table	
(Y-Ŷ)	0,067	0,079	Normal

Table 1 shows the results of the calculation (Lomax) of the estimated book error (Y-Ŷ) of 0.067 and Lt of 0.079, thus Lo < Lt = 0.067 < 0.079, so the estimated book error (Y-Ŷ) comes from a normally distributed population. The normality test is carried out to see whether the data obtained is normally distributed or not because if the data is normally distributed there will be little possibility of bias (Doddy et al. 2018).

Table 2. Summary of Homogenity Test Results

Group Varians	**Price**	**L**	**Conclusion**
Y score in terms	X^2count	X^2table	
of X	116,07	149,88	Homogen

Table 2 is the result of calculating the X^2 price with the X^2 table. if X^2 count (116.07) < X^2 table (149.88) then the data comes from a homogeneous population. This homogeneity test is carried out to find out whether the variance in each population is the same or not and to find out differences between groups of variables (Sianturi 2022). This homogeneity test is carried out when the data is normally distributed.

Table 3. Correlation test calculation results

N	**Correlation coefficient**	**Coefficient determination**	**Tcount**	**Significance**	**Conclusion**
	(r)	(r^2)		5%	
123	0,490	0,240	2,011	1,979	HO Rejected

This shows that there is a positive relationship between understanding (X) and creative thinking (Y) at a significance level of $\alpha = 0.05$, the coefficient of determination (r^2) is 0.2401 or 24.1%, which means an increase or decrease in students' creative thinking skills in managing waste is determined by an understanding of 24.1% while the remaining 75.9% is another factor that plays a role in students' creative thinking abilities.

Based on qualitative research that the ability to think creatively is not only important for driving schools but also for public schools because creative thinking is the most important essence during the learning process, with the ability to think creatively students will be more active in participating in the learning process so that the atmosphere will be more comfortable during learning going on. Creative thinking will also affect the variety of questions students ask so that it refers to increasing student knowledge so that it plays an important role when solving problems. Students' creative thinking abilities can be seen when formulating problems, looking for solutions to every problem they experience, there will be lots of ideas from students conveyed at the time of completion. Such as environmental problems, students will deal with these problems through two aspects, namely

environmental friendliness and entrepreneurship, students will use used bottles as planting media and use trash around their homes to make fertilizer, then sell the crops to meet the needs of class equipment. The ability to think creatively is influenced by several factors besides understanding including teacher guidance factors, environmental factors, hobby factors, organization and several school activities as well as participating in creativity webinars and finally social media factors.

Understanding plays an active role in students' creative thinking abilities, with understanding students will know what to do to deal with waste so that the environment is maintained, waste greatly contributes to environmental damage, educational institutions need to provide understanding and also emphasize creative thinking skills so that students can reduce use waste that is difficult to recycle and recycle waste into items that can be reused (Lee and Lee 2023). The ability to think creatively with students' understanding of waste management are two interrelated aspects. When students have the ability to think creatively, they will have many ideas that can be created and channeled properly. In learning, the ability to think creatively needs to be developed, especially learning based on solving problems such as environmental problems (Evans and Jirout 2023).

Intelligence and creative thinking are two things that are related to each other based on knowledge and with the ability to think creatively, a person can be said to be intelligent because he is able to argue based on strong references so that when people have this ability they can be said to be intelligent people (Corazza et al. 2021). This intelligence can occur in students on the basis of encouragement from educational institutions, because the low ability to think creatively in students is based on a learning process that does not dominate students so that students are not trained in expressing their knowledge (Ernaeni and Gunawan 2019). Therefore the ability to think creatively is something that needs to be fostered in 21st century learning so that students' knowledge can develop according to changing times, learning based on changing times can encourage students to compete in the 21st century with good skills and intelligence. so as to encourage progress in educational institutions (Bullard and Bahar 2023).

The ability to think creatively is currently the most important goal of educational institutions, because learning is currently all based on problems so that students are trained to solve various problems, students need to be based on sufficient understanding so that they are able to know effective ways of solving problems (Swanzy-impraim et al. 2023). It can be assumed that the ability to think creatively is closely related to understanding, because understanding can be realized so as to generate ideas in solving various problems effectively.

4. CONCLUSIONS

Based on the results of the study it can be interpreted that there is a positive relationship between understanding and the ability to think creatively, with a regression value of $\hat{Y} = 44.464 + 0.458X$ and a correlation coefficient / $r = 0.490$ and a coefficient of determination / $r^2 = 0.2401$. in accordance with qualitative research that students' creative thinking abilities possessed by students can affect the learning process seen from the price of r^2 means that 24.1% of students' creative thinking abilities are influenced by understanding and the remaining 75.9% are influenced by internal factors (hobbies) and external factors (teacher guidance, environment, and several school activities such as organizations (osis) and performing arts (pensi), social media). There is cooperation between schools and teachers in developing learning designs so as to improve the quality of education which encourages the achievement of learning outcomes in order to improve students' creative thinking skills.

5. REFERENCES

Abdulredha, M., Khaddar, R. A. L., Jordan, D., and Hashim, K. 2017. The Development of a Waste Management System in Kerbala during Major Pilgrimage Events: Determination of Solid Waste Composition. *Procedia Engineering* The Author(s) 196(June): 779–784. DOI: 10.1016/j.proeng.2017.08.007.

Bullard, A. J., and Bahar, A. K. 2023. Common barriers in teaching for creativity in K-12 classrooms: A literature review. *Journal of Creativity* Elsevier Ltd 33(1): 100045. DOI: 10.1016/j.yjoc.2023.100045.

Çelik, E. Y., and Yüce, Z. 2019. Investigation of the Awareness and Habits of Secondary School Students about Cleanliness and Hygiene from Various Variables. *International Education Studies* 12(4): 173. DOI: 10.5539/ies.v12n4p173.

Cheng, V. M. Y. 2019. Developing individual creativity for environmental sustainability: Using an everyday theme in higher education. *Thinking Skills and Creativity* Elsevier 33(March): 100567. DOI: 10.1016/j.tsc.2019.05.001

Corazza, G. E., Reiter-Palmon, R., Beghetto, R. A., and Lubart, T. 2021. Intelligence and creativity in the space-time continuum for education, business, and development. *Journal of Creativity* Elsevier Ltd 31(July): 100003. DOI: 10.1016/j.yjoc.2021.100003.

Doddy, I., Masyithoh, S., and Setiawati, L. 2018. Analisis overreaction pada harga saham perusahaan manufaktur di bursa efek indonesia. *Jurnal Manajemen* 9(1): 31. DOI: 10.29264/jmmn.v9i1.2473.

Ernaeni, L., and Gunawan, I. 2019. Model Advanced Organizer : Pengaruhnya Terhadap Kemampuan Berpikir Kreatif Advanced Organizer Model : the Effect on Creative. *Indonesian Journal of Science and Mathematics Education* 2(1): 79–83.

Evans, N. S., and Jirout, J. J. 2023. Investigating the relation between curiosity and creativity. *Journal of Creativity* Elsevier Ltd 33(1): 100038. DOI: 10.1016/j.yjoc.2022.100038.

Khairunnisya. 2017. Kontribusi Supervisis Akademik Kepala Madrasah Dan Budaya Organisasi Terhadap Mutu Pembelajaran Di Madrasah Tsanawiyah Kabupaten Way Kanan. *Universitas Islam Negeri Raden Intan Lampung* (September 2012): 69–73.

Lee, J. H., and Lee, S. 2023. Relationships between Physical Environments and Creativity: A Scoping Review. *Thinking Skills and Creativity* Elsevier Ltd 48(January): 101276. DOI: 10.1016/j.tsc.2023.101276.

Mulatti, C., and Treccani, B. 2023. Perceived lack of control promotes creativity. *Journal of Creativity* Elsevier Ltd 33(1): 100040. DOI: 10.1016/j.yjoc.2022.100040.

Nasution, I. H., Parashakti, R. D., Wuryandari, N. E. R., and ... 2021. Pemanfaatan Sampah Plastik Rumah Tangga Dalam Upaya Meningkatkan Kualitas Hidup Masyarakat. *Andhara* 1(2): 81–88.

Pratiwi, S. N., Cari, C., and Aminah, N. S. 2019. Pembelajaran IPA Abad 21 dengan Literasi Sains Siswa. *Jurnal Materi dan Pembelajaran Fisika* 9: 34–42.

Purnami, W. 2021. Pengelolaan Sampah di Lingkungan Sekolah untuk Meningkatkan Kesadaran Ekologi Siswa. *INKUIRI: Jurnal Pendidikan IPA* 9(2): 119. DOI: 10.20961/inkuiri.v9i2.50083.

Putra, T. I., Setyowati, N., and Apriyanto, E. 2019. Identifikasi Jenis Dan Pengelolaan Limbah Bahan Berbahaya Dan Beracun Rumah Tangga: Studi Kasus Kelurahan Pasar Tais Kecamatan Seluma Kabupaten Seluma. *Naturalis: Jurnal Penelitian Pengelolaan Sumber Daya Alam dan Lingkungan* 8(2): 49–61. DOI: 10.31186/naturalis.8.2.9209.

Sianturi, R. 2022. Uji homogenitas sebagai syarat pengujian analisis. *Jurnal Pendidikan, Sains Sosial, dan Agama* 8(1): 386–397. DOI: 10.53565/pssa.v8i1.507.

Sunarsih, E. 2014. Konsep Pengolahan Limbah Rumah Tangga dalam Upaya Pencegahan Pencemaran Lingkungan. *Jurnal Ilmu Kesehatan Masyarakat* 5(3): 162–167.

Swanzy-impraim, E., Morris, J. E., Lummis, G. W., and Jones, A. 2023. An investigation into the role of innovative learning environments in fostering creativity for secondary visual arts programmes in Ghana. *Journal of Creativity* Elsevier Ltd 33(2): 100054. DOI: 10.1016/j.yjoc.2023.100054.

Tri Agustiana, I. G. A., Agustini, R., Ibrahim, M., and Tika, I. N. 2020. Efektivitas Model OPPEMEI untuk Meningkatkan Kemampuan Berpikir Kreatif Mahasiswa. *Journal of Education Technology* 4(2): 150. DOI: 10.23887/jet.v4i2.25343.

Wahdah, Z. N., Winarno, M. E., and Tama, T. D. 2020. Hubungan Antara Kecerdasan Ekologis Dengan Aktivitas Pemilahan Sampah Organik dan Anorganik Pada Siswa Kelas VII dan VIII di SMP Negeri 1 Malang. *Jurnal Penelitian Dan Pengembangan Kesehatan Masyarakat Indonesia* 1(9): 166–175.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Monitoring The Correlation of Climatics to The Airborne Bacteria at The Manggarai Station, South Jakarta, Indonesia

Reza Anindita[1*], Auliya Rahmawati[2], Maulin Inggraini[3], Melania Perwitasari[4], Dede Dwi Nathalia[5], Maya Uzia Beandrade[6], Intan Kurnia Putri[7]
[1,4,5,6,7]Department of Pharmacy, Stikes Mitra Keluarga, East Bekasi, Indonesia
[2,3] Department of Medical Laboratory Technology, STIKes Mitra Keluarga, East Bekasi, Indonesia
[*]Corresponding Author. E-mail address: rezaaninditaa@gmail.com

KEYWORDS:
Temperature, humidity, light intensity, manggarai station, bacteria

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The highest of microorganisms suspended in the air were bacteria with a percentage of 80.8%. If the intensity of bacterial exposure occurs in large quantities, it will accumulate in the respiratory tract which has the potential to trigger allergic reactions and respiratory infections. Given the problems and impacts caused by air microorganisms on public health, it is necessary to monitor the distribution of air bacteria. The purpose of this study was to determine the relationship between temperature and humidity with the number of bacteria in the Manggarai station area. Type of research is correlation. The sampling location is Manggarai Station, East Jakarta, Indonesia. The 10 sampling points in this study include the station hall, motorbike parking, prayer rooms, train platform 1-2, train platform 2-3, train platform 3-4, and train platform 5, toilet, and underpass. The results of this study included the highest number of bacteria found in the station hall 331 colonies, the highest percentage of bacterial morphology is monobacilli was 78%, the distribution of gram positive was more than gram negative with spore bacteria being more dominant than non spore. The correlation coefficient between temperature and number of bacterial colonies (0.134) and humidity with number of bacterial colonies (0.380) showed weak positive correlation, while the correlation coefficient for light intensity with the number of bacterial colonies -0.140 (very weak negative).

1. INTRODUCTION

According to Bragoszewska and Pastuszka (2018), the percentage of airborne microorganisms is 10% of the 24% of the total particles suspended in the air. Cho *et al*. (2019) reported that the highest types of microorganisms suspended in the air were bacteria with a percentage of 80.8%. The dominant bacterial phyla identified in the air were Proteobacteria (32.2%), Cyanobacteria (18.0%), Actinobacteria (16.5%), Firmicutes (15.5%), and Bacteroidetes (11.6%) (Liu *et al*., 2018).

Kallawicha *et al*. (2015) explained that bacteria are components of bioaerosols that are abundant in the air both outdoors and indoors. In addition to bacteria, other bioaerosol components are viruses, fungi, pollen, metabolites of microorganisms (mycotoxins), and endotoxins as the outer membrane of bacterial cells that are released during bacterial lysis and growth. The presence of bacteria and endotoxins as components of bioaerosols were identified as important factors affecting human health. According to Jones and Harrison (2004) bacteria have a size of 0.25–8 m. This size makes it easier for bacteria to enter the human body through inhalation of the respiratory tract. If the intensity of bacterial exposure occurs in large quantities, it will accumulate in the respiratory tract which has the potential to trigger allergic reactions and respiratory infections such as asthma, rhinitis, pneumonia, and atopic dermatitis.

Cho *et al*. (2019) reported that bacteria with a size of 5-10 m that accumulate in the upper respiratory tract can trigger rhinitis, while bacteria with a size of <5 m that accumulate in the alveoli can trigger allergic reactions. However, these reactions vary between individuals. This effect tends to be more dangerous in someone with a weakened, moderate, or weakened immune system, such as children, pregnant women, and the elderly.

Given the problems and impacts caused by air microorganisms on public health, it is necessary to monitor the distribution of air microorganisms. Monitoring can be done by conducting research on the relationship between physical quality and outdoor air bacteria, especially at stations as one of the centers of crowds in densely populated urban areas.

This research was conducted at the Manggarai Station in South Jakarta, Indonesia. This station is a transit center for trains that is full of people and is a source of spreading airborne bacteria in the outside environment through coughing, breathing, and exposure to human skin. The selection of research that focuses on outdoor air bacteria at the Manggarai station refers to previous studies which were more dominant in monitoring indoor air bacteria.

Several previous studies that examined the relationship between temperature and humidity on air microorganisms, among others, research Menteşe *et al*. (2009); Wu *et al*. (2012) ; Kumar *et al*. (2011); Bragoszewska and Pastuszka (2018) ; Cho *et al*. (2019) ; Goudarzi *et al*., (2017). The difference between this research and previous research is in terms of location, this research was conducted in Indonesia, especially at the Manggarai Station. The novelty of this research is that there has never been data on air bacteria in the outdoor environment in the Manggarai station area, East Jakarta, Indonesia, considering that research on air bacteria in Indonesia is more dominant indoors.

The purpose of this study was to determine the relationship between temperature and humidity with the number of bacteria in the Manggarai station area. The existence of data on airborne bacteria can be used as a reference in formulating better policies regarding Indonesian public health guidelines outdoors.

2. MATERIALS AND METHODS

This type of research is a correlation. The sampling location is Manggarai Station, East Jakarta, Indonesia. Samples were examined at the Microbiology Laboratory of STIKes Mitra Keluarga, East Bekasi.

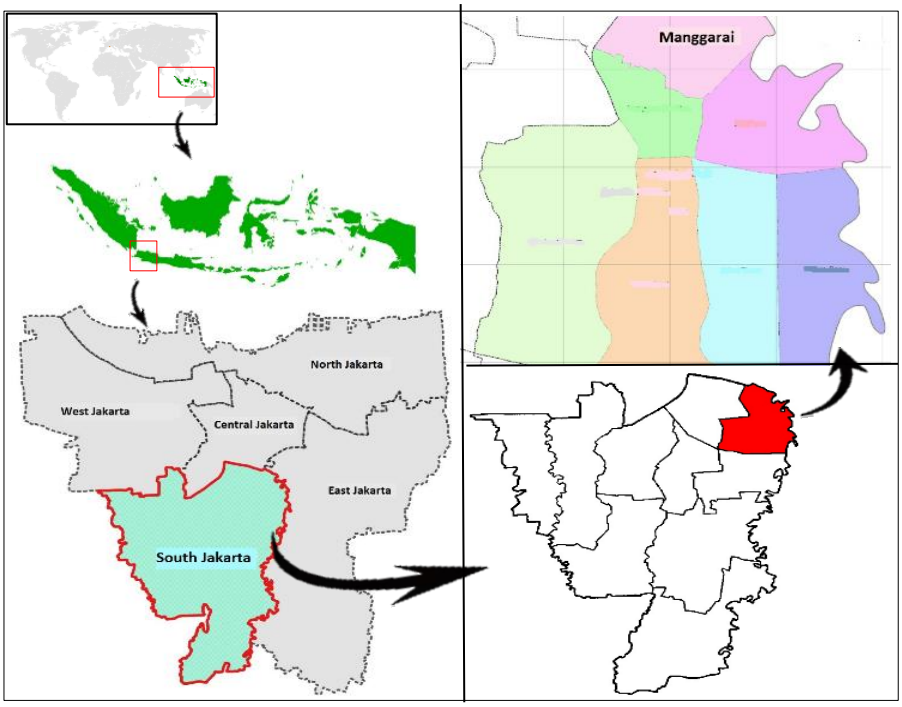


Figure 1. Map manggarai station location, south jakarta, indonesia

The instrument used in this study include Autoclave (Hirayama HG-50), Incubator (DNP), Analytical Balance (Adam), Microscope (Olympus CX22), Showcase (polytron), BSC (JSR), Hot plate and stirrer (Ika HS-10), Colony counter (KJY-020), petri dish (pyrex), bunsen's burner, Erlenmeyer (pyrex), spatula, beaker (pyrex), Thermohygrometer, Lux meter, tripod, needle loop, stirring rod, matches, dropper, object glass (sail brand) and coloring tub. The materials used in this study were 70% alcohol, spirits, aquadest, Nutrient Agar media (Himedia), Crystal violet (Be Reagent), Lugol's iodine (Merck), 95% alcohol, safranin, and Malachite Green (Riedel-De Haen).

The population in this study is the entire area of the Manggarai station. Determination of the sample area in this study using a purposive sampling technique with the criteria of a crowded area and frequently visited by passengers. The 10 sampling points in this study include the station hall, motorbike parking, prayer rooms, train platform 1-2, train platform 2-3, train platform 3-4, and train platform 5, toilet, and underpass.

The procedure of this research include pre-analytic, analytic, and post-analytic stages :

The Pre-analytic

The pre-analytic stage starts by making Nutrient Agar (NA) media to grow bacteria, measuring temperature and humidity with a thermohygrometer, light intensity with a lux meter, and taking bacterial samples at 10 points in the Manggarai station area. Each point is repeated three times on the same day and at different times, at 07.00 - 09.00 WIB. This time is the departure time of passengers at Manggarai station based on the results of a preliminary survey. The air sampling process is carried out using NA media that has been coded in the form of date, time, and location of collection placed in a predetermined sampling area with a height of 1.5 m. The NA medium was placed in an open petri dish for 10-15 minutes. The NA medium was closed again and incubated at 37°C for 2x24 hours. After incubation, the NA medium was observed and the number of bacterial colonies counted using colony counter.

The Analytic

The analytical stage is laboratory tests which include gram staining and spores. The staining results were observed using a light microscope with a magnification of 100x.

The post-analytic

The post-analytic stage is in the form of recording data on temperature, humidity, light intensity, number of bacteria, and types of bacteria based on morphology, gram, and presence of spores. All data were then analyzed by the Spearman Correlation test to determine the relationship between air physical factors such as temperature, humidity, and light intensity with the number of bacterial colonies.

The research has been conducted an ethical feasibility test by the Ethical Committee for Research health of Jakarta III Ministry of Health Polytechnic (KEPK-PKKJ3) with certificate ethic No. KEPK-PKKJ3 / 5 /II /2019

3. RESULTS AND DISCUSSION

3.1. Results

The results of examination bacteria after 2x24 hours incubation in this study showed that all areas showed the growth of bacterial colonies on petri dishes containing NA media. The results of the growth of bacterial colonies can be seen in **Figure 2.**

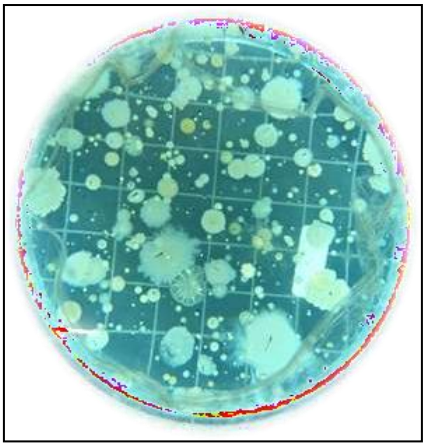


Figure 2. Bacterial colonies on NA media placed at the Manggarai station

The results of the calculation of the number of bacterial colonies after incubation of 2x24 NA media placed in 10 areas of Manggarai station in this study can be seen in **table 1.**

Table 1. The results of the calculation of the number of bacterial colonies

No	Areas	Colonies (CFU's)
1	The station hall	331
2	motorbike parking	189
3	Woman prayer rooms	33
4	Man prayer rooms	11
5	train platform 1-2	224
6	train platform 2-3	128
7	train platform 3-4	134
8	train platform 5	220
9	Woman toilet	169
10	Underpass	210

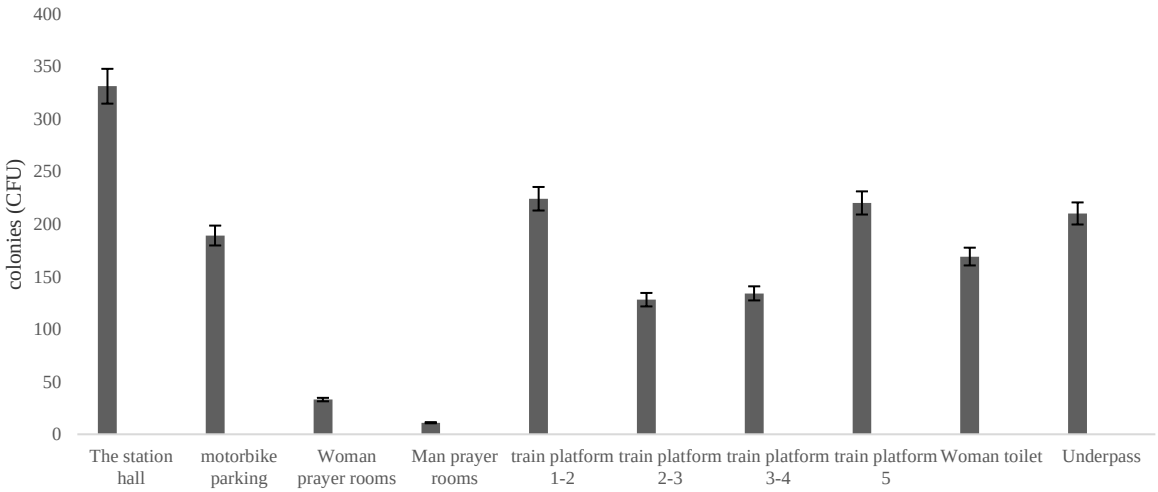


Figure 3. The number of bacterial colonies at Manggarai station

Table 1. shows that the average interval of the number of bacterial colonies found in 10 areas at the Manggarai station is between 11-331 colonies. The lowest number of bacterial colonies were found in the man prayer room as many as 11 colonies, while the highest was found in the hall area as many as 331 colonies (**Figure 3**). The distribution percentage of the number of bacteria based on their morphology can be seen in **Table 2** and **Figure 4**.

Tabel 2. The distribution percentage of the number of bacteria based on their morphology

Areas	Percentage of the number bacteria (%)								
	Monobacilli	***Diplobacilli***	***Streptobacilli***	***Coccobacilli***	***Monococci***	***Diplococci***	***Streptococci***	***Staphylococci***	***Sarcina***
The station hall	14	2	6	0	4	2	0	4	0
motorbike parking	12	7	7	1	8	5	10	10	1
Woman prayer rooms	3	0	0	0	1	0	0	0	0
Man prayer rooms	6	8	8	2	2	0	0	7	0
train platform 1-2	10	3	3	1	2	1	1	7	1
train platform 2-3	1	2	2	4	2	1	0	2	0
train platform 3-4	4	1	1	0	8	0	1	7	0
train platform 5	9	1	1	0	6	1	4	7	0
Woman toilet	7	1	1	0	7	1	2	4	0
Underpass	12	2	2	0	6	2	0	12	0
Total	78%	27%	31%	8%	46%	13%	18%	60%	2%

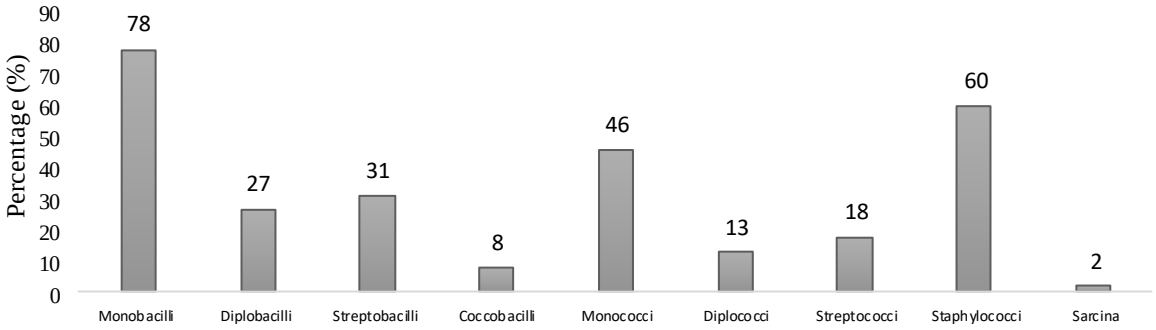


Figure 4. Diagram of the percentage number of bacterial colonies based on morphology

Table 2. show that there are 9 bacterial morphologies found in 10 areas of the Manggarai station, namely monobacilli, diplobacilli, streptobacilli, cococobacilli, monococci, diplococci, streptococci, staphylococci, and sarcina. The percentage of bacterial morphology that had the highest number was monobacilli, while the lowest was sarcina (**Figure 4**).

The results of the distribution of the number of bacteria based on gram staining can be seen in **Table 3**. and **Figure 5**.

Table 3. Distribution of bacteria based on gram staining

Area	Gram	
	Positive	**Negative**
The station hall	12	6
motorbike parking	19	7
Woman prayer rooms	2	2
Man prayer rooms	9	5
train platform 1-2	12	6
train platform 2-3	11	2
train platform 3-4	13	6
train platform 5	17	9
Woman toilet	1	15
Underpass	1	22

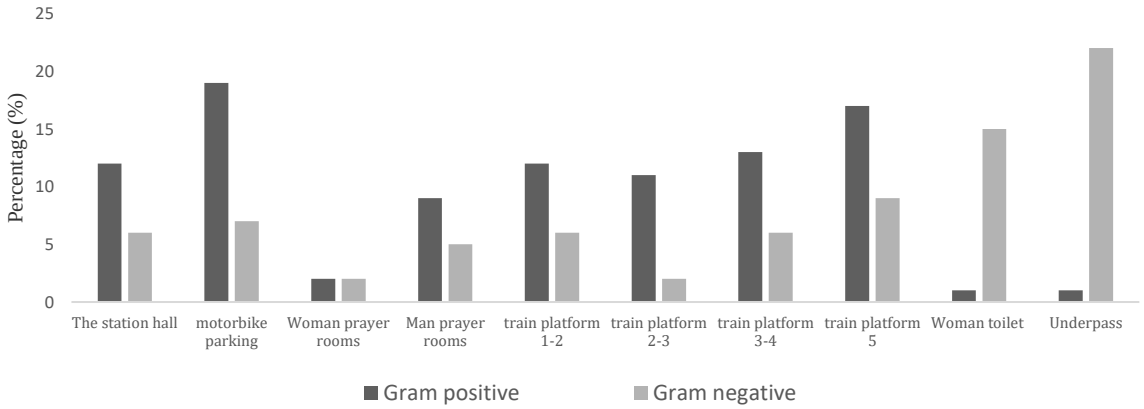
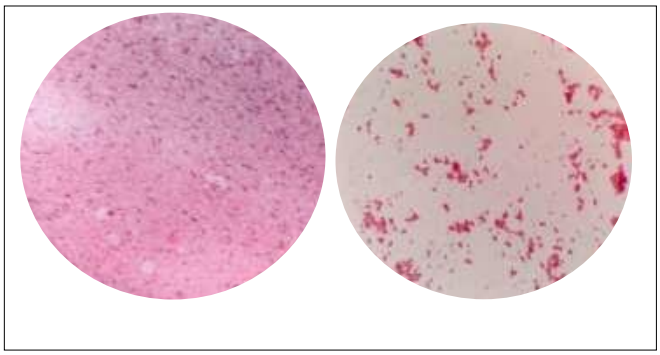


Figure 5. Distribution of bacteria based on gram staining



A **B**

Figure 6. Gram-positive (A) and Gram-negative (B) bacteria.

In this study, the number of bacterial colonies based on the presence/absence of spores showed that the number of bacteria that did not have spores was more dominant than bacteria that had spores. The results of the number of bacterial colonies based on the presence or absence of spores are shown in **table 4** and **figure 7**.

Table 4. The number of bacterial colonies based on spores.

Area	Spora	
	Spore	**Non-spore**
The station hall	12	6
motorbike parking	12	14
Woman prayer rooms	3	1
Man prayer rooms	6	8
train platform 1-2	9	9
train platform 2-3	5	8
train platform 3-4	3	16
train platform 5	3	23
Woman toilet	5	11
Underpass	11	12

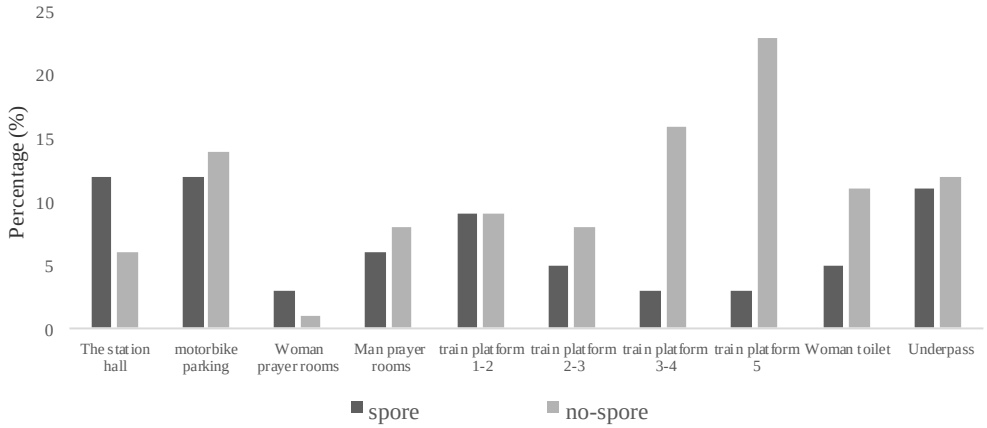


Figure 7. Diagram of the distribution of bacteria based on the presence of spores

The results in **table 4** and **figure 8** show that the percentage of bacteria that have spores in the hall (67%), motorbike parking (46%), women's prayer room (75%), men's prayer room (43%), platform 1-2 (50%), platform 2-3 (38%), platform 3-4 (16%), platform 5 (12%), women's toilet (31%), and underpass (48%), while the percentage of bacteria that did not have spores in the hall (33%), motorbike parking (54%), women's prayer room (25%), men's prayer room (57%), platform 1-2 (50%), platform 2-3 (62%), platform 3-4 (84%), platform 5 (88%), women toilets (69%), and underpass (52%). The microscopic picture of the structure of spore and non-spore bacteria can be seen in **Figure 8.**

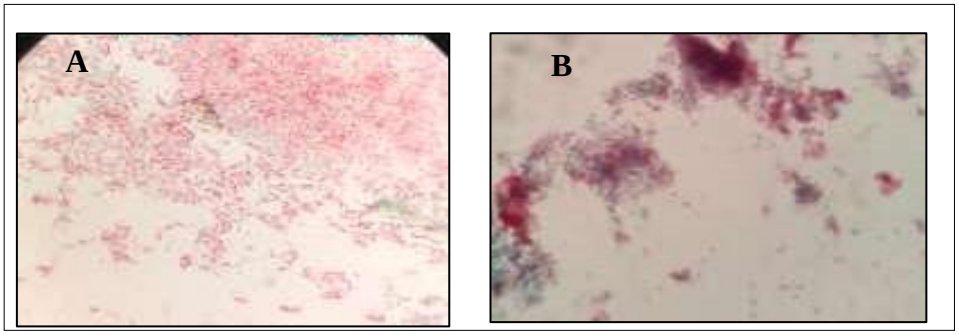


Figure 8. Spore bacteria (a) and bakteri non-spore bacteria (b) (1000x).

In this study, measurements of physical factors at Manggarai Station were carried out simultaneously with air sampling at Manggarai Station. Measurement of physical factors was carried out at 10 sampling points at Manggarai Station. The data obtained consisted of temperature, humidit, and light intensity which can be seen in **table 5.**

Table 5. Results of measuring physical factors

Area	Temperature (°C)	Humidity (%)	Light Intensity (lux)
The station hall	31.8	63	405
motorbike parking	32.4	61	9324
Woman prayer rooms	30.1	64	1015
Man prayer rooms	29.8	66	83
train platform 1-2	31.6	63	3613
train platform 2-3	31.7	62	4100
train platform 3-4	32.1	60	2865
train platform 5	31.8	61	3057
Woman toilet	31	63	260
Underpass	31.1	63	67

Table 5. shows that the interval of the average temperature is between 29.8°C-32.4°C, humidity 60%-66%, and light intensity 83-9324 lux. The results of statistical tests on the correlation of physical factors of air quality toward the number of bacterial colonies using the Spearman correlation test with a 95% significance level can be seen in **table 6.**

Table 6. Correlation test results of temperature, humidity, and light intensity on the number of bacterial colonies

Test variable	Result	correlation coefficient
Temperature with the number of bacterial colonies	p = 0,000	r = 0,134
Humidity with the number of bacterial colonies	p = 0,000	r = 0,380
Light Intensity with the number of bacterial colonies	p = 0,000	r = -0,141

Table 6. shows that all test variables produce a p-value <0.05 or that there is a correlation between physical factors of air quality and the number of bacterial colonies. The correlation coefficient value between temperature and the number of bacterial colonies and humidity with the number of bacterial colonies showed a weak positive correlation, respectively 0.134 and 0.380, while the correlation coefficient (r) for light intensity with the number of bacterial colonies was -0.140 or classified as correlation. very weak negative.

3.2. Discussion

The results of the Spearman correlation test in this study showed that there was a correlation between temperature and the number of bacterial colonies at the Manggarai station (P<0.05). However, this correlation is included in the very weak category (r=0.134). The results of this study are in accordance with the research of Bragoszewska and Pastuszka (2018); Saadati *et al*. (2022) reported that there was a positive correlation between air temperature and the number of bacterial colonies.

According to Zhong *et al*. (2016), the correlation between temperature has a weak positive correlation with the number of bacterial colonies due to the presence of too high a temperature which can also inhibit bacterial growth. This is shown in the research results of Wu *et al*. (2012) who reported that increasing the temperature of UV light can significantly reduce the number of bacterial colonies outdoors. Therefore, the correlation between temperature and the number of bacterial colonies is very weak, considering that each bacterium has varying optimum temperature characteristics.

Another factor that correlates with the number of bacterial colonies is humidity. The correlation between humidity and the number of bacterial colonies in this study resulted in a positive correlation with a weak category. The results of this study are in accordance with the research of Kallawicha *et al*. (2015)**;** Hwang and Yoon (2017) who reported that air humidity was positively correlated with the number of bacterial colonies. The difference in previous studies is that the correlation is strong, while in this study it is weak.

Hwang and Yoon (2017); Zhong *et al*. (2016); Hiwar *et al.* (2021) stated that humidity is related to the amount of water vapor in the air needed to increase cell wall strength and bacterial metabolism so that increasing air humidity can increase bacterial growth. However, humidity that is too high is often accompanied by very low temperatures that can inactivate protein enzymes that play a role in bacterial growth. Therefore, the correlation of humidity with the number of bacterial colonies often results in a weak positive correlation.

In contrast to temperature and humidity, in this study, the correlation between light intensity and the number of bacterial colonies resulted in a very weak negative correlation. The results of this study are in accordance with the research of Kamel *et al*. (2016); Fithri *et al*. (2016) who reported that light intensity was weakly negatively correlated with bacterial colonies. This is because some bacteria can have mutations that make them resistant to light exposure.

Gola *et al.* (2019) added that light intensity has bactericidal activity and plays an important role in spontaneous sterilization in natural conditions because sunlight contains ultraviolet light. Examples of bacteria that die from exposure to high light intensity are Streptococcus and other bacteria that cause respiratory tract infections.

Research result Gladka *et al.* (2021) ; Santos *et al*. (2011) ; Mohana *et al*. (2013) explained that although light intensity can inhibit the growth of some airborne bacteria, there are some bacteria that are resistant to high light intensity, such as *Micrococcus* sp. The resistance of these bacteria is obtained because some bacteria are able to form spores to survive and grow to spread to the environment without being affected by the intensity of sunlight. Therefore, the negative correlation between light intensity and the number of bacterial colonies is weak.

In this study, areas with a high number of bacterial colonies were station halls, platforms, and underpasses. The high number of bacteria is due to the fact that these three areas are the center of crowds at the station, thereby increasing the number of bacterial colonies carried by dust and humans as station users (Fang *et al*., 2007); (Maier *et al*., 2010).

The results of this study also showed that the dominant forms of airborne bacteria in the Manggarai station area were coccus and bacillus. These results are in accordance with the research of Menteşe *et al*. (2009) which states that the most common bacteria found in outdoor areas are coccus and bacillus with the dominant genus Micrococcus sp. Streptococcus sp and Bacillus sp. Goudarzi *et al*. (2017) added that in addition to the dominant fungal genus bacteria in the outdoor, among others, *Aspergillus* sp., *Penicillium* sp., and *Cladosporium* sp.

The results of this study also found the spread of the number of gram-positive and spore-forming bacterial colonies in large numbers. Kumar *et al*. (2011) explained that gram-positive bacteria are more resistant than gram-negative bacteria to high UV exposure. The resistance of bacteria to extreme environments is influenced by the presence of spores, pigments and high amounts of Guanine (G) and Cytosine (C), considering that bacteria with endospores and DNA with high G and C content are more resistant to temperature, humidity, light intensity, UV rays, chemicals, and free radicals.

The advantages of this research are the locations that have never been studied and the research variables are large in number. The limitation of this study is the identification of bacterial and fungal species in the Manggarai station area has not been carried out

4. CONCLUSIONS

This study concludes that there is a correlation between temperature, humidity, and light intensity in the number of bacterial colonies in the Manggarai station with a weak category. As for further researchers, besides analyzing the correlation between environmental factors and the number of bacterial colonies, it is also recommended to identify bacteria and fungi in the Manggarai station environment.

5. ACKNOWLEDGMENTS

The researchers would like to thank the Head of UPT Station Manggarai who has permitted a research site

6. REFERENCES

Bragoszewska E, Pastuszka J. Influence of Meteorological Factors on The Level and Characteristics of Culturable Bacteria in The Air in Gliwice, Upper Silesia (Poland). Silesian, Poland: Springer US; 2018. p. 241–55. https://doi.org/10.1007/s10453-018-9510-1

Cho, E.M., Hong, H.J., Park, S.H., Yoon D.K., Goung, S.J.N., Lee, C.M. Distribution and Influencing Factors of Airborne Bacteria in Public Facilities Used by Pollution-Sensitive Population: A Meta-analysis. Int J Environ Res Public Health. 2019;16(9). http://dx.doi.org/10.3390/ijerph16091483

Liu, H., Zhang, X., Zhang, H., Yao, X., Zhou, M., He, Z., Zhang, H., Lou, L., Mao, W., Zheng, P., Hu, B. Effect Of Air Pollution On The Total Bacteria And Pathogenic Bacteria In Different Sizes Of Particulate Matter. Environmental Pollution. 2018;233:483–93. https://doi.org/10.1016/j.envpol.2017.10.070

Kallawicha, K., Lung, S.C.C., Chuang, Y.C., Wu Da, C., Chen Hsuan, T., Tsai Y.J. Chao, J.H. Spatiotemporal Distributions And Land-Use Regression Models Of Ambient Bacteria And Endotoxins In The Greater Taipei Area. Aerosol Air Quality Research. 2015;15(4):1448–59.

Jones, A.M. and Harrison, R.M. The Effects Of Meteorological Factors On Atmospheric Bioaerosol Concentrations - A Review. Science of Total Environment. 2004;326(1–3):151–80. doi:10.1016/j.scitotenv.2003.11.021

Mentese, S., Arisoy, M., Rad,Y.A., Güllü, G. Bacteria and Fungi Levels in Various Indoor And Outdoor Environments In Ankara, Turkey. Clean Journal 2009;37(6):487–93. DOI: 10.100/c1en.2008002200

Wu, Y.H., Chan, C.C., Chew, G.L., Shih, P.W., Lee Te, C., Chao, J.H. Meteorological Factors And Ambient Bacterial Levels in A Subtropical Urban Environment. Int J Biometeorol. 2012;56(6):1001–9. DOI 10.1007/s00484-011-0514-6

Kumar, P, Mahor, P, Goel, A.K., Kamboj, D.V., Kumar O. Aero-microbiological Study On Distribution Pattern Of Bacteria and Fungi During Weekdays At Two Different Locations In Urban Atmosphere Of Gwalior, Central India. Sci. Res. Essays. 2011: 6(25):5435–41. DOI : 10.5897/SRE11.1485

Goudarzi, G., Soleimani, Z., Sadeghinejad, B., Alighardashi, M., Latifi, S.M., Moradi, M. Visiting Hours Impact on Indoor to Outdoor Ratio of Fungi Concentration at Golestan University Hospital in Ahvaz, Iran. Environ. Pollut. 2017;6(1):62. https://doi.org/10.5539/ep.v6n1p62

Saadati, Z., Shahryari, T, Ramazani, A.A., Sahlabadi, F., Nikoomanesh, F., Namaie, M.H. International Journal of Molecular and Clinical Microbiology Investigation of Indoor and Outdoor Fungal Bioaerosols and Environmental Factors in Indoor Air Quality of Nursery Schools. Int. J. Mol. Clin. Microbiol. 2022;12(1):1596–604.

Zhong, X., Qi, J., Li, H., Dong, L. and Gao, D. Seasonal Distribution Of Microbial Activity In Bioaerosols In The Outdoor Environment Of The Qingdao Coastal Region. Atmos. Environ. 2016;140:506–13. http://dx.doi.org/10.1016/j.atmosenv.2016.06.034.

Hwang, S. H. and Yoon, C.S. Main Environmental Factors Affecting Concentrations 0f Culturable Airborne Bacteria in Indoor Laboratories Over A Period of One Year. Appl. Ecol. Environ. Res. 2017;15(1):321–33. http://dx.doi.org/10.15666/aeer/1501_321333

Hiwar, W, King, M.F., Shuweihdi, F., Fletcher, L.A., Dancer, S.J., Noakes, C.J. What is The Relationship Between Indoor Air Quality Parameters and Airborne Microorganisms in Hospital Environments? A Systematic Review And Meta-Analysis. Indoor Air. 2021.31(5):1308–22. DOI: 10.1111/ina.12846

Kamel, H.F, Saeed, H.C. and Hassan Ismael, N. Comparative Effect Of Different Visible Light Energy On Bacterial Growth. Int. J. Adv. Res. 2016;4(2):263–70. http://www.journalijar.com.

Fithri, N. K., Handayani, P. dan Vionalita, G. Faktor-Faktor yang Berhubungan dengan Jumlah Mikroorganisme Udara Dalam Ruang Kelas Lantai 8 Universitas Esa Unggul. Forum Ilm. 2016;13(1):15–6.

Gola, M., Settimo, G. and Capolongo, S. Indoor Air Quality in Inpatient Environments: A Systematic Review on Factors that Influence Chemical Pollution in Inpatient Wards. J. Health. Eng. 2019;2019. https://doi.org/10.1155/2019/8358306

Gladka, G., Hovorukha, V., Romanovskaya, V., Tashyrev, O. Correlation Between Resistance to UV Irradiation and The Taxonomic Position of Microorganisms. Environ. Res. Eng. Manag. 2021 : 77(1):67–75. DOI 10.5755/j01.erem.77.1.23832

Santos, A. L, Lopes, S., Baptista, I., Henriques, I., Gomes, N.C.M., Almeida A., Correia, A. and Cunha, A. Diversity in UV Sensitivity and recovery Potential Among Bacterioneuston And Bacterioplankton Isolates. Lett Appl Microbiol. 2011;52(4):360–6. doi:10.1111/j.1472-765X.2011.03011.x

Mohana, D., Thippeswamy, S.and Abhishek, R.. Antioxidant, antibacterial, and Ultraviolet-Protective Properties of carotenoids Isolated From *Micrococcus* sp. Radiat. Prot. Environ. 2013;36(4):168.

Fang, Z., Ouyang, Z., Zheng, H., Wang, X., Hu, L. Culturable Airborne Bacteria In Outdoor Environments in Beijing, China. Microb. Ecol. 2007;54(3):487–96. DOI: 10.1007/s00248-007-9216-3

Maier, R.M., Palmer, M.W., Andersen, G.L., Marilyn, J., Halonen, Karen, C., Josephson, Robert, S. Maier, Fernando, D. Martinez, Julia, W. Neilson, Debra, A. Stern, Donata Vercelli and Anne, L. Wright. Environmental Determinants Of And Impact On Childhood Asthma By The Bacterial Community In Household Dust. Appl. Environ. Microbiol. 2010;76(8):2663–7. doi:10.1128/AEM.01665-09

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Effect of Active Learning Integrated with Everyone Is A Teacher Here Strategy Based on Questioning and Answering on The Critical Thinking Skills and Biology Learning Retention of Class XI Senior High School Students In The Industrial Agriculture Area

Kurnia Suciningsih, Bea Hana Siswati*, Nadyatul Ilma Indah Savira
Biology Education Department, Faculty of Teacher Training and Education, University of Jember. Kalimantan Street Number 37, Sumbersari, Jember 68121, Jawa Timur, Indonesia
*Corresponding Author. E-mail address: beahana.fkip@unej.ac.id

KEYWORDS:
Critical Thinking, Everyone is A Teacher Here, Questioning and Answering, Retention

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

This study aimed to improve student's critical thinking skill and student retention in learning biology through active learning strategy innovation Everyone Is A Teacher Here (ETH) based on Questioning and Answering (Q&A). Moreover, the type of research used is a quasi-experimental research using a pre-test, post-test, and re-test research pattern. In addition, the research was conducted at SMAN 3 Jember in the even semester of the 2022/2023 academic year. The XI MIPA 2 class was selected as the experimental class and XI MIPA 4 as the control class. Based on the results of this study, the ETH strategy based on Q&A has a significant effect on students' critical thinking skills and retention in biology class XI. This is evidenced by the results of the significance of the Anakova test using SPSS, critical thinking skills have a significance of 0.000 ($p<0.05$) and student retention has a significance of 0.000 ($p<0.05$). The innovative learning strategy used in this study can be applied in class because it can increase student focus and motivation, especially in biology.

1. INTRODUCTION

The revised 2013 curriculum in its implementation emphasizes affective, cognitive, and psychomotor aspects that are in accordance with the characteristics of students and integrates 4 important things namely Strengthening Character Education (PPK), Literacy, (basic literacy, library, media, technology, and visual), 21st Century Skills (4C), and *Higher Order Thinking Skills* (HOTS) (Sholekah, 2020; Effendi et al., 2021).

Student's critical thinking skills in Indonesia are in the low category, as evidenced by data from the *Program for International Student Assessment* (PISA) which stated that in 2015, student's' critical thinking skills in Indonesia had a score of 397, which was 62nd place out of 72 countries, while in 2018 it had a score of 371, which was 74th place out of 79 countries, (Agnafia, 2019; Hewi dan Shaleh, 2020). One way to hone students' thinking skills is through learning activity that involves critical thinking processes. According to research by Kartimi & Liliasari (2012) that to improve critical thinking there needs to be a training process, such as getting students used to work on questions that develop critical thinking (Susilawati et al., 2020).

Retention is the ability to remember material that has been studied. It is related to memory, which the output is student learning outcomes (Sudirman and Yusnaeni, 2022). The ability to remember previously learned material is one of the student problems found in classroom. According to Astuti and Muldayanti (2018) that some of all students in the class have low memory,

this was proven during the next meeting only a few students could answer the teacher's questions when reviewing the material with simple questions and answers.

Student's critical thinking skills and learning retention must be improved, one of which is by making changes from Teacher-Centered Learning to Student-Centered Learning through active learning. The principle of active learning is student-centered (Hartikainen et al., 2019). One of the active learning strategies is Everyone is A Teacher Here (ETH). Students get a card containing questions, then the student is given the opportunity to answer questions that behave like teachers to other students in their own style and language (Pratama and Pratiwi, 2019). Questioning and Answering (Q&A) activities are method in the form of reciprocity between teachers and students or students and students (Syahrir, 2018). According to Sulfemi (2017) and Sadariya (2021) that the question-and-answer (Q&A) method for students can increase thinking stimulus, learning motivation, and adding insight, communication strengthening between teachers and students, which can train learning independence. Research by Pratama and Pratiwi (2019) used questions from students. This is less effective because the questions are still basic. So, researchers innovate by preparing critical question cards that are displayed through a projector so that all students can focus and follow the learning process properly.

Biology subjects requires students to be able to find a scientific fact through the process of observing, analyzing, comparing with theory, and concluding (Senisum, 2021). Biology subject is classified as a difficult material for students at SMAN 3 Jember. Based on the observation results, the UAS average score for biology class XI MIPA has not reached the KKM, which is still below 75. Therefore, innovation is needed in the learning process to improve students' critical thinking skills and biology learning retention. The material used by researchers were in accordance with what is being taught at the beginning of the even semester, namely the human respiratory system. Respiratory system material is one of the difficult materials, because during the learning process students cannot see directly the organs of the respiratory system and the processes that occur in the respiratory system (Panjaitan et al., 2020). Biology learning at SMAN 3 Jember, which is an industrial agricultural area, can be connected to phenomena in the surrounding environment to trigger students' thinking stimulus.

Based on the background above, the authors conducted a study entitled The Effect of Active Learning with Everyone is A Teacher Here Strategy Based on Questioning and Answering on Critical Thinking Ability and Retention in Learning Biology for Class XI High School Students in Industrial Agricultural Areas.

2. MATERIALS AND METHODS

The type of research used was quasi-experimental. This study used a pre-test, post-test, and re-test research pattern on 2 classes, one class as the control class and the other class as the experimental class.

Table 2.1 Research design pre-test, post-test, and re-test

E	O1	→	X1	→	O2	→	O3
K	O1	→	X2	→	O2	→	O3

Information:
E : experimental class
K : control class
O1 : pre-test results
O2 : post-test results
O3 : re-test result
X1 : using Q&A based ETH strategy
X2 : using the lecture method

Research in the experimental class applied The ETH learning strategy based on Q&A. While the control class used the lecture method learning model. The material used in this study is the human respiratory system. The research was conducted at SMAN 3 Jember in the even semester

of the 2022-2023 academic year, in January-March 2023. The meetings were held 3 times, both in the control class and the experimental class. The research population were all students of grade XI at SMAN 3 Jember. The research sample was selected through equality test of the classes that would be sampled using the ANOVA test, so XI MIPA 2 and XI MIPA 4 classes were selected as sample classes.

The data collection techniques used in this study were interview, observation, documentation, and test (pre-test, post-test, and re-test). Interview and observation activity were held at SMAN 3 Jember. The data collection techniques of this study can be seen in the following table:

Table 2.2 Data Collection Techniques

Data	Data Collection Technique	Instrument
Validity of ETH learning strategy based on Q&A	Expert validity (validated by lectures)	Validation Sheet
Critical Thinking Ability and Retention	Test	Test Questions
Implementation of learning	Observer response	Observation Sheet

In this study, all samples were tested using the normality and homogeneity tests first. Then, test the equality of the classes that will be sampled using the Anova test. The analysis of covariance (anakova) data analysis approach was applied in this study. Critical thinking skills in control and experimental classes were measured by using the pre-test and post-test. The questions tested used multiple choice questions and essays. The test results then were analyzed by using anakova. The following was the formula for scoring students' critical thinking skills:

$$\text{Skor} = \frac{score\ obtained}{skor\ maximum} \text{ x } 100\%$$

Student retention in the experimental and control classes measured through post-test and re-test scores and then analyzed using anacova. The test results are calculated by the following formula:

$$\text{Skor} = \frac{score\ obtained}{skor\ maximum} \text{ x } 100\%$$

3. RESULTS AND DISCUSSION

3.1. The impact of Everyone is A Teacher Here Based on Questioning and Answering for Student's Critical Thinking Skills

The results of the hypothesis test for critical thinking skills can be seen in the following table.

Table 3.1 Hypothesis Test Results of Students' Critical Thinking Skills

Class	N	Average		Sig.
		Pretest	Posttest	
Control Class	31	64,77± 6,88	73,54± 9,88	0,00
Experiment Class	31	66,06± 7,65	87,09± 8,24	

Based on the table 3.1 of data analysis results of students' critical thinking skills, the significance value was 0.00 ($p < 0.05$) which indicated that the Everyone is A Teacher Here strategy based on Questioning and Answering had a significant impact on students' critical thinking skills. This was in accordance with Sari's research, (2014) that the ETH strategy is able to optimize learning independence and students' ability to think critically. This research was also supported by

Liasari, Sudjarwo & Purnomo, (2017) that the ETH strategy has a significant effect on learning outcomes and students' critical thinking skills.

The implementation stages of the ETH strategy based on Q&A were as follows. The first step was orientation by showing video and introduction according to the material. This stage triggers students to explore a phenomenon that can increase students' curiosity (Jeffery et al., 2016; Arsal, 2017; Mcnew-birren & Kieboom, 2017). Then students formed groups of 4-5 people. Group activities involved students to discuss so they can explore, explain, and refute opinions and consider the most reasonable answers to solve the problems given (Wood and Shirazi, 2020). Fauzan et al., (2022) stated that group discussion activities were effective in increasing critical thinking skills in high school students.

The second step was the teacher chooses one student randomly to answer the question by selecting question cards randomly. According to Usman et al., (2020) stated that asking questions can stimulate students to answer and express opinions. So, through this stage students had carried out the basis of the critical thinking process.

The third step was students conducted discussion sessions under the guidance of the teacher in conducting investigation and gathering information. According to Kurniahtunnisa (2016) learning that involves students to understand, formulate problems, search for and analyze data to find alternative solutions to a problem can improve students' critical thinking skills.

The fourth step was the questioning and answering session where the selected students had to answer questions in front of the class, then the teacher gave an opportunity to one of the students from a different group to provide feedback. This stage trained students' communication skills. According to Andriyani (2020), communication skills are one of the aspects in 4C so it needs to be trained to improve. The last step was that students summarized and concluded the material followed by a reflection from the teacher regarding the material that students had learned. Self-reflection based on Dewey's reflective thinking theory and Marzano's opinion, can train students to control themselves and is a process that aims to encourage students to know how effective the learning process for them (Saputri et al., 2019).

The results of the frequency distribution of student's critical thinking skills can be seen in the following table :

Table 3.2 Frequency Distribution Table of Critical Thinking Skills

No.	Critical Thinking Indicators	Experiment Class			Control Class		
		***Pre-Test* Average**	***Post-Test* Average**	**Average Difference**	***Pre-Test* Average**	***Post-Test* Average**	**Average Difference**
1	Provides a simple explanation	2.87	4.32	1.45	3.88	4.30	0.42
2	Building basic skills	3.48	4.68	1.20	2.97	3.03	0.06
3	Building conclusions	3.48	4.39	0.91	2.87	3.68	0.81
4	Make further explanations	2.77	4.35	1.58	2.97	3.52	0.55
5	Organize strategies and tactics	3.84	4.03	0.19	3.48	3.84	0.36
Total				**5.33**			**2.20**

Based on table 3.2 of data frequency distribution of students' critical thinking skills, it can be seen that the experimental class got better scores than the control class. Assessment of critical thinking skills were also measured through 5 critical thinking indicators. The maximum point for

each indicator was 5. The first indicator was to provide a simple explanation, the experimental class scored 4.32 (very high) and the control class got 4.30 (very high). This score was in the very high category because students were able to identify problems in the questions and the answers they write aligned with the answer key (Putri and Latisma, 2022).

The second indicator was building basic skills, in the experimental class got a score of 4.68 (very high) and in the control class got a score of 3.03 (enough). Students in the experimental class obtained very high scores, meaning that they were able to examine information through relevant sources and then process and analyze problems using the information they found (Putri and Latisma, 2022). Whereas in the control class students were still have difficulty in analyzing and finding evidence relevant to the problems given. This was characterized by thinking that was not according to proper standards, irrelevance and limited thinking stages (Nugraha et al., 2017).

The third indicator was making conclusions, in the experimental class got a score of 4.39 (very high) and in the control class got a score of 3.68 (high). Students in the experimental class got very high scores because they were able to find solutions and draw conclusions appropriately based on existing facts. Students in the control class were able to conclude problems but could not explain in detail about the analysis of the answers they found. One of the characteristics of someone with optimal critical thinking skills were being able to draw conclusions and provide alternative solutions with valid arguments and evidence (Nugraha et al., 2017).

The fourth indicator was making further explanations, in the experimental class got a score of 4.35 (very high) and in the control class got a score of 3.52 (high). This indicated that students in the experimental class had been able to think comprehensively in solving a problem. Characterized by being able to solve problems using an open, broad, and detailed mind consistently and being able to use their instincts for existing concepts and then linking these concepts to solving problems (Nugraha et al., 2017). Students in the control class obtained lower scores because they were able to think deeply and solve problems, but they were still could not explain completely.

The fifth indicator was organizing strategies and tactics, in the experimental class got a score of 4.03 (very high) and in the control class got a score of 3.84 (high). Students got very high scores because they had been able to find the right alternative answers and describe conclusions according to the problem (Putri and Latisma, 2022). Students with high critical thinking skills can consider the several options provided to determine the most effective problem solving solutions (Nugraha et al., 2017). Meanwhile, students in the control class obtained lower scores because they were able to explain answers correctly, but they were incomplete in finding alternative answers. As a result, additional information is required. (Putri and Latisma, 2022).

The implementation of the ETH strategy based on Q&A created interaction between students that helped students to understand the material in their own way. The understanding that was 'self-created' through students' own language can make it easier for students to remember what they had learned so that they can complete evaluation questions and have better cognitive learning outcomes (Yusuf, 2018). In addition, questions at the beginning of learning can hone students' critical thinking skills to a higher level.

3.2.The impact of Everyone is A Teacher Here Based on Questioning and Answering for Student's Retention

The results of the student learning retention hypothesis test can be seen in the following table.

Table 3.3 Student Learning Retention Hypothesis Test Results

Class	N	Average		Sig.
		Posttest	Retest	
Control Class	31	82,54± 4,65	64,35± 11,46	0,00
Experiment Class	31	87,03± 6,14	80,93± 8,38	

Based on table 3.3 of student learning retention results, the significance value is 0.00 ($p < 0.05$). It can be interpreted that the implementation of ETH strategy based on Q&A had a significant effect on student learning retention. Retention of students' knowledge using an active learning approach in class can increase long-term retention of students than the lecture approach (Wood and Shirazi, 2020). Learning using the ETH strategy in the experimental class manifested a better change in students compared to conventional methods (lectures) in the control class. According to Kurniawan (2014) that conventional learning which is usually teacher-centered can lead to low retention (memory) of students on the material being studied.

The implementation stages of the ETH strategy based on Q&A were as follows. The first step was orientation by showing the video and introduction. This can be the first step to train students' memory because students can use their minds to explore a phenomenon that can increase students' curiosity (Saputri et al., 2021).

Then students formed groups of 4-5 people. Group activities involved students in discussing so they can explore, explain, and refute each other's opinions and consider the most reasonable answer to solve the given problem (Wood and Shirazi, 2020). This can increase student retention because they go through the learning process by experiencing directly so that information can last longer in their minds and learning becomes meaningful (Candra and Yanto, 2020).

The second step was the teacher chose one student randomly to answer the question by selecting question cards randomly. Giving questions can stimulate students to think scientifically, understand problem-based concepts, and make them into hypotheses. Students will also plan alternative solutions based on previously understood concepts (Pedaste et al., 2015; Lotter et al., 2016). Well-trained questioning skills will develop higher-order thinking skills, curiosity, creativity, critical thinking skills, and one's character as a lifelong learner (Yang et al., 2005; Tofade et al., 2013). This means that these stages can help students to store material in long-term memory.

Discussion activities were still guided by the teacher in conducting investigations and gathering informations. The information exploration stage trained students to analyze and develop several attitudes such as being honest, conscientious, polite, communicative, and increasing good learning habits so that they got learning experience from the discussion activities that had carried out (Musfiqon & Nurdiansyah, 2015; Maybee et al., 2016). The more often students took an active role in learning, the more they will maximize their memory of the material being studied.

The third step was the questioning and answering (Q&A) session so that the selected students had to answer questions in front of the class, then the teacher invited other group members to present their arguments. Discussion and Q&A activities between groups can train students' communication skills with one to another. In addition, this stage trained students' analytical skills, those who were able to analyze well mean that they were able to process information well. According to Widayati et al., (2015) that students' memory abilities will be good if they are able to understand information well.

The final step was that students concluding the material followed by a reflection from the teacher regarding the material that had been learned. Based on Dewey's reflective thinking theory, explaining activities in front of the class can train students to conclude the results of information findings to answer questions or problems presented. Self-reflection based on Dewey's reflective thinking theory and Marzano's opinion, can train students to control themselves and is a process that aims to encourage students to know how effective the learning process for them (Saputri et al., 2019).

The syntax of the ETH strategy based on Q&A had a high impact because students were trained to use their thinking power and memory to solve problems through the questions given. According to Wahyuni et al., (2019) that someone who is able to remember well will trigger a cognitive process stimulus to develop critical thinking skills. Critical thinking skills were related to students' memory in biology learning. The ETH strategy based on Q&A attracted more students' attention

to focus while studying, triggered student stimulus to hone thinking and memory, then can increase students' courage and skills to express opinions.

4. CONCLUSIONS

Based on the description of the results of the data analysis that had been carried out, the ETH strategy based on Q&A on critical thinking skills had a Sig value. 0.00 ($p < 0.05$), meaning that it had a significant effect on students' critical thinking skills. The ETH strategy based on Q&A on student retention had a Sig. 0.00 ($p < 0.05$), meaning that it had a significant effect on student retention.

5. REFERENCES

Agnafia, D. N. 2019. Analisis kemampuan berpikir kritis siswa dalam pembelajaran biologi. *Florea*: *Jurnal Biologi dan Pembelajarannya*. 6(1): 45-53).

Arsal, Z. 2017. The impact of inquiry-based learning on the critical thinking dispositions of pre-service science teachers. *International Journal of Science Education*. 1–11.

Astuti, S., dan N. D. Muldayanti. 2018. Studi komparasi round club dan tai menggunakan media audio visual terhadap hasil belajar dan retensi pada materi kingdom animalia di kelas X SMA Negeri 1 Sungai Kakap. *Jurnal Bioeducation*. 5(2): 53-58.

Candra, O. dan D. T. P. Yanto. 2020. The active learning strategy "everyone is a teacher here" to improve student learning outcomes. *Jurnal PAJAR (Pendidikan dan Pengajaran)*. 4(3): 616-623.

Effendi, I., M. Prawitasari, dan H. Susanto. 2021. Implementasi pembelajaran pada kurikulum 2013 mata pelajaran sejarah. *Prabayaksa: Journal of History Education*. 1(1): 21-25.

Eriawan, P. E., M. Yusuf Q, dan S. Sanuddin. 2017. Pengaruh pertanian, industri, dan jasa terhadap peningkatan pertumbuhan ekonomi di Kota Palopo. *Jurnal Manajemen*. 3(2): 13-20.

Fauzan, M. F., L. A. Nadhir, S. Kustanti, Suciani, S. Kamilah. 2022. Pembelajaran diskusi kelompok kecil: seberapa efektif kah dalam meningkatkan keterampilan berfikir kritis pada siswa?. *AKSARA: Jurnal Ilmu Pendidikan Nonformal*. 8(3): 1805-1814.

Hartikainen, S., H. Rintala, L. Pylväs, dan P. Nokelainen. The concept of active learning and the measurement of learning outcomes: a review research in engineering higher education. *Journal Education Sciences*. 9(4): 1-19.

Hewi, L., dan M. Shaleh. 2020. Refleksi hasil PISA (*The Programme For International Student Assessment*): upaya perbaikan bertumpu pada Pendidikan anak usia dini. *Jurnal Golden Age*. 4(1): 30-41.

Jeffery, E., K. Nomme, T. Deane, C. Pollock, & G. Birol. 2016. Investigating the role of an inquiry-based biology lab course on student attitudes and views toward science. *CBE-Life Sciences Education*. 1–12.

Kurniahtunnisa., N. K. Dewi, dan N. R. Utami. 2016. Pengaruh model *problem based learning* (PBL) terhadap keterampilan berpikir kritis siswa. *Jurnal Pendidikan Hayati*. 5(1): 31-38.

Kurniawan, A. 2014. Penerapan model pembelajaran inkuiri terbimbing berbantuan cmaptools dalam pembelajaran fisika untuk meningkatkan kemampuan kognitif dan mempertahankan retensi siswa. *Jurnal Penelitian Pendidikan*. 14(1): 17-26.

Liasari, V., Sudjarwo, S., dan Purnomo, E. 2017. Perbandingan hasil belajar menggunakan model *everyone is a teacher here* dan *make a match*. *Jurnal Studi Sosial*. 5(2).

Lotter, C. R., S. Thompson, T. S. Dickenson, & W. F. Smiley. 2016. The impact of a practice-teaching professional development model on teachers ' inquiry instruction and inquiry efficacy beliefs. *International Journal of Science and Mathematic Education*. 1–19.

Maybee, C., C. S. Bruce, M. Lupton, & K. Rebmann. 2016. Designing rich information experiences to shape learning outcomes. *Studies in Higher Education*. 5079: 1–16.

Mcnew-birren, J., & L. A. Van Den Kieboom. 2017. Exploring the development of core teaching practices in the context of inquiry-based science instruction : an interpretive case study. *Teaching and Teacher Education*. 66: 74–87.

Menéndez, M. H., A. V. Guevara, J. C. T. Martinez, D. H. Alcántara, dan R. M. Menendez. 2019. Active learning in engineering education: a review of fundamentals, best practices and experiences. *International Journal on Interactive Design and Manufacturing* (*IJIDeM*). 13: 909-922.

Musfiqon & Nurdiansyah. 2015. *Pendekatan saintifik (Scientific Approach)*. Sidoarjo: Nizamia Learning Center.

Nugraha, A. J., H. Suyitno, dan E. Susilaningsih. 2017. Kemampuan berpikir kritis ditinjau dari keterampilan proses sains dalam motivasi belajal melalui PBL. *Journal of Primary School*. 6(1): 35-43.

Panjaitan, R. G., Titin, dan N. N. Putri. 2020. Multimedia interaktif berbasis game edukasi sebagai media pembelajaran materi sistem pernapasan di kelas XI SMA. *Jurnal Pendidikan Sains Indonesia*. 8(1): 141-151.

Pratama, R. A. dan I. M. Pratiwi. 2019. Hasil belajar sejarah Indonesia melalui pembelajaran akif tipe *everyone is a teacher here* berdasarkan kemandirian belajar. *Sosial Horizon: Jurnal Pendidikan Sosial.* 6(1): 96-107.

Pedaste, M., M. Mäeots, L. A. Siiman, T. D. Jong, Z. C. Zacharia, & E. Tsourlidak. 2015. Phases of inquiry-based learning: definitions and the inquiry cycle. *Educational Research Review*. 14: 47–61.

Putri, W. A., dan Latisma DJ. 2022. Deskripsi kemampuan berpikir kritis siswa dalam menyelesaikan soal-soal kimia pada materi laju reaksi di kelas XI IPA 1 SMAN 7 Padang. *Entalpi Pendidikan Kimia*. 3(2): 9-16.

Sadariya. 2021. Penerapan metode pembelajaran tanya jawab dengan variasi media pembelajaran untuk meningkatkan hasil belajar PPKn materi idiologi pancasila bagi siswa kelas X IPA 2 SMAN 3 Baubau tahun pelajaran 2019/2020. *Jurnal Akademik FKIP Unidayan*. 10(1): 19-29.

Saputri, A. C., Sajidan, Y. Rinanto, Afandi, dan N. M. Prasetyanti. 2019. Improving student's critical thinking skills in cell-metabolism learning using stimulating higher order thinking skills model. *International Journal of Instruction*. 12(1): 327-342.

Sari, D. I. 2014. Penerapan strategi pembelajaran *everyone is a teacher here* untuk meningkatkan kemandirian belajar ekonomi siswa kelas VIII C SMP Negeri 2 Colomadu tahun ajaran 2013/2014. Universitas Muhammadiyah Surakarta..

Senisum, M. 2021. Keterampilan proses sains siswa SMA dalam pembelajaran biologi. *JKPM: Jurnal Pendidikan dan Kebudayaan Missio*. 13(1): 76-89.

Sholekah, F. F. 2020. Pendidikan karakter dalam kurikulum 2013. *Childhood Education: Jurnal Pendidikan Anak Usia Dini*. 1(1): 1-6.

Sudirman., dan Yusnaeni. 2022. Korelasi metakognitif dengan retensi belajar siswa SMA Negeri di Kabupaten Rote Ndao Nusa Tenggara Timur. *Jurnal Riset Pendidikan Kimia*. 12(1): 1-9.

Sulfemi, W. B., dan A. Qodir. 2017. Hubungan kurikulum 2013 dengan motivasi belajar peserta didik di SMK Pelita Ciampea. *Jurnal Ilmiah Edutecno*. 17(2): 1-12.

Susilawati, E., Agustinasari, A. Samsudin, dan P. Siahaan. 2020. Analisis tingkat keterampilan berpikir kritis siswa SMA. *Jurnal Pendidikan Fisika dan Teknologi (JPFT)*. 6(1): 11-16.

Syahrir. 2018. Pengembangan pola berpikir siswa kelas XI tentang pengoprasian dasar pada matriks identitas melalui metode pembelajaran tanya jawab. *Jurnal Ilmu Sosial dan Pendidikan*. 2(1): 358-360.

Tofade, T., E. Jamie, & S. T. Haines. 2013. Best practice strategies for effective use of questions as a teaching tool. *American Journal of Pharmaceutical Education*. 77(7): 155.

Usman., E. Utari, dan N. Yulita. 2020. Hubungan berpikir kritis dengan kreativitas siswa melalui mind map pada pembelajaran biologi. *BIO-Lectura: Jurnal Pendidikan Biologi*. 7(2): 143-152.

Widayati, T. U., B. A. Prayitno, dan J. Ariyanto. 2015. Perbedaan kemampuan memecahkan masalah dan retensi menggunakan model PBL (*problem based learning*) dan ceramah bervariasi pada materi keanekaragaman hayati Indonesia siswa kelas X SMA Negeri 2 Surakarta tahun pelajaran 2014/2015. *BIO-PEDAGOGI: Jurnal Pendidikan dan Pembelajaran Biologi*. 4(1): 53-58.

Wahyuni, V. A., E. Surahman, dan R. F. Musthofa. 2019. Pengaruh pembelajaran *guided inquiry* terhadap kemampuan berpikir kritis dan retensi peserta didik pada konsep sistem indera manusia. *Bioedusiana: Jurnal Pendidikan Biologi*. 4(2): 72-79.

Wood, R., dan S. Shirazi. 2020. A systematic review of audience response systems for teaching and learning in higher education: the student experience. *Computer & Education*. 153.

Yang, Y. C., T. J. Newby, & R. L. Bill. 2005. Using socratic questioning to promote critical thinking skills through asynchronous discussion forums in distance learning environments. *American Journal of Distance Education*. 19(3): 163–181.

Yusuf, M. 2018. Peningkatan keterampilan berpikir kritis dan hasil belajar siswa SD dengan menerapkan strategi *everyone is a teacher here* pada model pembelajaran kooperatif. *Jurnal Ilmiah Sekolah Dasar*. 2(1): 18-30.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Effect of STEM (Science, Technology, Engineering, and Mathematics) based Textbooks in Biotechnology Learning Material on The Critical Thinking Skills and Learning Results of Senior High School Students in The Industrial Agriculture Area

Kamilatul Khoiroh, Bea Hana Siswati*, Kamalia Fikri
Biology Education Department, Faculty of Teacher Training and Education, Universitasity of Jember, Kalimantan Street Number 37, SUmbersari, Jember 68121, Jawa Timur, Indonesia
*Corresponding Author. E-mail address: beahana.fkip@unej.ac.id

KEYWORDS:
Biotechnology
Critical Thinking Skills
Learning Outcomes
STEM-based Textbooks

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The study entitled the effect of STEM (Science, Technology, Engineering, and Mathematics) based textbooks in biotechnology learning material on the critical thinking skills and learning results of senior high school students in the industrial agriculture area. The purpose of this study was to determine the effect of STEM-based textbooks on the subject of biotechnology on critical thinking skills and student learning outcomes in industrial agriculture areas. This type of research is quasi-experimental research (quasi experiment). The sampling technique was carried out through the normality test and ANOVA homogeneity test using the end of semester exam scores for biology subject then the determination of the sample was carried out randomly (random sampling). The research samples were class XII MIPA 2 as the experimental class and XII MIPA 4 as the control class. The place of this research is at SMAN 3 Jember. Data analysis used the covariance analysis test (Anacova) and Independent Sample T-Test for data that met the parametric test requirements, namely normal and homogeneous. The significance value obtained was <0.05 so it can be concluded that there is an influence of STEM (Science, Technology, Engineering, and Mathematics) based textbooks on the subject of biotechnology on critical thinking skills and learning outcomes.

1. INTRODUCTION

The 21st century is characterized by the implementation of learning that is balanced due to the rapid development of science and technological advances so that information can be accessed easily (Angin, 2020). The ease of accessing information needs to be balanced with critical thinking so that the information obtained can be filtered properly (Hasibuan and Prastowo, 2019). Thus, the skills to deal with learning in the 21st century era must be mastered by students, one of which is critical thinking skills (Rusyati *et al.*, 2019). Critical thinking skills according to Mustafa and Dwiyogo (2020) are important for learners to master because the ability to conclude logically requires a directed mindset so that the assessment of certain information or situations can be considered carefully and based on the assessment of evidence in the form of knowledge, thoughts, and experiences (Girsang *et al.*, 2022). Meanwhile, critical thinking skills in Indonesia as shown by data in 2015 with a score of 397 are still ranked 62nd with a total of 72 countries participating, while data in 2018 Indonesia is still ranked 71 out of 79 participating countries based on the Program for International Student Assessment (PISA). So it can be concluded that the critical thinking skills of students in Indonesia are still relatively low (Agnafia, 2019; Sa'adah *et al.*, 2020).

In addition to critical thinking, student learning outcomes are an important indicator in learning that describes students' mastery of certain knowledge or skills (Sulfemi and Mayasari, 2019). In this case, if student learning outcomes meet the minimum assessment criteria, it can be indicated

that students' critical thinking skills are also good (Dakhi, 2020). The problem found is that student learning outcomes are still classified as a low category in the results of research by Zulpadly (2016) that out of 644 students, 574 students' biology grades, especially in biotechnology material, are declared incomplete or have not met the KKM (minimum completeness criteria). Other data that support this statement are research by Inayatin (2020) that the average value of learning outcomes in biotechnology material is still not complete, with a percentage of learning completeness of 56.2% of the desired target of 85%. Factors that cause low learning outcomes are caused by external factors and internal factors. External factors, for example, school facilities such as laboratories and the availability of textbooks, while internal factors such as students' interest, motivation, and talent. External factors get a percentage of 44% followed by internal factors with a percentage of 43% with details of the factors causing the availability of textbooks of 45% which is ranked second highest after internal factors, namely talent at 50% (Nasution *et al.,* 2022; Rahmadani *et al.,* 2017).

External factors, namely textbooks, play an important role because textbooks contain all teaching materials that must be mastered by students during the learning process (Kosasih, 2020). According to Yuanita and Kurnia (2019) the use of textbooks during learning can support students to learn independently and with this opportunity students will be free to explore the knowledge being studied. In addition, the use of textbooks in the classroom can concretize something abstract so that it can facilitate students' difficulties in understanding the material. One of the abstract biology materials is biotechnology material. This material is actually an interesting topic because the application of this material is very related to everyday life, it should be easier to convey to students. But in fact, this material is difficult to convey because the explanation of molecular biotechnology and textbooks supporting this material in Indonesian are still limited (Purwaningsih, 2019). Biotechnology includes material that explains how to apply living organisms to services and manage the environment, which is closely related to activities in industrial agricultural areas. Learning about this material in industrial agricultural areas should be packaged and delivered to be more meaningful (Anantyarta and Sholihah, 2020). One of the industrial agricultural areas is Jember Regency (Reykasari *et al.,* 2021). Industrial agricultural areas are characterized by an abundance of natural resources with good soil fertility, making them suitable for the agricultural or agro-industrial sector because they have the potential to produce various products and can support a variety of consumption needs in the form of food or as raw materials for other industries (Husniah *et al.,* 2019). Thus, these environmental conditions have the potential to be associated with learning activities for surrounding schools so that the learning carried out in the classroom is in line with the conditions around industrial agricultural areas. This is different from the current situation where many schools have not yet associated and accommodated learning that features activities or problems in industrial agricultural areas (Pasuari, 2022). Based on this, an alternative that can be applied is to use STEM-based textbooks, especially on the subject of biotechnology in the learning process in industrial agricultural areas. The STEM-based textbook is a book that is integrated with four aspects of scientific disciplines (science, technology, engineering, and mathematics) so that students can gain an understanding that the knowledge gained is very useful and can explain phenomena that occur in the real world (Izzah *et al.,* 2021).

2. MATERIALS AND METHODS

The type of research included quasi-experiment research at SMAN 3 Jember in the even semester of the 2022/2023 school year through random sampling techniques through the equality test. The research samples selected were XII MIPA 4 class as the control class and XII MIPA 2 as the experimental class with the number of students in each class as many as 31. The research design used was Pre Test Post Test Control Group Design which is as follows.

Table 1. Research Design

Class	*Pre Test*	Learning	*Post Test*

E	O1	X1	O2
K	O3	X2	O4

(Source: Rahma, 2021)
Information:
E : Experimental class
K : Control class
O1 : Pre test results of the experimental class
O2 : Post test results of the experimental class
O3 : Pre test results of the control class
O4 : Post test results of control class
X1 : Learning using STEM-based textbooks
X2 : Learning using ordinary textbooks

Data collection techniques in this study include interviews, observation, tests, and documentation. Interviews were conducted to obtain initial data regarding conditions, models, and textbooks used during learning. Observations are used to retrieve data on affective and psychomotor learning outcomes. The indicators of affective learning outcomes that are measured include focus on learning, active participation, respect, and responsibility. Indicators of psychomotor learning outcomes that are measured include preparing practicum tools and materials, carrying out practicum according to procedures, criticizing the results of the observation data obtained, and concluding the observations. The instrument used to measure cognitive learning outcomes or the domain of students' cognitive knowledge and critical thinking skills uses tests, namely through pre-test and post-test. The critical thinking indicators that are measured include focusing questions, analyzing arguments, identifying assumptions, understanding situations, explaining the meaning of key terms, and determine the results of the conclusion. Other supporting data is in the form of photo documentation during learning activities during this research.

The analysis technique used in this study for cognitive learning was analyzed using a parametric test, namely the *Anacova Test* after the prerequisite test was carried out, namely the data must be normal and homogeneous. The *Anacova Test* used to analyze critical thinking skills data and cognitive learning outcomes while affective and psychomotor learning outcomes data used the *Independent Sample T-Test* analysis.

3. RESULTS AND DISCUSSION

3.1. Data Results of Critical Thinking Skills

Data on students' critical thinking skills obtained are shown in **Table 2.** The summary of the data is as follows.

Table 2. Summary of Critical Thinking Data

Component	Class			
	Experiment		Control	
	Pre Test	Post Test	Pre Test	Post Test
The Highest Score	66,6	100	62,5	100
The Lowest Score	37,5	79	33,3	79

Based on **Table 2.** it is obtained that the average value of critical thinking in the experimental class is greater than that of the control class, but further data analysis is needed to determine the difference in significance between the two classes using Anakova.

Based on the results of the *Anacova Test*, critical thinking data obtained Sig. (2-tailed) namely 0.000 <0.05, so that it can be interpreted that H_0 is rejected and H_1 is accepted, namely there is a significant difference in the use of STEM-based textbooks on students' critical thinking skills between the experimental class and the control class. Can be seen in **Table 3.** below:

Table 3. *Anacova* Hypothesis Test for Critical Thinking Skills

Class	N	Average				F	Sig.
		Pre Test	Std. Deviation	Post Test	Std. Deviation		
Experiment Class	31	51,02	8,11	91,50	5,75	16,9	0,00
Control Class	31	47,40	7,25	87,45	6,20		

Then, to find out the difference in the value of critical thinking on each indicator for the experimental class and the control class is shown in **Table 4.** below:

Table 4. Frequency Distribution of Critical Thinking Skills

Num.	Critical Thinking Indicator	Experiment Class			Control Class		
		Average *PreTest*	Average *PostTest*	Average Difference	Average *PreTest*	Average *PostTest*	Average Difference
1	Focusing questions	2,74	4,00	1,26	2,77	4,00	1,23
2	Analyze arguments	1,68	3,00	1,32	1,29	2,61	1,32
3	Identify assumptions	1,61	3,35	1,74	1,39	3,10	1,71
4	Understanding the situation in thinking	1,77	3,61	1,84	1,52	3,32	1,80
5	Explain the meaning of key terms	2,13	4,00	1,87	2,13	4,00	1,87
6	Determine the results of the conclusion	2,32	4,00	1,68	2,32	4,00	1,68
	Total			9,71			9,61

Based on **Table 4.** It is well known that each critical thought indicator is increasing in both experimental and control classes. As for the same indicators that increase in experiment and control classes, that are indicators that analyze arguments, explain the meaning of key terms and determine the outcome of conclusions. While the indicator of improvement is higher in experimental classes than the control class is on indicators of focusing questions, identifying assumptions, and understanding the situation in thinking.

3.1.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Critical Thinking Skills

This study aims to find out how the influence of the use of STEM-based textbooks, especially on Biotechnology material, is compared to the use of textbooks commonly used by teachers at SMAN 3 Jember on students' critical thinking skills. Critical thinking is self-regulation in making a decision that involves an intellectual process through interpretation, analysis, evaluation, and considering the presentation of information using evidence as a basis for making decisions (Syafitri *et al.*, 2021). According to Herunata *et al.* (2020) critical thinking skills can be trained and developed through various fields of study such as Biotechnology. Students' critical thinking flow can also be trained by solving test questions or contextual problems related to everyday life. The 6 indicators of critical thinking put forward by Ennis are focusing questions, analyzing arguments, identifying assumptions, understanding situations in thinking, explaining the meaning of key terms, determining the results of conclusions, which are relevant to the material and subject matter contained in STEM-based textbooks .

In this study, it was found that STEM-based textbooks had a significant effect on students' critical thinking skills (**Table** 4.2). This is in accordance with the results of research by Nugraha

and Syafi'ah (2020) which state that STEM-based textbooks can improve students' critical thinking skills because students' interest in learning science is much higher than using ordinary textbooks. Aspects which include *Science, Technology, Engineering and Mathematics* contained in textbooks have an impact on increasing students' skills in critical thinking. In addition, textbooks that contain contextual problems become reinforcement for students to understand the material being studied with problems that exist in everyday life (Oktaviani *et al.*, 2022).

Besides that, according to Setyowibowo and Prasetyo (2017) Jember Regency, which is an industrial agricultural area, has a community that develops one of the biotechnology products, namely tofu and tempeh as an alternative food in the village so that real phenomena in life are discussed directly in class. This also helps students to understand the difference between knowledge and its direct application in their environment so that students gain good mastery of concepts and improve their critical thinking skills (Puspitasari *et al.,* 2021). Other research that explains the superior product of the Jember industrial agricultural area, namely edamame, is currently still being developed through improvements starting from planting, using pesticides and fertilizers to maintain its quality (Munir and Masyhuri, 2021). With the existence of a phenomenon that is closely related to biotechnology material, it is then discussed together and students can explain the material and give examples of certain events that are around them. This can motivate students further so that students are able to connect the concepts obtained with the real world. Thus, patterns of thinking and reasoning that are trained continuously during learning can trigger students' critical thinking skills (Oktaviani *et al.*, 2022).

In addition, STEM-based textbooks that are attractively packaged make students more enthusiastic and not bored while learning. also the use of language that is easily complemented by appropriate text and image captions will increase the reader's interest in acquiring new knowledge so that their critical thinking skills will also increase (Rizkika *et al.*, 2022).

Based on **Table 4.** it is found that the first indicator of critical thinking is focusing on the question of the difference in the average experimental class being higher than that of the control class. This indicator requires students to identify the problems and elements contained in the problem so students can understand and reformulate the problem to be simpler (Apiati and Hermanto, 2020). Students' ability to focus on questions can increase because STEM-based textbooks provide certain book features, in this case, "Case Studies" which increase students' understanding of basic concepts by presenting interesting and reliable data so that they can help students with difficulty in interpreting and condensing information. Zulaiha and Kusuma, 2020). This indicator according to Sa'adah *et al.* (2020) aims to train students to focus on determining the questions contained in the questions.

The second indicator is analyzing the argument that the difference in the average values obtained by the experimental class is the same as the difference in the average values obtained by the control class. However, the average post-test score for the experimental class was higher than that for the control class. This is because in STEM-based textbooks, reading is presented about contextual problems related to everyday life, both local, national and global problems. According to Santosa *et al.* (2021) material packaged in this way can lead students to understand the concept of biotechnology effectively and facilitate students during learning to practice analyzing readings and arguing. In addition, students also find it easier to generate their own arguments and present them after going through the stages of evaluating information sources and identifying appropriate reasons to support the conclusions of these arguments (Roviati and Widodo, 2019). According to Agoestanto *et al.* (2019) analyzed arguments including critical thinking skills which involve aspects of logic to think so that in this indicator students are presented with a problem and then students are asked to give opinions on this problem. Thus, students can provide arguments and defend them from the results of the interpretation of the information or evidence obtained.

The third indicator is identifying assumptions that have a higher average value in the experimental class than the control class. Identifying assumptions is defined as the student's ability to determine which opinion is correct or which opinion is wrong by considering rational reasons

and also based on understanding the correct basic concepts (Agustina, 2019). The increase in students' abilities towards this indicator is because STEM-based textbooks are equipped with the "Did You Know?" feature. so that this feature can train students' reasoning and representation abilities. This opinion is reinforced by Nurhidayat and Asikin (2021) who state that the presentation of additional features regarding the material is accompanied by interesting illustrations, examples that are closely related to everyday life, and the use of the latest technology related to the material being studied makes it easier for students to understand the concept thoroughly so that students can distinguish the appropriate assumptions.

The fourth indicator is understanding the situation, which means students' ability to understand and maintain situations in thinking to help clarify questions and know meaning as a support for decisions taken (Affandy *et al.*, 2019). The average value obtained for this indicator is higher in the experimental class compared to the control class. This is because in STEM-based textbooks it has been reconstructed in a simple way so that it can enrich students' knowledge by inserting additional information that can strengthen the concept of the material being discussed (Rusyati *et al.*, 2019). The additional information referred to is the “Info at a Glance” feature in STEM-based textbooks that can provide students with learning opportunities to explore Biotechnology material in more detail so that the learning experience obtained is more meaningful (Davidi *et al.*, 2021). To measure students' ability on this indicator, students are given questions that are faced with a situation regarding one of the manufacture of biotechnology products, then students have to answer what will happen to the product if it is in conditions like the problem.

The fifth indicator, namely explaining the meaning of key terms, has the same average value between the experimental class and the control class, meaning that in this indicator students do not experience any difficulties. Explaining the meaning of key terms, which means students are asked to identify and understand the relationship between the statement and the concept of the problem given so that they are able to describe the description correctly (Hidayati *et al.*, 2021). The similarity in the average scores obtained is because students are used to understanding the key issues that cause a certain situation and then providing an explanation of the meaning of the terms used after re-examining in making decisions (Harianada *et al.*, 2022). In line with the opinion of Maziyah and Hidayati (2022) who stated that STEM-based textbooks are suitable for use during learning because they can stimulate students' critical thinking skills so that students are able to analyze and carry out investigations when asked to interpret certain terms into a statement.

The sixth indicator determines the results of conclusions, namely the ability of students to determine results based on a background of facts and consider them into rational final conclusions (Rohmah *et al.*, 2021). Based on the results obtained, the total average difference of the six indicators of critical thinking in the experimental class is higher than that of the control class. This shows that the use of STEM-based textbooks has an effect on students' critical thinking skills because STEM-based textbooks provide learning material facilities for students with STEM aspects that occur in real life so that they can develop students' reasoning and analytical abilities (Andini *et al.*, 2022) . Part of the STEM-based textbook that trains students is the presentation of information about the material compiled in relation to new knowledge so as to increase students' understanding of concepts as a whole. Agnesi *et al.* (2019) also strengthens this opinion based on the results of his research which states that STEM-based textbooks can support students' critical thinking skills.

3.2. Data Results of Cognitive Learning Outcomes

Learning outcomes are competencies or abilities that can be achieved by someone after following a certain learning process which includes cognitive, affective, and psychomotor abilities (Nurrita, 2018). In this study, the learning outcomes measured were cognitive, affective, and psychomotor learning outcomes.

Data on cognitive learning outcomes were obtained from the assessment of the pre-test and post-test question sheets. The following is a summary of cognitive learning outcomes data presented in **Table** 5.

Table 5. Summary of Cognitive Learning Outcomes Data

Component	Class			
	Experiment		Control	
	Pre test	***Post test***	***Pre test***	***Pots test***
The Highest Score	69	100	61	100
The Lowest Score	37	81	25	71
Average	52	92,7	45,8	84,6

Based on **Table 5.** it is obtained that the average value of learning outcomes in the cognitive domain in the experimental class is greater than the control class, but further data analysis is needed to determine the difference in significance between the two classes using anacoa analysis. The results of the ANAKOVA hypothesis test are shown in **Table** 6 below.

Table 6. Ancova Hypothesis Test on Cognitive Learning Outcomes

Class	N	Average				F	Sig.
		Pre Test	**Std. Deviation**	***Post Test***	**Std. Deviation**		
Experiment Class	31	52,03	8,84	92,70	4,99	20,64	0,00
Control Class	31	45,83	8,80	84,58	6,42		

Based on the **Table 6.** above, the value of Sig. namely 0.00 <0.05, so that it can be interpreted that H_0 is rejected and H_1 is accepted, namely there is a significant difference in the use of STEM-based textbooks on cognitive learning outcomes between the experimental class and the control class.

3.2.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Cognitive Learning Outcomes

Based on **Table 6.** the results of the analysis are 0.00 <0.05 proving that STEM-based textbooks have a significant effect on students' cognitive learning outcomes and the experimental class obtains better learning outcomes compared to the control class. The difference in student learning outcomes in the two classes was due to the fact that in the experimental class students learned to use STEM-based textbooks while the control class used biology textbooks as usual. This statement is in line with the results of Pangesti *et al.* (2017) which states that STEM-based textbooks provide opportunities for students to understand the concept of material better because they have been integrated with the four STEM elements namely Science, Technology, Engineering and Mathematics during learning activities that take place through discussion and practicum activities so that it has implications for improving learning outcomes. student cognitive. According to Fitria and Asrizal (2021) that STEM-based textbooks are effective for improving learning outcomes in cognitive, affective and also psychomotor aspects because students can study with various scientific disciplines directly and systematically.

Increased cognitive learning outcomes are also due to the fact that the textbooks used during learning accommodate up-to-date material according to the student's study area, namely the industrial agricultural area, namely Jember Regency (Hariyadi, 2023). It is also due to the fact that biotechnology material which focuses on technology, engineering, and support for biological agents uses knowledge in the scientific field, then this concept can develop well if it is brought up in learning in harmony with industrial agricultural areas (Siswati, 2020).

Then, the four aspects of STEM namely Science, Technology, Engineering, Mathematics which are contained in textbooks have different functions. Science in a book that contains contextual biotechnology material so that it can lead to building curiosity and openness to new ideas. Technology, contains knowledge about the use of technology in daily activities as an aspect of solving problems in the environment as well as the development of certain new products. Engineering in the form of experiments and knowledge of science in product manufacturing so that students can build on their own experiences and develop more meaningful knowledge skills about the biotechnology material being studied. Meanwhile, Mathematics is shown to evaluate or solve certain problems using calculations of formulas and numbers (Yuanita and Kurnia, 2019). The application of these STEM elements contained in textbooks can make students learn more relevant so as to stimulate the emergence of broader learning experiences and support students to develop their thinking skills and can improve their cognitive learning outcomes (Andaresta, 2021).

3.3. Data Results of Affective Learning Outcomes

Affective learning outcome data were obtained from the assessment of student activity observation sheets during learning. The following is a summary of affective learning outcomes data presented in **Table** 7.

Table 7. Summary of Affective Learning Outcomes Data

Component	Class	
	Experiment	**Control**
The Highest Score	84,375	84,375
The Lowest Score	68,75	65,625
Average	77,9	73,7

Affective learning outcome data have fulfilled the prerequisite test for further analysis using the parametric test using the *Independent Sample T-Test* based on the normal and homogeneous prerequisite test results. Following are the results of the *Independent Sample T-Test* hypothesis test analysis presented in the form of **Table** 8. below:

Table 8. *Independent Sample T-Test* Hypothesis Test on Affective Learning Outcomes

Class	N	Average	Std. Deviation	F	Sig.
Experiment Class	31	77,92	5,07	12,907	0,001
Control Class	31	73,68	5,01		

Based on the **Table** above, the value of Sig. namely 0.001 <0.05, so that it can be interpreted that H_0 is rejected and H_1 is accepted, namely there is a significant difference in affective learning outcomes between the experimental class and the control class.

3.3.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Affective Learning Outcomes

Affective learning outcomes or attitudes are obtained from observation sheets of student activity during learning. Based on the analysis of the data, it was found that there were differences in the average learning outcomes of the attitudes of the students in the experimental class and the control class, namely the experimental class obtained a score of 77.9 and the control class of 73.7. Then studied the differences in learning outcomes in the domain of attitudes in the two classes using the *Independent Sample T-Test* to obtain a significance value (2-tailed) of 0.001 <0.05. These results state that the learning outcomes in the attitude domain of the experimental class are better than the

control class. This proves that the use of STEM-based textbooks has a significant effect on learning outcomes in the attitude domain.

The affective learning outcomes measured in this study included a focus on learning, active participation, respect and responsibility. The STEM-based textbooks used during the learning process encourage students to actively participate and focus on paying attention so that there are differences in student learning outcomes with classes that do not use STEM-based textbooks. This statement is in line with the opinion of Zulfa *et al.* (2022) which states that learning using STEM-based textbooks can create fun learning between teachers and students.

The next aspect regarding respect for the elements of Science, Technology, Engineering and Mathematics in student textbooks that have been combined can then help students to teach care for the environment, foster students' creative and innovative souls so as to improve affective learning outcomes or attitudes from students. The reading context that has been understood makes students more sensitive to the conditions around them and respects when there are differences of opinion (Zulfa *et al.* 2022). In line with the opinion expressed by Yulanda and Rahmi, (2022) that the material contained in STEM-based textbooks contains trigger material that can train students to practice problem-solving skills, critical thinking skills, and good communication so that students have high enthusiasm. during the learning process. Thus, the attitude of students in respecting the opinions of other students during discussion activities.

As for the aspect of responsibility according to Muliawan *et al.* (2022) STEM-based textbooks are considered suitable for use in learning because they provide opportunities for students to analyze material themselves in depth on the guidance contained in textbooks so that learning activities run smoothly due to active involvement of students in class. Thus, each student feels they have a responsibility with the same role contribution in solving the problems given tends to increase. Another opinion was conveyed by Fitria *et al.* (2022) in his journal said that the STEM components contained in textbooks that make it easier for students to learn to use the book, and the presentation of teaching materials with good quality in terms of format clarity and equipped with pictures, videos, and other supporting features can improve students' interest in studying the material in the classroom which also has implications for increasing student learning outcomes both in terms of knowledge, attitudes and skills.

3.4. Data Results of Psychomotor Learning Outcomes

Psychomotor learning outcomes data were obtained from the assessment of student activity observation sheets during practicum activities. The following is a summary of psychomotor learning outcomes data presented in **Table 9.**

Table 9. Summary of Psychomotor Learning Outcomes Data

Component	Class	
	Experiment	Control
The Highest Score	96,875	90,625
The Lowest Score	81,25	78,125
Average	89,1	85,7

To analyze data using a parametric test, the data must meet the requirements that it must be normally distributed and homogeneous. After the test was carried out, the result was that the psychomotor learning outcomes data fulfilled the prerequisite test for further analysis using the parametric test using the Independent Sample T-Test. Following are the results of the *Independent Sample T-Test* hypothesis test analysis presented in the form of **Table 10.** below:

Table 10. *Independent Sample T-Test* Hypothesis Test on Psychomotor Learning Outcomes

Class	N	Average	Std. Deviation	F	Sig.

Experiment Class	31	89,11	6,02	20,110	0,00
Control Class	31	85,68	5,19		

Berdasarkan tabel di atas diperoleh nilai Sig. yaitu 0,000<0,05, sehingga dapat diartikan bahwa H_0 ditolak dan H_1 diterima yaitu ada perbedaan yang signifikan hasil belajar psikomotor antara kelas eksperimen dan kelas kontrol.

3.4.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Psychomotor Learning Outcomes

Based on the analysis of the data, it was found that there were differences in the average psychomotor learning outcomes of students in the experimental class and the control class, namely the experimental class obtained a score of 89.1 and the control class of 85.7. Then studied the differences in learning outcomes in the skills domain in the two classes using the Independent Sample T-Test so that a significance value (2-tailed) was obtained of 0.00 <0.05. These results state that the learning outcomes of the experimental class are better than the control class. This proves that the use of STEM-based textbooks has a significant effect on learning outcomes in the skills domain.

According to Widodo *et al.* (2021) the difference in skills learning outcomes between the 2 classes is due to the STEM-based textbooks used in the experimental class helping to provide effectiveness to improve skills learning outcomes because the book is equipped with STEM aspects, especially in this case Technology and Engineering. Technology is reflected in the feature of scanning barcodes and inserting videos in books, facilitating students to access supporting materials and visualization videos so that students can fully understand the concept of the material. The Engineering aspect in the book displays a simple experimental design to find a solution which is then conveyed through the provision of practicum activities to train students' skills (Pratiwi and Rachmadiarti, 2022).

STEM-based textbooks can involve students in real contexts so that they are able to support skills learning outcomes through fun, simple variations of experiments that allow students to improve psychomotor learning outcomes (Lukitasari *et al.*, 2022). According to Syafei *et al.* (2019) practicum activities carried out in class can encourage students to improve their skills in discussing, conveying ideas in groups so that learning takes place collaboratively. Students' psychomotor learning outcomes have also increased based on the development of mental processes through aspects of moving muscles so as to shape student skills (Samsuar *et al.*, 2023).

The use of STEM-based textbooks in which experimental designs are contained and then practiced can meet students' needs to learn abstract material concepts to become more concrete (Ate *et al.*, 2022). Thus, it can improve students' psychomotor learning outcomes. This statement was later reinforced by Mawaddah *et al.* (2022) which states that students' skills learning outcomes have increased through the use of STEM-based learning resources so that students feel interested and can be actively involved when learning activities are carried out.

Furthermore, with regard to the integration of scientific disciplines in STEM, it can foster a more meaningful understanding between the principles and concepts of biotechnology material. Students are also trained to collaborate in scientific investigations and problem solving through thinking, learning, and doing directly (Suroto, 2021). Therefore, increasing students' active participation in learning is in line with increasing student skills learning outcomes (Alaini *et al.*, 2022). The problems that are reviewed and used as learning topics are taken from problems that exist in the student's industrial agricultural area itself, so that learning becomes more applicable because the surrounding area is indirectly used as a means of supporting student learning in the classroom. this makes it easier for students to understand the learning that takes place (Damayanti *et al.*, 2021).

4. CONCLUSIONS

Based on the results of the research that has been described, the following conclusions can be obtained: a). There is an influence of STEM-based textbooks on the critical thinking skills of class XII students of SMAN 3 Jember with a Sig (2-tailed) value of 0.00 <0.05 which obtained the highest score of 91.50 in the experimental class with the very high category. b). There is an influence of STEM-based textbooks on the cognitive, affective, and psychomotor learning outcomes of class XII students of SMAN 3 Jember with a Sig (2-tailed) score of 0.00 <0.05 for cognitive learning outcomes that get a score of 100 in the very high category, next namely the value of Sig. 0.001 <0.05 for affective learning outcomes which scored 84.375 in the high category, and 0.00 <0.05 for psychomotor learning outcomes which scored 96.875 in the very high category.

5. REFERENCES

Affandy, H., N. S. Aminah, N. S., dan S. Supriyanto. 2019. Analisis Keterampilan Berpikir Kritis Siswa pada Materi Fluida Dinamis di SMA Batik 2 Surakarta. *Jurnal Materi dan Pembelajaran Fisika*. 9(1): 25-33.

Agnezi, L. A., N. Khair, dan S. Yolanda. 2019. Analisis Sajian Buku Ajar Fisika Sma Class X Semester 1 Terkait Komponen Science, Technology, Engineering, Mathematics (STEM). *Jurnal Eksakta Pendidikan (Jep*). 3(2): 167-175.

Agustina, I. 2019. Pentingnya Berpikir Kritis dalam Pembelajaran Matematika di Era Revolusi Industri 4.0. *Jurnal Pendidikan Indonesia*. 8(1): 1-9.

Alaini, U. N., I. Wahyudi, dan A. Suyatna. 2022. Implementasi E-Modul Berbasis STEM Berbantuan LMS Untuk Meningkatkan Hasil Belajar Peserta Didik di Era Covid-19. *Jurnal Ilmu Fisika dan Pembelajarannya (JIFP)*. 6(2): 1-8.

Andaresta, N., dan F. Rachmadiarti. 2021. Pengembangan E-Book Berbasis STEM pada Materi Ekosistem untuk Melatihkan Kemampuan Literasi Sains Siswa. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*. 10(3): 635-646.

Andini, R., E. R. Winarti, dan M. Mintarsih. 2022. Kemampuan berpikir kritis matematis siswa pada model problem-based learning berbantuan bahan ajar dengan pendekatan STEM. In *PRISMA, Prosiding Seminar Nasional Matematika*. 5 (1): 467-474.

Angin, R. Z. P. 2020. Penerapan STEM pada Pembelajaran IPA Materi Bioteknologi. *Jurnal Peran Pendidikan dalam Konservasi dan Pengelolaan Lingkungan Berkelanjutan*. 5(1): 300-307.

Anantyarta, P., dan F. N Sholihah. 2020. Pengembangan Multimedia Pembelajaran pada Materi Bioteknologi menggunakan Program Autoplay. *Journal of Natural Science and Integration*. 3(1): 45-57.

Apiati, V., dan R. Hermanto, R. 2020. Kemampuan Berpikir Kritis Peserta Didik dalam Memecahkan Masalah Matematik Berdasarkan Gaya Belajar. *Mosharafa: Jurnal Pendidikan Matematika.* 9(1): 167-178.

Ate, O., C. Sundaygara, dan K. B. Pranata. 2022. Pengembangan Buku Ajar Berbasis PjBL dengan Pendekatan STEM untuk Meningkatkan Pemahaman Konsep Siswa pada Materi Fluida Statis Class XI SMA. *RAINSTEK: Jurnal Terapan Sains & Teknologi*. 4(4): 246-255.

Dakhi, A. S. (2020). Peningkatan Hasil Belajar Siswa. *Jurnal Education and development*. 8(2): 468-468.

Davidi, E. I. N., E. Sennen, dan K. Supardi. 2021. Integrasi pendekatan STEM (*Science, Technology, Enggeenering And Mathematic*) untuk Peningkatan Keterampilan Berpikir Kritis Siswa Sekolah Dasar. *Scholaria: Jurnal Pendidikan dan Kebudayaan*. 11(1): 11-22.

Fitria, Y., dan A. Asrizal. 2021. Pengembangan Bahan Ajar Elektronik Energi dan Momentum Terintegrasi STEM Untuk Meningkatkan Hasil Belajar Siswa SMA. *Jurnal Pendidikan Fisika dan Teknologi*. 7(2): 119-130.

Girsang, B., E. A. L. Sinaga, P. G. Tamba, D. I. Sihombing, dan F. B. Siahaan. 2022. Analisis Kemampuan Berpikir Kritis Siswa dengan Model *Program For International Student Assesment* (PISA) Konten Quantitiy Pada Materi Himpunan di Class VII SMP HKBP Sidorame Medan. *Sepren*: *Journal of Mathematics Education and Applied.* 1(1): 1-9.

Hasibuan, A. T., dan A. Prastowo. 2019. Konsep Pendidikan Abad 21: Kepemimpinan Dan Pengembangan Sumber Daya Manusia Sd/Mi. *MAGISTRA: Media Pengembangan Ilmu Pendidikan Dasar Dan Keislaman*. 10(1): 1-10.

Hidayati, N., F. Irmawati, dan T. A. Prayitno. 2019. Peningkatan Keterampilan Berpikir Kritis Mahasiswa Biologi Melalui Multimedia STEM Education. *JPBIO (Jurnal Pendidikan Biologi)*. 4(2): 84-92.

Husniah, F. A., T. D. Hapsari, dan T. Agustina. 2019. Analisis Nilai Tambah Agroindustri Kerupuk Tempe di Kecamatan Puger Kabupaten Jember. *Jurnal Ekonomi Pertanian Dan Agribisnis*. 3(1): 195-203.

Inayatin, A. 2020. Upaya Meningkatkan Hasil Belajar Biologi Pada Materi Bioteknologi Melalui Model Pembelajaran Project Based Learning Pada Siswa Class XII SMA Negeri 4 Pandeglang Tahun 2015. *Metakognisi*. 2(2): 58-69.

Izzah, N., Asrizal, dan F. Festiyed. 2021. Meta Analisis Effect Size Pengaruh Bahan Ajar IPA dan Fisika Berbasis STEM terhadap Hasil Belajar Siswa. *Jurnal Pendidikan Fisika*. 9(1): 114-130.

Kosasih, E. 2020. *Pengembangan Bahan Ajar.* Jakarta Timur: Bumi Aksara.

Lukitasari, M., W. Waris, C. N. Primiani, M. A. Setiawan, W. L. Yuhanna, T. A. Prayitno, N. Hidayati, Hardani, dan P. Pujiati. 2022. Book Chapter Stem Dalam Pembelajaran Biologi. Madiun: UNIPMA Press.

Mawaddah, R., R. Triwoelandari, dan F. Irfani. 2022. Kelayakan LKS Pembelajaran IPA berbasis STEM untuk Meningkatkan Keterampilan Kolaborasi Siswa SD/MI. *Jurnal Cakrawala Pendas*. 8(1): 1-14.

Maziyah, K. N., dan F. H Hidayati. 2022. Pengembangan E-Modul dengan Pendekatan STEM untuk Memfasilitasi Kemampuan Berpikir Kritis Siswa pada Materi Trignometri. *Jurnal Tadris Matematika*. 5(2): 241-256.

Muliawan, W., S. Sarwati, dan H. Andriyana. 2022. Pengembangan Perangkat Pembelajaran Biologi SMA Class X Berbasis Science, Tecnology, Engineering, Arts, And Mathematics (Steam) Terintegrasi Literasi Sains. *Jurnal Perspektif Pendidikan*. 16(2): 271-277.

Mustafa, P. S., dan W. D. Dwiyogo. 2020. Kurikulum pendidikan jasmani, olahraga, dan kesehatan di Indonesia abad 21. *Jurnal Riset Teknologi dan Inovasi Pendidikan (JARTIKA)*. 3(2): 422-438.

Nasution, M. R., M. S. Arilia, P.P. Sari, V. P. Fadhillah, M. K. Nasution, I. F. Tanjung, dan U. N. A. D. Jayanti. 2022. Analisis Faktor Kesulitan Belajar Materi Bioteknologipada Siswa SMA di Pematang Siantar. *BEST Journal (Biology Education, Sains and Technology)*, *5*(2), 229-234.

Nugraha, A. W., dan R. Syafi'ah. 2020. Pengembangan Buku Ajar Bioteknologi Berbasis Science, Technology, Engineering, Math (STEM) untuk Meningkatkan High Order Thinking Skill (HOTS) Mahasiswa. *Jurnal BIOEDUIN: Program Studi Pendidikan Biologi*. 10(2): 1-9.

Nurhidayat, M. F., dan M. Asikin, M. 2021. Bahan Ajar Berbasis STEM dalam Pembelajaran Matematika: Potensi dan Metode Pengembangan. In *PRISMA, Prosiding Seminar Nasional Matematika*. 4(1): 298-302.

Nurrita, T. 2018. Pengembangan Media Pembelajaran Untuk Meningkatkan Hasil Belajar Siswa. *Jurnal Misykat*. 3(1): 171-187.

Oktaviani, I. M., Sutarto, dan S. Hariyadi. 2022. Textbooks Based On Stem-Cp (Science, Technology, Engineering, Mathematics, And Contextual Problems) Materials On Viruses To Improve Critical Thinking Skills For High School Students. *International Journal of Advanced Research (IJAR).* 10(5): 818-825.

Pasuari. 2022. Penguatan Nilai Pertanian Industrial pada Siswa Sekolah Vokasi di Kabupaten Jember. *Jurnal Entitas Sosiologi*. 11(1): 19-41.

Pangesti, K. I., D. Yulianti, dan S. Sugianto. 2017. Bahan ajar berbasis STEM (Science, Technology, Engineering, and Mathematics) untuk meningkatkan penguasaan konsep siswa SMA. *UPEJ Unnes Physics Education Journal*. 6(3): 53-58.

Pratiwi, R. S., dan F. Rachmadiarti. 2022. Pengembangan E-Book Berbasis Science, Technology, Engineering, and Mathematics (STEM) Materi Pertumbuhan dan Perkembangan Tumbuhan untuk Melatihkan Keterampilan Literasi Sains. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*. 11(1): 165-178.

Purwaningsih, W. 2019. Identifikasi Kesulitan Pembelajaran Bioteknologi pada Guru SLTA se Jawa Barat. *Inovasi Biologi dan Pendididkan Biologi Dalam Pengembangan Sumber Daya Manusia*. 1(1): 1-14.

Puspitasari, E., D. A., Putra, dan R. D. 2021. Pengembangan Buku Ajar Fisika Berbasis Science, Technology, Engineering, and Mathematics (STEM) pada Pokok Bahasan Suhu dan Kalor di SMA. Jurnal Literasi Pendidikan Fisika. 2(1): 44–52.

Rahma, A. A. 2021. Efektivitas Penggunaan Virtual Lab Phet Sebagai Media Pembelajaran Fisika Terhadap Hasil Belajar Siswa. *Pedagogy: Jurnal Ilmiah Ilmu Pendidikan*, 8(2): 47-51.

Rahmadani, W., F. Harahap. dan T. Gultom. 2017. Analisis faktor kesulitan belajar biologi siswa materi bioteknologi di SMA negeri se-kota Medan. *Jurnal Pendidikan Biologi*. 6(2): 279-285.

Reykasari, Y., L. Ubaidillah, N. Maulidya, dan M. Huda. 2021. Alih Fungsi Lahan Pertanian Menjadi Lahan Perumahan di Kabupaten Jember. *Fairness and Justice: Jurnal Ilmiah Ilmu Hukum*. 19(1): 48-58.

Rizkika, M., Putra, P. D. A., dan Ahmad, N. 2022. Pengembangan E-LKPD Berbasis STEM pada Materi Tekanan Zat untuk Meningkatkan Kemampuan Berpikir Kritis Siswa SMP. *PSEJ (Pancasakti Science Education Journal)*. 7(1): 41-48.

Rohmah, H. N., A. Suherman, A., dan I. S. Utami. 2021. Penerapan Problem Based Learning Berbasis Stem pada Materi Alat Optik untuk Meningkatkan Kemampuan Berpikir Kritis Peserta Didik. *Jurnal Penelitian Pembelajaran Fisika*. 12(2): 117-123.

Rusyati, R., A. Permanasari, dan D. Ardianto. 2019. Rekonstruksi Bahan Ajar Berbasis Stem untuk Meningkatkan Literasi Sains dan Tekonologi Siswa pada Konsep Kemagnetan. *Journal of Science Education And Practice*. 2(2): 10-22.

Sa'adah, M., S. Suryaningsih, dan B. Muslim. 2020. Pemanfaatan Multimedia Interaktif pada Materi Hidrokarbon untuk Menumbuhkan Keterampilan Berpikir Kritis Siswa. *Jurnal Inovasi Pendidikan IPA*. 6(2): 184-194.

Santosa, T. A., A. Razak, L. Lufri, Z. Zulyusri, E. Fradila, dan F. Arsih. 2021. Meta-Analisis: Pengaruh Bahan Ajar Berbasis Pendekatan STEM Pada Pembelajaran Ekologi. *Journal of Digital Learning and Education*. 1(1): 1-9.

Sulfemi, W. B., dan N. Mayasari, N. 2019. Peranan Model Pembelajaran Value Clarification Technique Berbantuan Media Audio Visual untuk Meningkatkan Hasil Belajar IPS. *Jurnal Pendidikan*. 20(1): 53-68.

Syafei, I., A. Saregar, Hairul, A. Thahir, P. M. Sari, dan A. Anugrah. 2019. E-learning with STEM-Based Schoology on Static Fluid Material. *Journal of Physics.* 1(1): 1-10.

Widodo, C. A., I. K. Sukendra, dan I. W. Sumandya. 2021. Pengembangan Bahan Ajar Digital Matematika SMA Class X Berbasis STEM. *Widyadari*. 22(2): 478-486.

Yuanita, Y., dan F. Kurnia. 2019. Pengembangan Bahan Ajar Berbasis STEM (Science, Technology, Engineering, and Mathematics) Materi Kelistrikan Untuk Sekolah Dasar. *Profesi Pendidikan Dasar*. 6(2): 199-210.

Yulanda, G., dan Y. L Rahmi. 2022. Analisis Kebutuhan Lembar Kerja Peserta Didik Terintegrasi Stem Pada Materi Keanekaragaman Hayati Untuk Class X SMA/MA. *Bioilmi: Jurnal Pendidikan*. 8(2): 128-136.

Zulaiha, F., dan D. Kusuma. 2020. Pengembangan Modul Berbasis Stem untuk Siswa SMP. *Jurnal Pendidikan Fisika Dan Teknologi*. 6(2): 246-255.

Zulfa, R. N., M. Masykuri dan M. Maridi. 2022. Efektivitas Perangkat Pembelajaran Terintegrasi STEM terhadap Kemampuan Berpikir Kritis Siswa. *SAP (Susunan Artikel Pendidikan)*. 7(1): 43-49.

Zulpadly, Z., F. Harahap, dan S. Edi. 2016. Analisis Kesulitan Belajar Siswa Materi Bioteknologi SMA Negeri Se-Kabupaten Rokan Hilir. *Jurnal Pendidikan Biologi*. 6(1): 242-248.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of *Moringa oleifera* Leaf and Kiambang (*Salvinia molesta*) Solid Organic Fertilizer with Banana Peel Bioactivator

Desvia Puput Apriani, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Banana peel waste
Moringa leaves
Nutrient content tests
Salvinia molesta
Sensory tests
Solid organic fertilizers

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Moringa oleifera leaves and kiambang (*Salvinia molesta*) can fulfill plants' N, P, and K elements to become solid organic fertilizers with banana peel waste as a bioactivation. This study aimed to determine the quality of solid organic fertilizers for *Moringa oleifera* leaves and Kiambang with banana peels as a bioactivator based on sensory tests and nutrient content. This study used an experimental method with a factorial pattern. As for factor 1, namely the comparison of ingredients, K1 = 300 g: 200 g and K2 = 200 g: 300 g. Factor 2 is the concentration of bioactivator, M1 = 25 mL and M2 = 30 mL. The results showed that the best quality of Fertilizer from sensory characteristics was demonstrated by the K2M2 treatment in black color, less pungent scent, crumb texture, and a pH of 7. In contrast, the N, P, and K content test was shown by the K1M1 treatment with N content (3.29%), P (0 .10%), and K (0.24%). So that, it can be concluded fertilizers for *Moringa oleifera* leaves and Kiambang (*Salvinia molesta*) with banana peel waste as bioactivator have good quality according to SNI 19-7030-2004.

1. INTRODUCTION

Waste is leftover material from human or community activities that, if appropriately managed, will positively impact the environment. The waste generated by the community is in the form of solid, liquid, and gas waste. Therefore, waste management in society could be more optimal. One of the solid wastes is household waste, both vegetable and fruit waste. An alternative to treating solid waste is to use it as organic Fertilizer. Fertilizer is an additional material given to agricultural land that can support plant growth and development. Fertilizers can be divided into two, namely organic fertilizers and inorganic fertilizers. Excessive use of inorganic fertilizers will cause a decrease in soil fertility. The use of organic fertilizers is more environmentally friendly than inorganic fertilizers. Solid organic fertilizers can improve soil structure and increase the soil's ability to retain water content (Anggraeni et al., 2019). One of the organic materials from a combination of moringa leaves and kiambang plants, with the addition of fruit peel waste as a bioactivator, can be used to make solid organic Fertilizers.

Moringa leaves are one part of the plant that contains many benefits. Moringa leaves have benefited from nutritional value, agriculture, therapy, industry, and health. Moringa leaf extract contains flavonoids, alkaloids, terpenoids, saponins, and tannins (Tenri & Rivai, 2020). Based on research that has been done (Wahyudi & Agustina, 2018) that Moringa leaf extract has a burn healing effect of up to 10 %. Moringa leaves can be used optimally in agriculture because contain many nutrients. Moringa leaves contain nutrients N (4.02%), P (1.17%), K (1.80%), Ca (12.3%), Mg (0.10%), and Na (1.16%) (Adiaha, 2017). The nutrient content in Moringa leaves is beneficial for plant growth, so it can be used as material for making organic Fertilizers.

Kiambang plant or apu wood (*Salvinia molesta*) is a plant that is often considered a pest in rice fields. Kiambang is abundant in nature; it is easy to find floating in pond waters and weed plants

in rice fields (Ashari, 2021). Kiambang has yet to be used optimally by the community. Kiambang (*Salvinia molesta*) has a reasonably high nutrient content and can be used for plant growth. Based on research (Sismiyanti et al., 2018), kiambang plants contain nutrients that have not been composted, namely C (39.90%), (N 4.50%), P (0.50%), K (2.90%), S (0.62%), lignin (17.00%), C/N 8.87, C/P 64.35, C/S 64.35. The high content of nutrients in the kiambang plant can be used to make solid organic Fertilizers to benefit plant growth.

The manufacture of solid organic Fertilizers is produced through a fermentation process for 30 days. The duration of fermentation will affect the physical and chemical characteristics of the fertilizer. Based on research (Tallo & Sio, 2019), the best fermentation time is 35 days. Microorganisms are needed to help speed up fermentation in fermenting solid organic fertilizers. Biological decomposition during fermentation can be assisted by bacteria, actinomycetes, fungi, protozoa, worms, and several types of larvae (Widyastuti et al., 2021). Materials that are commonly added to speed up the decomposition process are bio activators (Andriany, 2018). The bioactivator used can be derived from natural ingredients. Bioactivator materials that can be used are fruit waste, including bananas, mangoes, papayas, and apples, which are called local microorganisms (MOL) (Ali, 2016). The material for making bioactivator can use banana peels. Banana peel contains *Pseudomonas* sp. and *Bacillus* sp., which can accelerate the fermentation process to manufacture solid organic Fertilizers (Moiedi, 2013). Based on research (Fauzi, 2021), adding 30 mL MOL with a composting time of 23 days is the best treatment for making fertilizers. Based on research (Almastin, 2022), the combination of Moringa leaves and 300 grams of Kiambang leaves has the highest nitrogen content. Solid organic fertilizers can be tested by sensory tests, including smell, color, and texture, and can be tested for N, P, and K content. Based on research (by Asngad et al., 2019) states that the total N-value of solid organic fertilizers meets the requirements, namely >0.40%.

Based on the above background, the problem in this research is: What is the quality (N, P, and K content) of the solid organic fertilizer combination of Moringa leaves and Kiambang plant (*Salvinia molesta*) with the addition of fruit peel as a bioactivator based on SNI 19-7030-2004. Therefore, the objectives to be achieved in this study were: to determine the quality (N, P, and K content) of a solid combination organic fertilizer for Moringa leaves and kiambang (Salvinia molesta) with the addition of fruit peel as a bioactivator based on SNI 19-7030-2004.

While the benefits the results of this study are expected to provide information to 1). Provide information to researchers about the benefits of combining moringa leaves and kiambang (*Salvinia molesta*) with adding fruit peels as a bioactivator as solid organic Fertilizer. 2). Providing information to the public that combining moringa leaves and kiambang plants with fruit peels as a bioactivator can be used as solid organic Fertilizers. 3). Providing ideas in the field of biology, especially the use of a combination of moringa leaves and kiambang plants with the addition of fruit peels as a bioactivator that can be used as solid organic Fertilizers.

2. MATERIALS AND METHODS

This research was conducted at Tlangu RT 03 RW 01, Bulan, Wonosari, Klaten. This study used tools including basin, plastic, analog scales, knives, blenders, hoses, stirring rods, filters, containers, bottles and 1000 ml beaker glass, pH indicators, stationery, and documentation tools. In comparison, the materials used in this study were moringa leaves, kiambang plants, brown sugar, leri water, and water.

The research procedures include making banana peel waste bioactivator is mixing leri water and brown sugar water in a ratio of 1:1 as a food source for microorganisms, stirring and mixing with mashed banana peels, stirring and covering the container with a plastic bottle with holes perforated which is plugged with a hose (air can enter but flies cannot enter), ferment 5-7 days. Making solid organic fertilizer is prepare the activator solution that has been made, weigh the solid organic Fertilizer and activator solution according to the formulation, mix the dough until it is clenched by hand, then no water will come out of the dough, and if the fist is released the dough

expands again, the dough is closed using a lid for 4-5 weeks during the fermentation or incubation process.

The method used is the experimental method and completely randomized design (CRD) with two factors: a combination of moringa leaves and kiambang (*Salvinia molesta)* with adding a banana peel waste bioactivator. As for factor 1, namely the comparison of ingredients, K1 = 300 g: 200 g and K2 = 200 g: 300 g. Factor 2 is the concentration of bioactivator, M1 = 25 mL and M2 = 30 mL. This study used four treatments with three repetitions, and the technique used to analyze the data was descriptive qualitative analysis.

3. RESULTS AND DISCUSSION

3.1 N, P and K Content

Based on the results of laboratory tests for the macronutrient content, including nitrogen (N), phosphorus (P), and potassium (K) in the solid organic fertilizer combination of *Moringa oleifera* leaves and Kiambang plants (*Salvinia molesta*) with the addition of banana peel waste as a bio activator, it can be seen content test results in the following table 1.

Table 1. N, P, and K content in solid organic fertilizer combination of moringa leaves and kiambang plants (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator

Combination	Average Analysis Results		
	N (%)	P (%)	K (%)
K_1M_1	3,29	0,10**	0,24**
K_1M_2	2,22*	0,08	0,22
K_2M_1	2,45	0,08	0,20
K_2M_2	3,38**	0,07*	0,19*

Information : (*) highest result
(**) lowest result

The results of the analysis of the average content of N, P, and K in Table 2 show that the highest percentage of nitrogen (N) is owned by the K2M2 treatment combined with a test result of 3.38%, and the lowest percentage is owned by the K1M2 treatment combined with a test result of 2.22 %. In the test for the content of phosphorus (P) and potassium (K), the highest percentage was owned by the K1M1 combination with test results of 0.10% and 0.24%, and the lowest percentage content was in the K2M2 treatment combination with test results of 0.07% and 0.19%.

3.1.1 Nitrogen Content (N)

Based on the test results for the N, P, and K content in Table 1, nitrogen (N) has a higher percentage of content test results than P and K. The total N content in each treatment combination shows a percentage difference; the highest nitrogen content is found in the combination of the treatment of moringa leaves and plant kiambang (*Salvinia molesta*) and more activators, namely 3.38%. Meanwhile, the lowest nitrogen content was found in the combined treatment of moringa leaves and kiambang (*Salvinia molesta*) with more bioactivators, namely 2.22%. This shows that the nitrogen content of four treatments obtained meets the excellent quality of solid organic Fertilizers according to SNI 19-7030-2004, which states that the

quality standard for solid organic fertilizer content is a minimum of 0.40% (Andriawan, 2022).

Table 2. The results of a two-way ANOVA statistical analysis of the nitrogen content of a combination of Moringa leaf and kiambang (*Salvinia molesta*) fertilizer with the addition of banana peel waste as a bioactivator

Tests of Between-Subjects Effects

Dependent Variable: Nitrogen Content Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.091[a]	3	1.030	877.021	.000
Intercept	96.447	1	96.447	82082.298	.000
Faktor_2	.015	1	.015	12.511	.008
Faktor_1	.077	1	.077	65.362	.000
Faktor_2 * Faktor_1	3.000	1	3.000	2553.191	.000
Error	.009	8	.001		
Total	99.548	12			
Corrected Total	3.101	11			

a. R Squared = ,997 (Adjusted R Squared = ,996)

The Two Way Anova analysis results in Table 2 show a significant result: the combination of Moringa leaf and *Salvinia molesta* treatments has a significant probability. 0.000 < 0.05. The probability of the number of moles factor has sig. 0.008 < 0.05. The probability is sig in the interaction between treatment combinations and the number of moles. 0.000 < 0.05. From these results, factor 1, factor 2, and the interaction of both have significant results in solid organic Fertilizers that affect the level of nitrogen content produced. The nitrogen analysis test results showed that the K2M2 treatment combination had the highest nitrogen content, 3.38%. This is under the statistical calculations of the mean K2, 2.9150, and M2, 2.8700. So that the results of the mean statistical calculations are by the results of the nitrogen content test that the K2M2 treatment has the highest nitrogen content.

When viewed from the composition of the essential ingredients, Fertilizer with a higher concentration of *Salvinia molesta* will have the highest percentage of nitrogen content test results because it has a protein content of 15.90% (Warasto et al., 2013), while young Moringa leaves have a protein content of 1.3092 % and old Moringa leaves 11.3473 % (Saputri, 2019). The fermentation process used in making solid organic Fertilizer, a combination of moringa leaves and kiambang (*Salvinia molesta*), affects the results of nitrogen tests on fertilizers; in research (Arafat, 2017) that during the fermentation process using bioactivators, the final result of the fermented product will experience a decrease in protein content.

3.1.2 Fosfor Content (P)

Based on the test results for the content of N, P, and K in Table 1, the content of phosphorus (P) in each treatment combination showed a percentage difference;

the highest test results were found in the K1M1 treatment combination, which was 0.10%, while the lowest test results were in the K2M2 treatment combination, namely 0.07%. The high and low content of phosphorus (P) can be influenced by the content of the nutrient phosphorus (P) found in Moringa leaves based on research (Adiaha, 2017) 1.17% more than in kiambang plants 0.50%.

Table 3. The results of a two-way ANOVA statistical analysis of the phosphorus content of a combination of Moringa leaf and kiambang (*Salvinia molesta*) fertilizer with the addition of banana peel waste as a bioactivator

Tests of Between-Subjects Effects

Dependent Variable: Phosphorus Content Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.001[a]	3	.000	.905	.480
Intercept	.082	1	.082	155.571	.000
Faktor_2	.001	1	.001	1.286	.290
Faktor_1	.001	1	.001	1.286	.290
Faktor_2 * Faktor_1	7.500E-005	1	7.500E-005	.143	.715
Error	.004	8	.001		
Total	.087	12			
Corrected Total	.006	11			

a. R Squared = ,253 (Adjusted R Squared = -,027)

Based on the Two Way Anova analysis results in Table 3, there were insignificant results, namely the combination of Moringa leaf treatment and *Salvinia molesta* sig. 0.290 > 0.05 while the number of moles is sig. 0.290 > 0.05. The probability of the interaction of the two has a significant value. 0.715 > 0.05. From these results, the combination of treatments and the number of moles used in solid organic fertilizers did not affect the level of phosphorus content produced. In terms of the results of the average test for phosphorus content, there is a difference. However, statistically, there is no significant difference because the test results for each treatment are slightly different. The results of the phosphorus analysis test found that the K1M1 treatment combination had the highest phosphorus content, namely 0.10%. This follows the statistical calculations of the mean K1, which is 0.0900, and M1, which is 0.0900. So that the results of calculating the mean statistic are under the results of the phosphorus content test that the K1M1 treatment combination has the highest phosphorus content.

3.1.3 Potassium Content (K)

Based on the test results for the content of N, P, and K in Table 1, the content of potassium (K) in each treatment combination showed a percentage difference; the highest test result could be seen in the K1M1 treatment combination, which was

0.24%, while the lowest test result was in the K2M2 treatment, namely 0.19%. The potassium nutrient content influences this in the raw material for Moringa leaves from research (Adiaha, 2017), 1.90%, while the potassium nutrient content in *Salvinia molesta* is 2.90% (Sismiyanti et al., 2018).

Table 4. The results of a two-way ANOVA statistical analysis of the potassium content of a combination of Moringa leaf and kiambang (*Salvinia molesta*) fertilizer with the addition of banana peel waste as a bioactivator.

Tests of Between-Subjects Effects

Dependent Variable: Potassium Content Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.004[a]	3	.001	4.538	.039
Intercept	.542	1	.542	1667.308	.000
Faktor_2	.001	1	.001	2.077	.188
Faktor_1	.004	1	.004	11.308	.010
Faktor_2 * Faktor_1	7.500E-005	1	7.500E-005	.231	.644
Error	.003	8	.000		
Total	.549	12			
Corrected Total	.007	11			

a. R Squared = ,630 (Adjusted R Squared = ,491)

Based on the Two Way Anova analysis results in Table 4, there were significant results, namely the combination of Moringa leaf treatment and *Salvinia molesta* sig. 0.010 <0.05 while not significant for the number of sig moles. 0.188 > 0.05. The probability of the interaction of the two has a significant value. 0.644 > 0.05. From these results, the combination of treatments used in solid organic fertilizers affects the level of potassium content produced. In contrast, the number of moles and the interaction between the two does not affect it. From the results of the potassium analysis test, it was found that the K1M1 treatment combination had the highest phosphorus content, namely 0.24%. This is by the statistical calculations of the mean K1, 0.2300, and M1, 0.2200 so that the results of the mean statistical calculations follow the potassium level test results that the K1M1 treatment combination has the highest potassium content.

3.2. Sensory Test

Based on the results of sensory observations that have been carried out, including color, scent, texture, and degree of acidity (pH) in solid organic Fertilizer, a combination of moringa leaves and kiambang plants (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator can be seen in the following table 5.

Table 5. The results of sensory observations on solid organic fertilizer combinations of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator after being fermented for 30 days.

Combination	Average Observation Results			
	Color	**Scent**	**Texture**	**pH**
K_1M_1	Dark brown	Pungent	Rather rough	7
$K1M_2$	Black	Less Pungent	Rather subtle	7
K_2M_1	Dark brown	Pungent	Rather rough	7
K_2M_2	Black	Less Pungent	Crumb	7

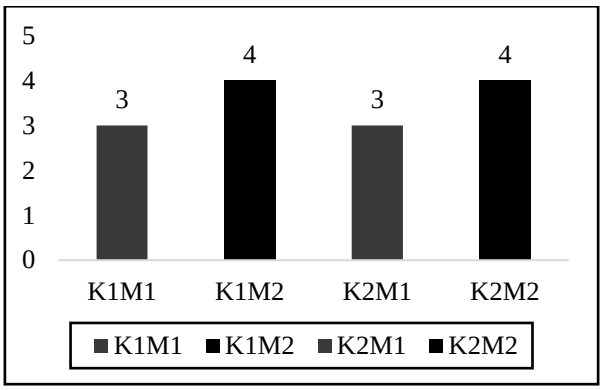
Information:
K_1M_1 = Solid organic Fertilizer with a concentration of 300 g of Moringa leaves and 200 g of Kiambang with the addition of 25 mL banana peel bioactivator.
$K1M_2$ = Solid organic Fertilizer with a concentration of 300 g of Moringa leaves and 200 g of kiambang with 30 mL banana peel bioactivator.
K_2M_1 = Solid organic Fertilizer with a concentration of 200 g of Moringa leaves and 300 g of Kiambang with the addition of 25 mL banana peel bioactivator.
K_2M_2 = Solid organic Fertilizer with a concentration of 200 g of Moringa leaves and 300 g of Kiambang with the addition of 30 mL banana peel bio activator.

Based on the table data, it is known that the sensory observations in the samples have similarities, namely in the sensory test results for the pH parameter. Meanwhile, the sensory test results for color, scent, and texture have differences.

3.2.1 Color Parameters

After observing the color of the solid organic fertilizer combination of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator, which was carried out by organoleptic or sensory tests using the senses, the observations showed that the colors were different. Treatment samples K1M1 and K2M1 were blackish brown, while K2M1 and K2M2 were black. The color difference occurs due to the decomposition activity of the Fertilizer by bacteria. In addition, the compounds in these fertilizers' organic matter can affect the Fertilizer's color from brown to black. Moringa leaves have phenolic color pigments. This aligns with research (Kurang, 2020) that the phenolic compounds in Moringa leaves can cause a black color.

The sensory observations show that the four combination fertilizer treatments of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator had color differences caused by the organic matter in the solid organic fertilizer can be seen in following figure.



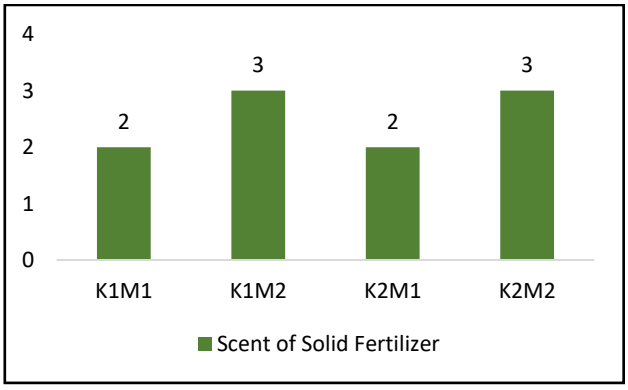
Information: 1 = light brown; 2 = brown; 3 = dark brown; 4= black

Figure 1. Color parameters of solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator

Based on Figure 1, there are color differences in the four treatment combinations observed. In the treatment combinations, K1M1 and K2M1 had a blackish brown color, while in the treatment combinations K1M2 and K2M2, the Fertilizer had a black color. This difference is influenced by mixing solid organic fertilizer ingredients, which were initially green in color, to produce a blackish brown Fertilizer to very black. This follows research (Mustika, 2019) that was seen in SNI 19-7030-2004. The process of composting organic Fertilizers will gradually change the color of the compost material towards blackish brown due to the ongoing transformation of organic matter and forming humus substances so that the four treatments have fertilizer colors that follow SNI 19-7030-2004.

3.2.2 Scent Parameters

Sensory observations of scent in solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator with organoleptic tests using the sense of smell can be seen in the following figure.



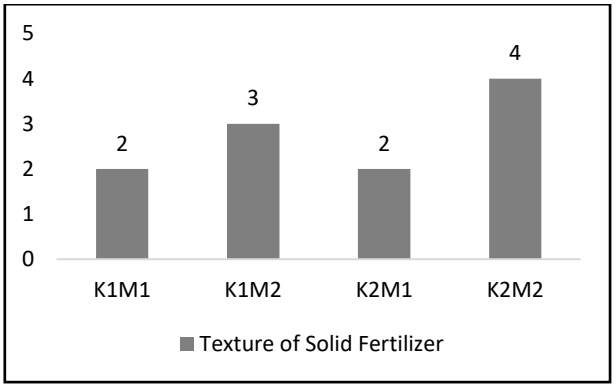
Information: 1 = sewage; 2 = pungent; 3 = less pungent; 4 = earthy.

Figure 3. Scent parameters in solid organic fertilizer combination of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator.

Based on the research results on the scent parameters in Figure 3, it is known that the scent of the four combinations of fertilizer treatments smells less pungent than pungent. For example, combining treatments K1M1 and K2M1 had a pungent odor, while K1M2 and K2M2 had a less pungent scent. This indicates the presence of a fermented scent influenced by using a bioactivator from banana peels. The four treatments show that the quality of solid fertilizers follows SNI-19-7030-2004 following Mustika's research (2019), which states that mature compost is characterized by an odor that does not sting or smell like earth because the material it contains resembles soil. This follows the National Standardization Agency SNI-19-7030-2004, which states that ripe compost will smell of earth.

3.2.3 Texture Parameters

After sensory observation of texture on solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator with organoleptic tests using the sense of touch can be seen in the following figure.



Information: 1 = rough; 2 = rather rough; 3 = rather subtle; 4 = crumb.

Figure 4. Texture parameters of solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator.

The results of the texture parameter research can be seen in Figure 4 that there are differences in each treatment combination; K1M1 and K2M1 have a somewhat rough texture, K1M2 has a relatively smooth texture, and K2M2 has a crumbly texture. In the fermentation process of solid organic fertilizers, the coarse material will break down into smaller sizes, causing the texture of the Fertilizer to become relatively smooth and even crumbly. According to Mustika's research (2019), the characteristics of good compost are crumb structure and loose consistency. Based on the research results, four treatments of solid organic fertilizer combination of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator meets good quality based on the National Standardization Agency for SNI 19-7030-2004.

3.2.4 pH Parameters

Sensory observations on solid organic fertilizer combinations of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator were carried out by measuring the degree of acidity in the Fertilizer which can be observed in the image below.

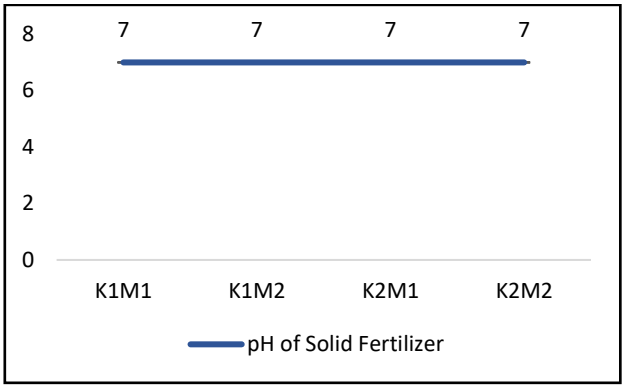


Figure 5. Line Diagram of pH Parameters of Solid Organic Fertilizer Combination of Moringa Leaves and Kiambang Plant (*Salvinia molesta*) with the Addition of Banana Peel Waste as a Bioactivator.

Based on the research results, the degree of acidity (pH) parameter can be observed in Figure 5 that the four treatment combinations have the same pH, namely 7. The pH value or degree of acidity is measured after a solid organic fertilizer combination of Moringa leaves and *Salvinia molesta* with the addition of banana peel waste as a bioactivator ripe. The pH value is 7, according to the requirements for solid organic Fertilizers based on the National Standardization Agency for SNI 19-7030-2004, and the standard pH for good quality compost is between 6.80 – 7.49. The pH value dramatically influences decomposer organisms' growth in the fermentation process. The pH value can increase; according to research by Dewilda (2017), the increase in pH is due to the composting process producing nitrogen and ammonia gas, so the pH value changes to alkaline due to increased bacterial activity. Based on the results of the study, the results showed that the pH content of four treatments of solid organic fertilizers combined with Moringa leaves and *Salvinia molesta* with the addition of banana peel waste as a bioactivator was classified as good because it met the quality standards of SNI 19-7030-2004.

4. CONCLUSIONS

Based on the study's results, it was shown that moringa leaves and kiambang plants (*Salvinia molesta*) could be used as solid organic Fertilizers with banana peel waste as activators. This can be seen from sensory observations: the color is brown-black, the smell is less pungent, the crumb texture, and the pH is acidic, namely, 7. Furthermore, in the observations of tests for the content of N, P, and K, it also meets good fertilizer quality standards. Thus, by using sensory observations and testing the content of nitrogen (N), phosphorus (P), and potassium (K), the average quality of fertilizers is good because the quality of the four combinations of fertilizers follows SNI 19-7030-2004.

5. REFERENCES

Adiaha, M. S. (2017). Potential Of *Moringa oleifera* As Nutrient-Agent For Biofertilizer Production. *World News of Natural Science*, 10(1), 101-104.

Ali, H. (2016). Efektifitas Mikroorganisme Lokal (MOL) Limbah Buah-Buahan Sebagai Aktifator Pembuatan Kompos. *Jurnal Media Kesehatan*, 9(1), 1-113.

Almastin, A. W., & Asngad, A. (2022, November). Pemanfaatan Limbah Jerami dan Bulu Ayam sebagai Bahan Baku Pop dengan Penambahan Lumbriscus terrestris dan Maggot BSF sebagai Dekomposer. In *Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek)* (pp. 118-124).

Andriawan, F., Walida, H., Harahap, F. S., & Sepriani, Y. (2022). Analisis Kualitas Pupuk Kascing Dari Campuran Kotoran Ayam, Bonggol Pisang Dan Ampas Tahu. *Jurnal Pertanian Agros*, *24*(2), 423-428.

Anggraeni, F. D., Hastuti, E. D., & Haryanti, S. (2019). Pengaruh Pupuk Organik Padat dan Cair dari Serasah Mangrove terhadap Pertumbuhan Tanaman Sorgum (*Sorghum bicolor* L. var. Numbu). *Jurnal Akademika Biologi*, *8*(2).

Arafat, F. A. (2017). *Integrasi Budidaya Azolla microphylla dengan Budidaya Ikan Lele*. Universitas Lampung.

Ashari, T. M., Alfasyimi, M., & Zulfahmi, I. (2021). Pengolahan Limbah Cair Organik Rumah Pemotongan Ayam (RPA) dengan Metode Fitoremediasi dengan Tumbuhan Kiambang *(Pistia stratiotes* L). *AMINA*, *3*(3), 141-148.

Asngad, A., Sari, D. A. K. S., & Primadianti, A. D. (2019). Kualitas Pupuk Organik dari Limbah Padat Pati Aren dengan Penambahan Mikroorganisme Lokal dari Krokot (*Portulaca oleracea* L.) dan Semanggi (*Marsilea crenata*). *Seminar Nasional Pendidikan Biologi Dan Saintek (SNPBS) Ke-IV 2019*, 1(1), 39–46.

Badan Standar Nasional. (2004). SNI 19-7030-2004 tentang *Spesifikasi Kompos dari Sampah Organik Domestik.*

Dewi, F. M., & Kusnoputranto, H. (2022). Analisis Kualitas Kompos dengan Penambahan Bioaktivator EM4 dan Molase dengan Metode Takakura. *Poltekita: Jurnal Ilmu Kesehatan*, *16*(1), 67-73.

Dewilda, Y., & Darfyolanda, F. L. (2017). Pengaruh komposisi bahan baku kompos (sampah organik pasar, ampas tahu, dan rumen sapi) terhadap kualitas dan kuantitas kompos. *Jurnal Dampak*, *14*(1), 52-61.

Fauzi, N. A., Hilal, N., & Yulianto, Y. (2021). Pengaruh Bioaktivator Dari Fermentasi Kulit Pisang Dan Air Cucian Beras Terhadap Waktu Matang Kompos Tahun 2020. *Buletin Keslingmas*, 40(1), 1-4.

Kurang, R. Y., Koly, F. V. L., & Kafolapada, D. I. (2020). Aktivitas Antioksidan Ekstrak Etil Asetat Daun Kelor (*Moringa oleifera* L). *Journal of Pharmaceutical Care Anwar Medika (J-PhAM)*, 3(1), 13-21.

Moiedi, Sunira Paul & Judia, Harriet Sumathy. (2013). Production of -amylase from banana peels with *Bacillus subtilis* using solid-state fermentation. *Chennai: Postgraduate & Research Department of Biotechnology*

Mustika, A. M., Suryani, P., & Aulawi, T. (2019). Analisis Mutu Kimia Dan Organoleptik Pupuk Organik Tandan Kosong Kelapa Sawit Dengan Dosis Em-4 Berbeda. *Jurnal Agroteknologi*, 9(2), 13-20.

Saputri, Gusti Rai., Tutik., & Permatasari, A. I. (2019). Penetapan Kadar Protein pada Daun Kelor Muda dan Daun Kelor Tua (*Moringa oleifera* L.) Dengan Menggunakan Metode Kjeldahl. *Jurnal Analis Farmasi*, 4(2), 108-116.

Sismiyanti, S., Hermansah, H., & Yulnafatmawita, Y. (2018). Klasifikasi Beberapa Sumber Bahan Organik Dan Optimalisasi Pemanfaatannya Sebagai Biochar. *Jurnal Solum*, 15(1), 8.

Tallo, M. L. L., & Sio, & S. (2016). Pengaruh Lama Fermentasi terhadap Kualitas Pupuk Bokashi Padat Kotoran Sapi. *Journal of Animal Science International Standard of Serial Number*, 4(1), 12–14.

Tenri, A., & Rivai, O. (2020). Identifikasi Senyawa yang Terkandung pada Ekstrak Daun Kelor (*Moringa oleifera*). *In 63 Indonesian Journal of Fundamental Sciences*, 6(2), 63-70.

Wahyudi, & Agustina, H. (2018). Sediaan Salep Ekstrak Daun Kelor (*Moringa oleifera Lam*) Sebagai Penyembuhan Luka Bakar Topikal Pada Kelinci (*Oryctolagus cuniculus*). *In Jurnal Farmasimed (JFM*), 1(1), 21-24.

Warasto, Yulisman, & Fitrani, M. (2013). Tepung kiambang (*Salvinia molesta*) terfermentasi sebagai bahan pakan ikan nila (*Oreochromis niloticus*). *Jurnal Akuakultur Rawa Indonesia*, 1(2), 173-183.

Widyastuti, S., Studi Teknik Lingkungan, P., & Teknik, F. (2021). Pengolahan Sampah Organik Pasar Dengan Menggunakan Media Larva Black Soldier Flies (BSF) Media Larva Black Soldier Flies (BSF). *Jurnal Teknik Waktu*, 19(1), 1-13.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Solid Organic Fertilizers for Duck Manure and Trembesi Leaves with Papaya Peel Bioactivator

Musdhalifah Husna Firdausi, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Duck Manure
Peel Papaya
Organic Fertilizer
Organic Fertilizer Solid
Trembesi Leaves

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Organic fertilizers can replace inorganic fertilizers that are not environmentally friendly. Duck manure and trembesi leaves can be used as raw materials for fertilizer. Adding local papaya peel microorganisms can help the decomposition process of organic fertilizers. This study aims to determine the quality of solid organic fertilizer made from duck manure and trembesi leaves by adding local papaya peel microorganisms as bioactivation. This study used a completely randomized design (CRD) with a factorial pattern and was repeated three times. The treatment factors are as follows: Factor 1 Raw materials (B1 = Duck Manure 300g: 200g Trembesi Leaves. B2 = Duck Manure 200g: 300g Trembesi Leaves). Factor 2 Papaya Peel Local Microorganisms (P1 = Papaya Peel Bioactivator 25 ml, P2 = Papaya Peel Bioactivator 30 ml). The results showed the best sensory quality in the B2P2 treatment; the fertilizer was blackish brown, smelled of soil, had a crumbs texture like soil, and had a pH of 7. The highest Nitrogen and Phosphorus content was found in the B1P2 treatment, while the highest Potassium content was in the B2P1 treatment. Thus, the quality of solid organic fertilizer is by SNI 19-7030-2004.

1. INTRODUCTION

Fertilizer has a crucial role in plant growth and development. Fertilizers can be divided into two types based on the constituent materials: organic and inorganic fertilizers. Organic fertilizers are made from organic materials, while inorganic fertilizers are made from chemicals. The use of inorganic fertilizers can cause problems in the environment. The negative impacts of the excessive use of inorganic fertilizers can damage the soil and the balance of natural nutrients. They can also kill microorganisms, thereby inhibiting the decomposition of organic matter (Kurniawan and Chusnah, 2021).

The existence of organic fertilizers can be used as a solution to replace the use of inorganic fertilizers. Organic fertilizers have many benefits for the environment compared to inorganic fertilizers, which harm the environment. According to Kurniawan's research (2017), organic fertilizers can trigger and increase the microbial population in the soil far better than inorganic fertilizers. Organic fertilizers can also improve soil structure and fertility. Therefore, organic fertilizers can prevent soil erosion.

Organic fertilizers can make from two different materials, a combination in the manufacture of organic fertilizers is needed to improve the quality of organic fertilizers. Duck manure contains the nitrogen, phosphorus, and potassium that plants need. According to Safriyani's research (2020), the results showed that duck manure had 1.03% N, 0.92% P, 0.53% Potassium, and 32.38 Organic C. With these contents, duck manure can be used as organic fertilizer. Besides being made from animal manure, organic fertilizer can make from organic waste from plant residues such as leaves. Trembesi leaves are not only useful as shade and animal feed but also have the potential to be used

as organic fertilizer. According to Darma's research (2020) regarding the content of fruit leaves for organic fertilizer, trembesi leaves contain 4.20% nitrogen, 0.12% phosphorus, and 0.62% potassium.

Fermentation is required to manufacture solid organic fertilizers that decompose organic matter. The fermentation process requires bioactivation to help decompose organic matter. Bioactivators are microbial isolates that have been purified and can digest organic matter containing cellulose (Suwahyono, 2017). Bioactivators made from organic materials can also be called local microorganisms. Fruit peel waste is often used as a natural bioactivator in the fermentation process of organic fertilizers. Fruit peel waste has microorganisms that can help in the decomposition process of organic matter. According to Wicaksono's research (2022) regarding the manufacture of liquid organic fertilizer using local microorganisms of papaya peel, the microbes found in local microorganisms of papaya peel are *Pseudomonas*, *Bacillus*, and *Aspergillus ninger*. The three microbes that act as phosphorus solvents in organic matter. The existence of microbial content in local microorganisms papaya peel, papaya peel waste can be used as a natural bioactivator or local microorganisms.

Based on the explanation above, the problems in this study are: What are the sensory characteristics and levels of nitrogen, phosphorus, and potassium content in solid organic fertilizers made from duck manure and trembesi leaves with the addition of microorganisms local to papaya peel as bioactivation? This study aims to determine the sensory characteristics and nutrient content of nitrogen, phosphorus, and potassium in solid organic fertilizers made from duck manure and trembesi leaves by adding microorganisms local to papaya peel as bioactivation.

Doing this research will provide the following benefits: 1). Providing new information and innovations to the public regarding solid organic fertilizers made from duck manure and trembesi leaves with the addition of papaya peel waste as a bioactivation 2). Be an alternative organic fertilizer for farmers to avoid adverse risks in long-term use.

2. MATERIALS AND METHODS

We conducted this research in Tlangu, Bulan, Wonosari, Klaten to manufacture organic fertilizers and sensory tests. Test for Nitrogen, Phosphorus, and Potassium nutrients at the Soil and Fertilizer Laboratory, Faculty of Agriculture, UMY Jl. Brawijaya Tamantirto, Bantul, Kasihan.

The research occurred on the stairs from February 4 to March 11, 2023. The tools used included: plastic, used gallons, baskets, measuring cups, knives, pH sticks, pH indicators, and stationery. The materials used include duck manure, trembesi leaves, and local microorganisms from papaya peel.

This study uses experimental research methods. This study uses a complete random design (CRD) with factorial patterns and is repeated three times. The treatment factors are as follows: Factor 1 Raw materials (B1 = Manure Duck 300 gram: Trembesi Leaves 200 gram. B2 = Manure Duck 200 gram: Trembesi Leaves 300 gram.). Factor 2: Local microorganisms of papaya peel (P1 = papaya peel local microorganisms 25 ml, P2 = papaya peel local microorganisms 30 ml).

The data analysis used is descriptive qualitative data analysis and quantitative data analysis. Qualitative data analysis is needed to explain the sensory properties of solid organic fertilizers. Using the Two Way ANOVA test, quantitative data analysis was used to test nitrogen, phosphorus, and potassium levels.

3. RESULTS AND DISCUSSION

3.1 Sensory Test

The results obtained regarding the quality of solid organic fertilizer, a combination of duck manure and leaf trembesi with the addition of papaya peel waste as bioactivation, sensory test results (color, smell, texture, and pH) are presented in the following table:

Table 1. Sensory Test (Color, Smell, Texture, and pH) Solid Organic Fertilizer Combination of Duck Manure and Trembesi Leaves with the Addition of Local Microorganisms Papaya peel as a bioactivator

No.	Treatment	Result of Observation			
		Color	Smell	Texture	pH
1	B_1P_1	Brown	Less stinging	Slightly Rough	7
2	B_1P_2	Blackish Brown	Less stinging	Slightly Smooth	7
3	B_2P_1	Brown	Less stinging	Slightly Rough	7
4	B_2P_2	Blackish Brown	Soil	Crumbs	7

Explanation:

B1P1: Manure duck 300g + Trembesi leaves 200g with local microorganism peel of papaya 25 ml.

B1P2: Manure duck 300g+ Trembesi leaves 200g with local microorganism peel of papaya 30 ml.

B2P1: Manure duck 200g+ Trembesi leaves 300g with local microorganism peel of papaya 25 ml.

B2P2: Manure duck 200g+ Trembesi leaves 300g with local microorganism peel of papaya 30 ml.

Fermentation of solid organic fertilizer with a combination of duck manure and trembesi leaves with the addition of local microorganisms papaya peel as a bioactivation obtained the following results:

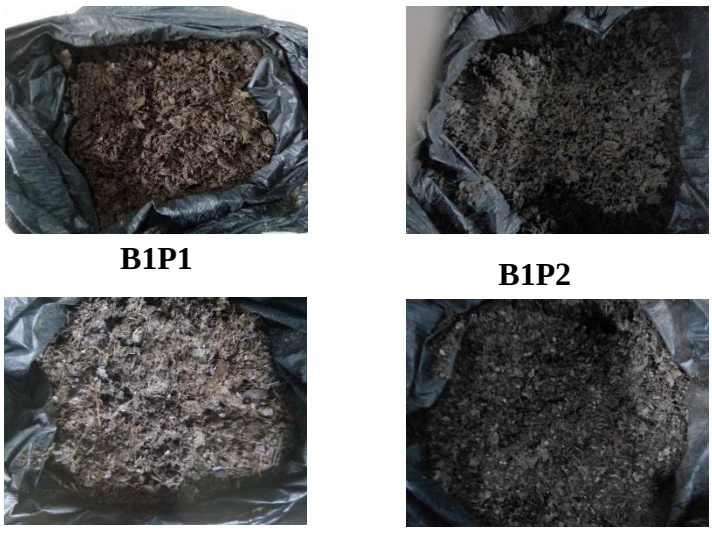
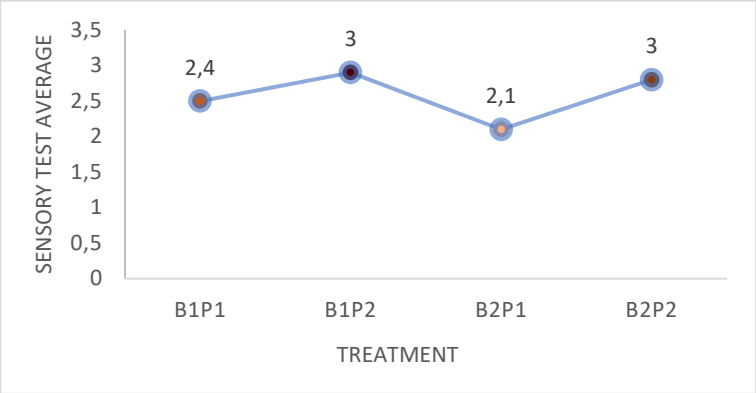


Figure 1. Solid Organic Fertilizer Combination of Duck Manure and Trembesi Leaves with the addition of local microorganisms from papaya peel

3.1.1 Color Parameters

Based on Table 1. and Figure 2. Sensory test results with color parameters on solid organic fertilizer, a combination of duck manure and trembesi leaves with the addition of local microorganisms papaya peel as a bioactivation, showed that the results obtained from the four treatments that had the best results were in the B1P2 and B2P2 treatments with fertilizer that was blackish brown.



Explanation: 1 = Yellowish Brown; 2 = Brown; 3 = Blackish Brown; 4= Blackish

Figure 2. Observation of the color of duck manure organic fertilizer and trembesi leaves with the addition of local microorganisms' papaya peel as a bioactivator.

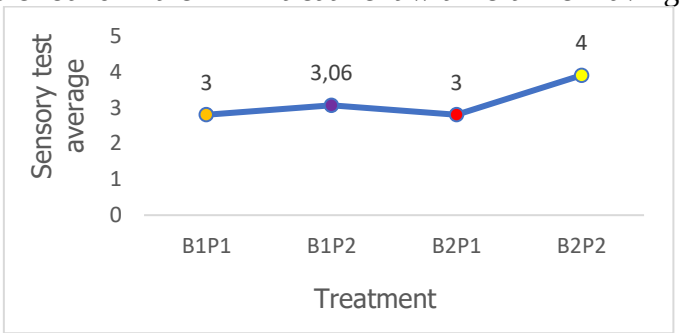
The color of the fertilizer at the beginning of the fermentation is different at the end. The discoloration of solid organic fertilizers is caused by the decomposition of organic matter carried out by microbes in the local microorganisms of papaya peel. These results align with Puspitasari's research (2022), which states that organic matter decomposes and changes during fermentation, forming microbial cell substances and turning into a dark amorphous form. This substance is called matter, like soil. After fermentation, the organic matter changes color to a blackish brown.

In addition, the decomposition process causes organic matter to lose its pigment color, causing the color to change to blackish brown. This statement is in line with the idea of Kumalasari (2016), which states that color change occurs because the decomposition process changes organic matter with complex C carbon chains into simple C carbon chains.

During the decomposition process, the organic matter loses its pigment so that it changes color to blackish brown according to the color of its constituents. Then, solid organic fertilizer with a blackish brown color is formed by standard provisions (SNI No 19-7030-2004), which state that solid organic fertilizer that has matured will have a blackish brown color like soil.

3.1.2 Smell Parameters

Based on Table 1. and Figure 3. Sensory test results with scent parameters on solid organic fertilizer, a combination of duck manure and trembesi leaves with the addition of local microorganisms papaya peel as a bioactivation, the results obtained from the four treatments that had the best results were found in the B2P2 treatment with fertilizer having a scent like soil.



Explanation: 1 = Waste; 2 = Stinging; 3 = Less Stinging; 4 = Soil

Figure 3. Observation of the smell of duck manure organic fertilizer and trembesi leaves with the addition of local microorganisms' papaya peel as a bioactivator.

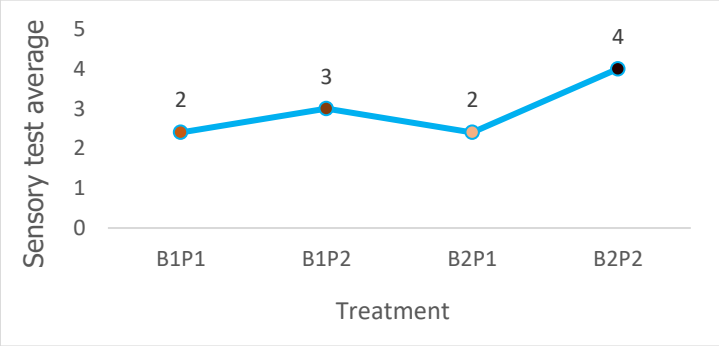
At the beginning of the fermentation, the solid organic fertilizer gave off the dominant rotting smell of duck manure. Still, on the 35th day or 5th week, the scent of solid organic fertilizer changed to a soil smell in the B2P2 treatment and a less pungent scent in the other three treatment

combinations. Changes in scent in solid organic fertilizers occur due to the activity of microorganisms. This statement aligns with research by Akbar & Asngad (2022), which states that the scent in organic fertilizer comes from microorganisms that decompose organic matter. In addition, microorganisms also produce volatile compounds, namely ammonia. This compound causes solid organic fertilizers to have a less stinging scent at the end of composting.

During the fermentation process, microorganisms decompose organic matter, which causes the scent in the fertilizer to change at the end of composting. This idea is in line with Amalia's research (2016), which states that when organic matter begins to be degraded by microorganisms, at that time, the smell of a mixture of organic matter will slowly disappear and will smell like soil. Then the resulting fertilizer with a soil smell by standard provisions (SNI No 19-7030-2004) states that when organic fertilizer is ripe, it will smell like soil (Andriawan, 2022).

3.1.3 Texture Parameters

Based on Table 1. and Figure 4. Sensory test results with textural parameters on solid organic fertilizer, a combination of duck manure and trembesi leaves with the addition of local microorganisms' papaya peel as a bioactivation, the results obtained from the four treatments that had the best results were found in the B2P2 treatment with fertilizer having a texture the crumbs.



Explanation: 1 = Rough; 2 = Slightly Rough; 3 = Slightly Smooth; 4 = Crumbs

Figure 4. Observation of the texture of duck manure organic fertilizer and trembesi leaves with the addition of local microorganisms papaya peel as a bioactivator

Adding local microorganisms aims to accelerate the process of decomposing organic matter. Fertilizers have a rough texture because microorganisms cannot decompose organic matter properly enzymatically. According to Kurniawan's research (2021), microorganisms produce cellulose enzymes that can degrade plant cellulose bonds. Cellulose bonds in organic matter will degrade, resulting in a smooth texture. *Bacillus* is one of the microbes found in local microorganisms of papaya peel. *Bacillus* microbes can degrade cellulose by secreting their cellulose enzymes so that they can degrade organic matter so that it compacts like soil (Rahman, 2022).

The sensory results of the texture parameter show that the fertilizer has a crumbly texture according to the standard provisions (SNI No 19-7030-2004). Fertilizers that have a crumbly texture are easy for plants to absorb because the nutrient content in the fertilizer has adequately decomposed.

3.1.4 Parameters pH

Based on Table 1. the results of sensory test observations with pH parameters on solid organic fertilizer, a combination of duck manure and trembesi leaves with the addition of papaya peel local microorganisms as bioactivators, of the four treatments showed a pH of around 7, with neutral properties. This pH result complies with the standard requirements (SNI No 19-7030-2004), namely 6.8 to 7.49.

High or low pH levels produced in fertilizers can be influenced by microbial activity that decomposes organic matter into organic acids. This statement aligns with Suwatanti's research (2017), which stated that microorganisms convert nitrogen into ammonia, accelerating the pH's increase to alkaline. Microbes will denitrify it and convert half of the ammonia into nitrate, bringing the pH of the fertilizer to a neutral level. *Pseudomonas* microbes contained in papaya peel local microorganisms can affect the increase in pH levels in fertilizers (Mangungsong, 2019). Local microorganisms of papaya peel can affect the rise in pH levels in fertilizers.

3.2 Content of Nitrogen, Phosphorus, and Potassium

Based on the results of laboratory tests of solid organic fertilizer combined with duck manure and trembesi leaves, the following results were obtained:

Table 2. Content of Nitrogen, Phosphorus, and Potassium in a solid organic fertilizer combination of duck manure and trembesi leaves with the addition of papaya peel as a bioactivator.

Combination	Results Content Test		
	Nitrogen (%)	Phosphorus (%)	Potassium (%)
B1P1	3.26	0.16	0.17*
B1P2	3.64**	0.18**	0.18
B2P1	3.10*	0.11*	0.20**
B2P2	3.43	0.13	0.19

Explanation: (*) lowest yield; (**) highest yield

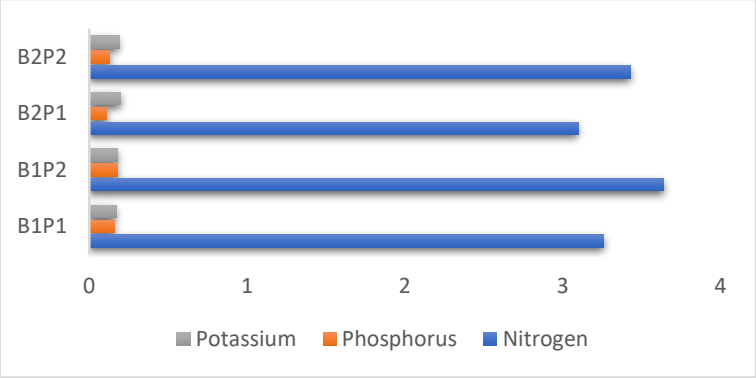


Figure 5. Content of Nitrogen, Phosphorus, and Potassium in solid organic fertilizers

Figure 5. and Table 2. show that the four combinations have different percentages of nitrogen content. The highest nitrogen percentage was found in the B1P2 treatment, with a nitrogen percentage of 3.64%. The highest phosphorus content was found in the B1P2 treatment, with a phosphorus percentage of 0.18%, while the highest potassium percentage was in the B2P1 treatment, with a potassium percentage of 0.20%.

3.2.1 Nitrogen Content

The data in Figure 5. and Table 2. shows that the four combinations have a high nitrogen content above 3%. The high nitrogen content is due to the increase in the value of nitrogen during the decomposition process. This statement is according to Ekawandani's research (2018), which stated that during the CO2 decomposition process, evaporation would occur so that C/N levels would decrease and nitrogen levels would increase. In addition, the high nitrogen content is due to the microbes found in the local microorganisms of papaya peel. One of the microbes in the local

microorganisms of papaya peel is *pseudomonas* which has an essential role in increasing nitrogen (Darmawan, 2018).

Table 3. Results of Two-Way ANOVA Nitrogen Content Analysis

Tests of Between-Subjects Effects

Dependent Variable: Nitrogen_Content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.483[a]	3	.161	386.527	.000
Intercept	135.408	1	135.408	324979.220	.000
Main_Ingredient	.103	1	.103	246.420	.000
Bioaktivator	.378	1	.378	907.380	.000
Main_Ingredient * Bioaktivator	.002	1	.002	5.780	.043
Error	.003	8	.000		
Total	135.895	12			
Corrected Total	.486	11			

a. R Squared = .993 (Adjusted R Squared = .991)

Based on Figure 5. the bar chart shows that the four treatments have different nitrogen percentages. This difference was caused by differences in the concentrations of the main ingredients of the fertilizer, namely duck manure and trembesi leaves, as well as differences in the concentrations of local microorganisms of papaya peel in each treatment. The bar chart results align with the statistical analysis performed with a two-way ANOVA. The results of the two-way ANOVA analysis between the concentration of the main ingredient with nitrogen content and the concentration of the bioactivator with nitrogen content showed sig. 0.00 <0.05 means that there is a difference in the average nitrogen content in each treatment combination, so the concentration of the main ingredient and bioactivator significantly affects the nitrogen content. Meanwhile, the interaction between the main ingredient and the bioactivator showed sig. 0.043 <0.05 means an interaction between the two ingredients on the nitrogen content. It can also be seen in Table 2. that the treatment with a 30 ml bioactivator has a high nitrogen content compared to the 25 ml bioactivator. The treatment with a higher concentration of duck manure has the highest nitrogen content, so the B1P2 (300g duck manure: 200g trembesi leaves + 30 ml papaya peel local microorganisms) treatment obtained the highest nitrogen percentage of 3.64%.

The high nitrogen content is due to the microbes in the papaya peel degrading organic matter to decompose proteins (complex compounds) into simple compounds, one of which is nitrogen, to obtain solid organic fertilizer by the standard provisions of SNI 19-7030-2004 where the nitrogen content contained in organic fertilizer is at least 0.40%.

3.2.2 Phosphorus content

Based on the results of laboratory tests on a solid organic fertilizer combination of duck manure and trembesi leaves with the addition of local microorganisms papaya peel as a bioactivator in the Phosphorus content test in Table 2. it was found that the B1P2 treatment had the highest phosphorus percentage of 0.18%. In comparison, B2P1 had the lowest phosphorus percentage, with a phosphorus percentage of 0.11%. During the maturation process, microbial fertilizers will die, and the phosphorus levels in the microbes will be mixed with compost material, thus increasing the phosphorus levels of organic fertilizers (Kaswinarni, 2020).

The high levels of phosphorus content in the B1P2 treatment were due to the large concentration of local microorganisms of papaya peel used, namely 30 ml. Microbes contained in the local microorganisms of papaya peel play an active role in dissolving phosphorus in organic matter. This statement is according to the research of Wicaksono (2022), which states that Pseudomonas bacteria will utilize previously formed ATP to dissolve phosphorus.

Table 4. Results of Two-Way Anova Analysis of Phosphorus Content

Tests of Between-Subjects Effects

Dependent Variable: Phosphorus_Content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.009[a]	3	.003	16.571	.001
Intercept	.252	1	.252	1441.714	.000
Main_Ingredient	.007	1	.007	42.857	.000
Bioaktivator	.001	1	.001	6.857	.031
Main_Ingredient * Bioaktivator	.000	1	.000	.000	1.000
Error	.001	8	.000		
Total	.262	12			
Corrected Total	.010	11			

a. R Squared = .861 (Adjusted R Squared = .809)

Based on the bar graph of Figure 5. there are differences in each treatment combination. These results align with the statistical analysis results using two-way ANOVA analysis. The results of the ANOVA show that the main ingredients with phosphorus content are sig. 0.00 < 0.05, then there is a difference in the results of the average phosphorus content based on the main ingredient. From the results of this analysis, we can interpret that the concentration of the main ingredients significantly affects the phosphorus content. This is similar to the result between the bioactivator with phosphorus content and sig. 0.031 <0.05, then there is a difference in the average phosphorus content based on the bioactivation, and the concentration of the bioactivator significantly affects the phosphorus content. Meanwhile, the interaction between the main ingredient and the bioactivator was sig. 1.000 > 0.05 results show no interaction between the concentration of the main ingredient and the bioactivator on the percentage of phosphorus content. It can also be seen in Table 2 and Figure 5. B1P1 treatment with a 25 ml bioactivator has a higher percentage of 0.16% phosphorus content than B2P2 with a 30 ml bioactivator having a proportion of 0.13%. However, the concentration of duck manure in the B1P1 treatment was higher than in B2P2.

The treatment with higher duck manure had a higher percentage of phosphorus than with higher trembesi leaves. This is because the phosphorus content in duck manure is 0.92% higher (Safriyani, 2020) compared to trembesi leaves, which have a phosphorus content of 0.12% (Darma, 2020), so a solid organic fertilizer with phosphorus content is obtained by the provisions of SNI 19-7030-2004, where the phosphorus content contained in organic fertilizer is at least 0.10%.

3.2.3 Potassium content

Based on Table 2. and Figure 5. the B2P1 treatment has the highest percentage of potassium content of 0.20%, while the B1P1 treatment has the lowest potassium percentage of 0.17%. These results indicate that the treatment with higher concentrations of trembesi leaves had a higher percentage of potassium than the treatment with higher concentrations of duck manure.

Table 5. Results of Two-Way Anova Analysis of Potassium Content

Tests of Between-Subjects Effects

Dependent Variable: Potassium_Content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.002[a]	3	.001	4.563	.038
Intercept	.414	1	.414	3108.063	.000
Main_Ingredient	.001	1	.001	10.562	.012
Bioaktivator	8.333E-006	1	8.333E-006	.062	.809
Main_Ingredient * Bioaktivator	.000	1	.000	3.062	.118
Error	.001	8	.000		
Total	.417	12			
Corrected Total	.003	11			

a. R Squared = ,631 (Adjusted R Squared = ,493)

Based on Table 2. and Figure 5. the B2P1 treatment has the highest percentage of potassium content of 0.20%, while the B1P1 treatment has the lowest potassium percentage of 0.17%. The two-way ANOVA analysis showed that the main ingredients with potassium content obtained sig. 0.012 < 0.05, so there is a difference in the average percentage of potassium based on the main ingredient. These results indicate that the concentration of the main ingredient significantly affects the presence of potassium content. Based on Table 2, the treatment with a higher concentration of trembesi leaves has a higher potassium percentage. While the results of the two-way ANOVA analysis between bioactivators with potassium content sig. 0.809 > 0.05, so there is no significant difference in the average potassium percentage based on the bioactivator. These results indicate that there is no effect of bioactivation concentration on the percentage of potassium content. As seen in Table 2. the B2P1 treatment with 25 ml of papaya peel local microorganisms had a potassium percentage of 0.20% higher than the B2P2 treatment with 30 ml of papaya peel local microorganisms. The interaction between the main ingredient and the bioactivator obtained sig. 0.118 > 0.05 results indicate no interaction between the main ingredient and the bioactivator on the percentage of potassium content.

Treatment with higher concentrations of trembesi leaves had a higher percentage of potassium than treatments with higher concentrations of duck manure. This is because the potassium content in trembesi leaves is 0.62% higher (Darma, 2020) compared to the potassium content in duck manure which has potassium of 0.53% (Safriyani, 2020). So that organic fertilizer is produced by the provisions of SNI 19-7030-2004, where the potassium content in organic fertilizer is at least 0.20%.

Microbial speed can affect the nutrient content level in fertilizer during fermentation. Each microbe has a different speed in decomposing organic matter. This statement is in line with Kusumadewi's research (2019); The results showed that the nutrient content of fertilizers in each treatment was different because the speed of microbes decomposing organic matter was different, where microbial activity during the fermentation process could be influenced by environmental factors such as temperature and pH.

4. CONCLUSIONS

Based on the results of the study, it can be concluded that a solid organic fertilizer combination of duck manure and trembesi leaves with the addition of local microorganisms papaya peel as a bioactivation has sensory quality by standard provisions (SNI No 19-7030-2004) with the color of the fertilizer being blackish brown, having a scent like soil, crumbly textured, and a pH of around 7, as well as the nutrient content of Nitrogen, Phosphorus, Potassium which meets the minimum requirements of the standard provisions of SNI No 19-7030-2004. Of the four treatments, the best sensory quality was found in the B2P2 treatment (200 g duck manure + 300 g trembesi leaves with 30 ml papaya fruit peel local microorganisms). While the highest Nitrogen and Phosphorus content was found in the B1P2 treatment (300 g duck manure + 200 g trembesi leaves with 30 ml papaya

peel local microorganisms), and the highest Potassium content was in the B2P1 treatment (200 g duck manure + 300 g trembesi leaves with microorganisms local papaya peel 25 ml).

5. ACKNOWLEDGMENTS

We want to thank all those who have helped us compile this scientific article so that this scientific article can be completed. This scientific article can be helpful for reading and reference.

6. REFERENCES

Akbar, N. A., and Asngad, A. 2022. Pemanfaatan Limbah Nanas Dan Limbah Bulu Ayam Sebagai Bahan Baku Pop Dengan Penambahan Lumbricus Terrestis Dan Tenebrio Molitor Sebagai Dekomposer. *Prosiding Seminar Nasional Pendidikan Biologi dan Saintek* 45.

Amalia, D. W., and Widiyaningrum, P. 2016. Penggunaan Em4 Dan Mol Limbah Tomat Sebagai Bioaktivator Pada Pembuatan Kompos. *Life Science* 5(1): 22.

Andriawan, F., Walida, H., Syawal Harahap, F., and Sepriani, Y. 2022. Analisis Kualitas Pupuk Kascing Dari Campuran Kotoran Ayam, Bonggol Pisang Dan Ampas Tahu. *Jurnal Pertanian Agros* 24(1): 423–428.

Badan Standar Nasional. 2004. SNI 19-7030-2004 tentang *Spesifikasi Kompos dari Sampah Organik Dosmestik.*

Darma, S., Ramayana, S., Sadaruddin, and Suprianto, B. 2020. Investigasi Kandungan C Organik, N, P, K dan C/N ratio Daun Tanaman Buah Untuk Bahan Pupuk Organik. *Agroekoteknologi Tropika Lembab* 3(1): 12–18.

Darmawan, R., Juliastuti, S. R., Hendrianie, N., Gunawan, S., and Aparamarta, H. W. 2018. Organic Fertilizer Potential Using Aspergillus Pseudomonas putida and Effective Microorganisms from Coconut Water Waste in Ponorogo , East Java - Indonesia. 03028: 4–7.

Ekawandani1, N., and Kusuma, A. A. 2018. Pengomposan Sampah Organik (Kubis Dan Kulit Pisang) Dengan Menggunakan Em4. *TEDC* 12(1): 38–43.

Kaswinarni, F., & Nugraha, A. A. S. 2020. Kadar Fosfor, Kalium dan Sifat Fisik Pupuk Kompos Sampah Organik Pasar dengan Penambahan Starter EM4, Kotoran Sapi dan Kotoran Ayam. *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, *12*(1), 1-6.

Kumalasari, R., and Zulaika, E. 2016. Pengomposan Daun Menggunakan Konsorsium Azotobacter. *Jurnal Sains Dan Seni ITS* 05(02): 64–66.

Kurniawan, C. A., Afriani, M., and Maulana, A. 2021. Studi Literatur: Uji Kemampuan Konsorsium Isolat Bakteri Selulolitik Dalam Mempercepat Dekomposisi Tandan Kosong Kelapa Sawit. *Jurnal Ilmu Tanah dan Lingkungan*, *23*(1), 28-32.

Kurniawan, E., Ginting, Z., and Nurjannah, P. 2017. Pemanfaatan Urine Kambing Pada Pembuatan Pupuk Organik Cair Terhadap Kualitas Unsur Hara Makro (NPK). *Seminar Nasional Sains dan Teknologi 201*.

Kurniawan, J. D., and Chusnah, M. 2021. *Penerapan Kombinasi Pupuk Organik dan Pupuk Kimia Terhadap Pertumbuhan Padi Varetas IN PARI 32*. Lembaga Penelitian dan Pengabdian Masyarakat Universitas KH. A Wahab Hasbullah, Jombang.

Kusumadewi, M. A., Suyanto, A., and Suwerda, B. 2019. Kandungan Nitrogen , Phosphor , Kalium , dan pH Pupuk Organik Cair dari Sampah Buah Pasar Berdasarkan Variasi Waktu. 11(2): 92–99.

Mangungsong, A., Soemarsono, & Zudri, F. (2019). Pemanfaatan Mikroba Tanah dalam Pembuatan Pupuk Organik serta Peranannya terhadap Tanah Aluvial dan Pertumbuhan Bibit Tanaman Kakao Utilization of Soil Microbes in the Production of Organic Fertilizers and Their Role in Alluvial Soil and Growth of Cocoa S. *J. Agron*, *47*(3), 318–325.

Puspitasari, Y., Suryanti, and Nontji, M. 2022. Lama Fermentasi Dan Volume Effective Microorganism-4 (Em4) Dalam Pembuatan Pupuk Organik Padat Berbahan Dasar Serbuk Gergaji Kayu Dan Kotoran Ayam. *AGrotekMAS* 3(2): 133.

Rahman, A., Rusmini, and Daryono. 2022. Isolasi Dan Karakterisasi Morfologi Bakteri Dekomposer Limbah Kulit Udang Dan Limbah Kelapa. *Median* 14(3): 120–129.

Safriyani, E., Hasmeda, M., Munandar, Sulaiman, F., and Holidi. 2020. Increasing the growth and production of irrigated rice through the integrated application of rice-duck-azolla. *Acta Agrobotanica* 73(2): 1–8. DOI: 10.5586/AA.7322

Suwahyono, U. 2017. *Panduan Penggunaan Pupuk Organik*. Swadaya Grup, Jakarta.

Suwatanti, E., and Widiyaningrum, P. 2017. Pemanfaatan MOL Limbah Sayur pada Proses Pembuatan Kompos. *Jurnal MIPA* 40(1): 1–6.

Wicaksono, G. D., and RJ, S. H. 2022. Analisis NPK Pupuk Organik Cair Limbah Ikan Nila dengan Pemanfaatan Mikroorganisme Lokal Kulit Pepaya. *Jurnal FishtecH* 11(1): 47–57.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Inventory of Moss Plants (Bryophyta) in the Montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province

Eva Diahayu Wardani[1] and Santhyami[1,2*]
[1]Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
[2]Environmental Study Centre, Universitas Muhammadiyah Surakarta, Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
[*]Corresponding Author. E-mail address: san915@ums.ac.id

KEYWORDS:
Moss
Montana zone
Inventory
Abiotic
Distribution

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Green plants known as moss plants (Bryophyta) are considered low plants. Mosses can dwell in tropical regions, the highlands, and the lowlands, and some species even live in water. Temperature, humidity, living conditions, light intensity, habitat pH, substrate, and altitude are all known to have an impact on moss growth. At a height of 1,500–2,400 meters, in the montana zone, the diversity of species declines. Samiran Village, Selo District, Boyolali Regency, Central Java Province is one of the locations in the montana zone. Numerous variables in this location contribute to the habitat for moss growth. This study aims to ascertain the diversity and distribution of moss plants (Bryophyta) in the montana zone, Samiran Village, Selo District, Boyolali District, Central Java Province. There has never been researching on the inventory of moss plants in the montana zone of Samiran Village, Selo District. The study's findings revealed three divisions, Bryopsida, Hepacopsida, and Anthoceropsida, which were further divided into seven families, Marchantiaceae, Hypnaceae, Pottiaceae, Polytrichaceae, Lejeuneaceae, and Anytoniaceae. At an elevation of 1600–1800 meters above sea level, in the montana zone of Samiran Village, Selo District, Boyolali Regency, Central Java Province, the index value of moss plant diversity is 1.679, which is categorized as moderate. This is so because the study site functions well as a moss plant habitat.

1. INTRODUCTION

A less-noticed part of biodiversity is moss. The humidity, temperature, the environment in which it lives, the amount of light, and the pH of the environment all have an impact on moss growth. Its development may also be aided by the presence of substrates including dirt, rocks, and bark (Santi 2021). The degree of moss dominance can be impacted by abiotic factors including height. The group of epiphytic plants also includes moss plants, which are poikilohydric, meaning that the turgor pressure of their body cells depends on the humidity of the surrounding environment.

Green plants known as moss plants (Bryophyta) are considered low plants. Bryopsida, Hepaticopsida, and Anthocerotopsida are the three major divisions of the phylum Bryophyta. The three Bryopsida divisions can easily be distinguished from vascular plants due to their very distinctive features. Because they initially appear unsightly and are frequently blamed for making the environment appear unclean, moss plants are a type of biodiversity plants that have not been investigated very extensively (Wati et al. 2016).

The montana zone is a mountainous region located between 1500 and 2400 meters above sea level. Typically, this area is covered in dense vegetation with skinny stems. Ferns and mosses can be found in the montana zone. Only the second stratum in the sub-mountain zone restricts the height of the trees in this zone (Anesta et al. 2020). Moss is one of the main plant types that may be found in the montana zone. Because they can protect themselves and rehydrate when moisture

is present, even when they lose a lot of water, mosses can survive in extremely dry or cold settings. (Jayanti 2020). One of the wet tropical forest formations that develops in high places is mountain forest, also known as montane forest (Hilwan and Wiraatmadja 2021). This forest is notable for its frequent cloud cover, which typically occurs at the height of the canopy roof. These forests have a lot of moss, which covers the trees and the ground frequently. The ability to withstand soil erosion, lessen the risk of flooding, absorb water during the dry season, maintain moisture, produce oxygen through a quick photosynthesis process, and act as a pollutant absorber are just a few of the traits and functions that moss species possess.

Based on the background above, research on the inventory of moss plants in the montana zone of Samiran Village, Selo District, Boyolali Regency, Central Java Province has never been carried out and information about the types of moss plants that exist is not yet available, so it is necessary to find information about the types and distribution of moss plants in the montana zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province. Therefore, this study aims to determine the species diversity and distribution of moss species (Bryophyta) in the montana zone of Samiran Village, Selo District, Boyolali Regency, Central Java Province.

2. MATERIALS AND METHODS

Sampling Location and Sampling

This sort of observational research is concerned with the cataloging of moss plants (Bryophyta) in the montana zone of Samiran Village, Selo District, Boyolali Regency, Central Java Province. This study was carried out in the Central Java Province's montana Zone, Samiran Village, Selo District, and Boyolali District. This study was done at a height of between 1600 and 1800 meters above sea level, which is where the montane zone begins. The study site is situated in Samiran Village, Selo District, Boyolali Regency, Central Java Province, along the Mount Merapi climbing route. Area maps, a GPS, digital cameras, thermohygrometers, stationery, lux meters, lups, altimeters, soil testers, and meters are among the equipment utilized. The moss plants (Bryophyta) employed in this study are located in the montana zone of Samiran Village, Selo District, Boyolali Regency, Central Java Province, between an altitude of 1600 masl and 1800 masl. The procedures for carrying out the research are as follows: 1) Determining the stations and points to be carried out based on the type of research and limiting moss plants in the montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province. Determination of the station is chosen based on the height of the montana zone and the cost of the point totaling 21 points, each of which is 10 meters (Susilo et al. 2022). 2) Conduct investigation. 3) Calculate the coordinates, height, temperature, air humidity, soil pH, and light intensity of the area. 4) With a distance of 10 meters between each location, calculate the cruising point vertically, or up, from 1600 meters to 1800 meters above sea level. 5) Conducting research to locate moss plants at each location. 6) Identify and note the many kinds of moss plants you come across.

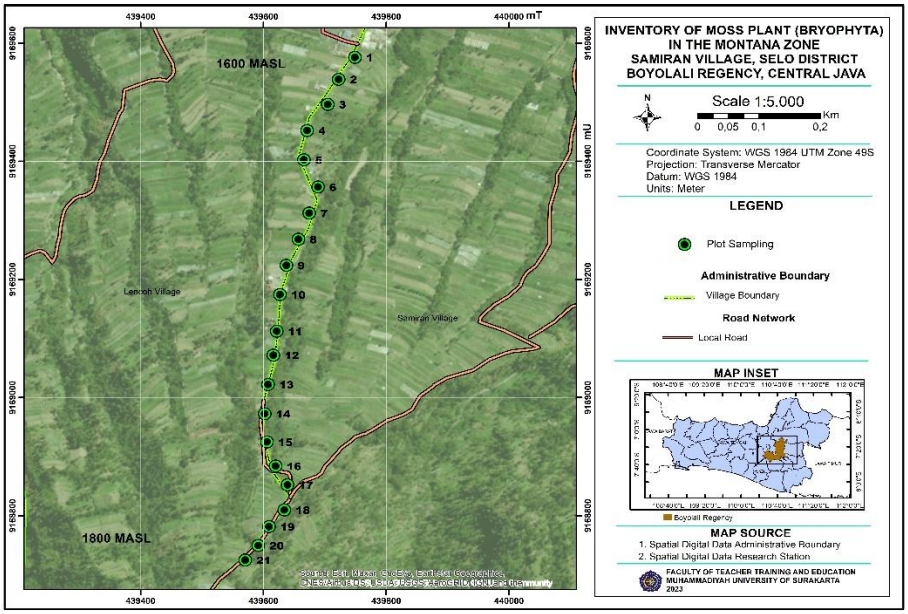


Figure 1. Locations for the map and research

Specimen Collection and Identification

Collections by gathering moss specimens of all species discovered. Thus the results of moss plants were identified at the University Muhammadiyah Surakarta's Biological Laboratory.

Data Analysis

Using the Species Diversity Index formula (Shannon & Wiener 1963), a search was conducted to ascertain the distribution of bryophytes discovered. The bigger the value of, the more diverse the species are. The following criteria are used to define Shannon species diversity value: 1) $\hat{H} > 3$ exhibit high species expertise in an area. 2) $1 \leq \hat{H} \leq 3$ indicates the current species' expertise in an area. 3) $\hat{H} < 1$ show low species yields in an area.

3. RESULTS AND DISCUSSION

The result of an inventory of moss plants found in the montana zone ecosystem of Samiran Village, Selo District, Boyolali Regency, Central Java Province, at an altitude of 1600–1800 meters, include the identification of 7 families: Marchantiaceae, Hypnaceae, Pottiaceae, Polytrichaceae, Lejeuneaceae, Anthocerotaceae, and Anytoniaceae. (Table 1). The Marchantiaceae family of moss plants, specifically *Marchantia treubii* Schiffn and *Marchantia polymorpha* L, were discovered based on the observations. One species was found in the Hypnaceae family, namely *Hypnum cupressiforme* Hedw. In the Pottiaceae family there is 1 species, namely *Barbula consanguiena* A. Jeger. In the family Polytrichaceae, 1 species was found, namely *Pogonatum neesi*. There are one species from the Lejeuneaceae family, namely *Cheilolejeunea meyeniana*. One species was found in the Anthocerotaceae family, namely *Phaeoceros laevis* L. This species lives on moist soil substrates. A total of 1 species from the Anytoniaceae family was found, namely *Reboulia hemisphaerica* L.

The ability of moss plants to survive can be impacted by host availability (Marhento and Zaenab 2021). Three substrates soil, aged trees, and rocks are employed as a place for mosses to live, according to the data collected. How well moss plants can support life depends on the presence of hosts. From the data collected, it has been determined that soil, worn trees, and rocks are the three substrates that serve as homes for mosses. (Table 1). This is consistent with research Fanani et al (2019) that shows lower plants like mosses may grow on a variety of substrates, such as rocks,

soil, trees, worn wood, and litter. The damp soil has the maximum moss growth on it of the three substrates that are covered in moss at a height of 1600–1800 meters above sea level. According to research Krisnawati (2022) moss habitats are on the ground because soil may create a variety of substrates that serve as a stable platform for spore germination and moss growth. Moss spores fall to the ground during the rainy season where they germinate to become new moss plants. The reason worn wood is a favorable substrate for moss growth, according to study Putri et al (2019) is because it holds water between its wood cells, creating a high humidity and the nutrients mosses require to grow.

The moss plants that inhabit a habitat are influenced by a number of additional elements in addition to the substrate. According to studies Purbasari and Akhmadi (2019) in addition to substrate, living moss plants need abiotic elements to support their growth, including humidity, light intensity, temperature, and soil pH.

Table 1. Types and Habitats of Moss Plants (Bryophyta) in the Montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province.

Num	Species	Family	Division	Number of Individuals	Habitats	Altitude and literature source
1	*Hypnum cupressiforme* Hedw.	Hypnaceae	Bryopsida	589	Soil, rocks, weathered trees	800 m asl (Kartikasari et al. 2023)
2	*Marchantia treubii* Schiffn	Marchantiaceae	Hepaticae	294	Soil and rocks	50-100 m asl (Azwir et al. 2022)
3	*Barbula consanguiena* A. Jeger	Pottiaceae	Bryopsida	222	Soil, rocks, weathered trees	<100 m asl, 100-200 m asl, 200-500 m asl, and >500 m asl (Aripulis and Sujadmiko 2019) 108 m asl (Salamah et al. 2019)
4	*Pogonatum neesi*	Polytrichaceae	Bryopsida	142	Soil	Around 1.000 m asl (Roziaty et al. 2019)
5	*Reboulia hemisphaerica* L.	Anytoniaceae	Hepaticopsida	118	Soil and rocks	<100 m asl, 100-200 m asl, 200-500 m asl, and >500 m asll (Aripulis and Sujadmiko 2019)
6	*Phaeoceros laevis* L.	Anthocerotaceae	Anthoceropsida	81	Soil	700-1.500 m asl (Pratama et al. 2022)
7	*Marchantia polymorpha* L.	Marchantiaceae	Hepaticae	31	Soil	1400 m asl (Febriansyah et al. 2019)
8	*Cheilolejeunea meyeniana*	Lejeuneaceae	Hepaticae	15	Soil	Lowland (Putrika et al. 2017)

Bryophyta has 3 divisions namely Bryopsida, Hepaticopsida, and Anthocerotopsida (Figure 2). Three of these divisions were discovered by observation and identification of moss plants at altitudes between 1600 and 1800 meters. This is evident from the varied morphologies and properties of the moss plants in each division. The three Bryopsida divisions can easily be distinguished from vascular plants due to their very distinctive features. Although most moss plants lack vascular tissue or are sometimes referred to as nonvascular plants, some species nevertheless contain water-carrying vessels (Lukitasari 2019).

Due to the complexity of the gametophyte and sporophyte, leaf mosses (Bryopsida) are the most developed mosses. The upright habitus and the body's differentiation into rhizoids, cauloids,

and phylloid are traits of the Bryopsida class (Sujadmiko and Vitara, Pantalea 2021). The liverworts, or Hepaticopsida class, are mosses with gametophytes that have differentiated into stems and leaves and are shaped dorsoventrally. The sporophyte develops elongated after the development of the capsule. While liverworts have a similar body structure to hornworts (Anthocerotopsida), the only distinction is the sporophyte phase. Elongated capsules known as hornwort sporophytes develop into horns (Mulyadi 2014).

Figure 2. Hepaticopsida: *Marchantia treubii* Schiffn (a), Bryopsida: *Barbula consanguiena* A. Jeger (b), dan Anthocerotopsida: *Phaeoceros laevis* L. (c).

The upper montana zone, which has relatively closed environmental conditions and high humidity, is where this species of big moss may be found (Nadhifah 2018). According to information obtained from the identification of the moss type *Marchantia treubii* Schiffn, it can be found living on soil and rock substrates, but is primarily found on soil substrates. It has a slightly thick thallus with a purple center line. In addition to growing in the montana zone, *Marchantia treubii* Schiffn can also be found at elevations lower than 1,000 meters above sea level. This is consistent with studies Azwir et al (2022) showing the *Marchantia treubii* Schiffn species can be found in the Great Mosque Forest of Aceh Besar District at an elevation range of 50 to 100 meters above sea level.

The species *Marchantia polymorpha* L. identified in this study has a light green, branching, thick, stiff, and fleshy thallus that forms a flat rosette. It is also found in damp soil. According to studies Solihat and Kurnia (2021), the talus's base and end are both blunt or flat, its tip is wavy and branch-like, and the talus itself is thick and stiff. This variety of moss can be found in areas with favorable conditions for moss plant life, not just in the montana zone. According to research Febriansyah et al (2019), *Marchantia polymorpha* was found growing on a soil substrate with an altitude range of 1400 m above sea level in the Parangkikis waterfall which is one of the mountainous areas in Gambiran Village, Pagerwojo District, Tulungagung.

The *Hypnum cupresiforme* species, which has a green thallus and is found growing and crawling on weathered rocks, soil, and trees, belongs to the Hypnaceae family. This moss has overlapping and intersecting leaves. The size of this moss is modest to medium. The branched stalks have leaves on them. It is well known for this species to dwell outside of its natural habitat. so that it might have a habitat that is not limited to the montana region. According to research Kartikasari et al (2023), *Hypnum cupresiforme* has a stem that is almost entirely covered in leaves and long, curved, green leaves with a pointed tip. About 800 meters above sea level is the altitude at which this kind of moss can be found.

A *Consanguineous barbula* A. Jeger has a low, fringed talus that is distinguished by its pale green hue. langued leaves. A spore capsule with a diameter of 0.3 cm, a reddish-brown color, and

a tube-like shape with a point is present. The moss *Barbula consanguiena* A. Jeger is a member of the Pottiaceae family. This particular variety of moss is typically found 1,300 meters above sea level. According to Aripulis and Sujadmiko (2019), the species *Barbula consanguiena* A. Jeger was discovered to grow at altitudes of 100 masl, 100–200 masl, 200–500 masl, and >500 masl. According to research, *Barbula consanguiena* A. Jeger was discovered in the Selarong Cave Area, which is situated in Bantul at an altitude of around 108 m asl (Salamah et al. 2019). This demonstrates that the moss plant *Barbula consanguiena* A. Jeger is not restricted to the montane zone.

The group of leaf mosses includes the moss plant species *Pogonatum neesi*. *Pogonatum nesii* typically grows between 700 and 2210 m above sea level, ranging from the lowlands to the highlands. *Pogonatum neesi* is a species that grows at an altitude of roughly 1,000 m asl (Roziaty et al. 2019). This shows that *Pogonatum neesi* is not only found in the montana zone.

Cheilolejeunea meyeniana is a moss that belongs to the class of leafy liverworts. The thallus of the *Cheilolejeunea meyeniana* moss has lateral leaves that are light green to yellowish in color. The shape is ovoid to elongated with a blunt tip and flat leaf edges. This moss has rhizoids with a length of 0,5 cm - 1 cm which are light brown in color. This type of moss is also found as an epiphyte in urban forests and on the main roads of the University of Indonesia campus (Putrika et al. 2017)

The thallus of *Phaeoceros laevis* L. is light green in color and measures 2 cm long by 2 cm wide. The thallus shape forms clusters with horn-shaped sporophytes. This species can be found elsewhere besides the montana region. However, it is also present at elevations lower than 1600 meters above sea level. *Phaeoceros laevis* L. is a type of hornwort that belongs to the Anthocerotophyta division, according to research Pratama et al (2022). This species can be found at the Nature Conservation Education Center Bodogol (PPKAB), which is a part of the Mount Gede Pangrango National Park (TNGGP), at an elevation of between 700 and 1,500 meters above sea level.

Reboulia hemisphaerica has a thick talus that widens from light green to dark green. The rhizoid is the place where the moss attaches to its substrate. The rhizoid or root of *Reboulia hemisphaerica* has a size of 4 cm, brownish white, cylindrical and fibrous. According to research Aripulis and Sujadmiko (2019) that at a range of altitudes, namely <100 masl, 100-200 masl, 200-500 masl, and >500 masl in Sleman Regency, *Reboulia hemisphaerica* was found, this is because the ambient temperature at that altitude is still optimal for growth. mosses in the tropics.

At an altitude of 1600 masl–1800 masl, moss plants (Bryophyta) with the division of leaf mosses (Bryopsida) are most frequently found. The leaf moss species with the highest population at the study site is *Hypnum cupressiforme* Hedw., which has a good survival rate. According to research Ivone et al (2022), mosses are frequently found in a variety of environments because they have a very wide geographic range and the greatest number of species when compared to other classes. These leaf mosses (Bryopsida) can flourish in grasses, amid rocks, on tree trunks, and on barren land that occasionally encounters drought. The identified division of hepaticopsida has a smaller number of individuals than the division Bryopsida. *Marchantia treubii* Schiffn is included in the liverwort which has a smaller number of individuals than the *Hypnum cupressiforme* Hedw species which is included in the leaf moss division. Meanwhile, the number of individuals from the division of anthocerotopsida has the least number, because the moss plants from this division are more susceptible to growth. This is in line with research Gista et al (2020) that few or even no hornworts are found due to the small distribution of hornworts in nature and are a small group in Bryophyta of less than 100 species with 8-9 genera.

Table 2. Species Diversity Index (H') Mosses (Bryophyta) in the Montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province.

Altitude Point	H’	Information
1.600 m asl-1800 m asl	1,679	Moderate

The level of diversity of moss species from an altitude of 1600 masl to 1800 masl in the montana zone of Samiran Village, Selo District, Boyolali Regency, Central Java Province is classified as moderate, as indicated by the Shannon-Wiener (H') diversity index value of 1.679 (Table 2). The significance of the derived moss species diversity demonstrates how variations in an ecosystem's or environment's conditions can have an impact on the diversity of moss plant species. In addition, removing land may result in less plant diversity of a particular kind.

Although the environment at the research site is suitable for moss growth, human activities and the opening of natural attractions have led to a moderate level of species diversity. According to research Raihan et al (2018), a community is said to have high species diversity if there are many species present together with a fairly even distribution of each species' members. The presence of physical-chemical elements in the environment, as well as the availability of nutrients, can contribute to the high or low values of diversity at each research location. These factors also have a significant impact on the diversity of the moss itself.

Table 3. Abiotic factors of moss plants (Bryophyta) in the Montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province.

Abiotic Factors	Altitude Point	
	1.600 m asl	**1.800 m asl**
Air temperature (°C)	28,7	21,3
Humidity (%)	57	73
Soil pH	6	6
Atmospheric pressure (atm)	835,4	815,6
Light intensity (Cd)	18200	2180

Moss growth is generally influenced by several factors including temperature, humidity, living habitat, light intensity, and habitat pH and altitude. The research location at an altitude of 1600 masl has an air temperature of 28.7 °C and at an altitude of 1800 masl has an air temperature of 21.3 °C, this supports moss plants living on the available substrate. According to studies Azwad et al (2020), mosses grow best at temperatures between 15 and 25 °C and can tolerate temperatures between 40 and 50 °C. Samiran Village, Selo District's montana zone has a temperature that is still suitable for moss growth and development since mosses can survive in environments with air temperatures between 40 and 50 degrees Celsius.

Altitude can affect the growth of moss plants. Air humidity at an altitude of 1600 masl, namely 57%, can be found to be less optimal for moss growth while at an altitude of 1800 m asl, it is 73% which indicates that 73% humidity can support moss growth. This is in line with research Sopacua et al (2020) that humidity also supports moss growth, in general, mosses require relatively high humidity to support their growth. Moss can live in a humidity range between 70% -98%.

Moss plants require a strong amount of light to perform photosynthesis. The level of humidity will drop if the light intensity is quite high. This is due to the fact that the ambient temperature rises when more light is allowed to reach the moss-growing region or substrate. 10,000 lux is the recommended light intensity for moss plants to grow at in order to support photosynthesis Yohendri et al (2021). At an altitude of 1600 masl, it has a light intensity of 18200 Cd, while at an altitude of 1800 masl it is 2180 Cd. So that at an altitude of 1800 meters above sea level, it is still a good habitat for mosses.

4. CONCLUSIONS

Based on the results of the research and discussion it can be concluded that the identified mosses consist of 3 divisions namely Bryopsida, Hepacopsida, and Anthoceropsida which consist of 7 families namely Marchantiaceae, Hypnaceae, Bryaceae, Polytrichaceae, Lejeuneaceae, Anthocerotaceae, and Anytoniaceae. From the observations, 2 species were found from the family

Marchantiaceae, namely *Marchantia treubii* Schiffn and *Marchantia polymorpha* L. In the family Hypnaceae, 1 species was found, namely *Hypnum cupressiforme* Hedw. This species has the most number of individuals found. In the Pottiaceae family there is 1 species, namely *Barbula consanguiena* A. Jeger. In the family Polytrichaceae, 1 species was found, namely *Pogonatum neesi*. One species was found in the Lejeuneaceae family, namely *Cheilolejeunea meyeniana*. A total of 1 species from the Anthocerotaceae family, namely *Phaeoceros laevis* L. One species was found from the Anytoniaceae family, namely *Reboulia hemisphaerica*. There are 3 substrates used as a place for moss to live, namely rocks, weathered bamboo, and soil. Based on these three substrates, moss grows the most on moist soil substrates. On these three substrates, not all moss plant species can be found. According to the Shannon-Wiener (H') diversity index value of 1.679, the diversity of moss plant species in the montana zone of Samiran Village, Selo District, is in the moderate range.

5. REFERENCES

Anesta, A. F., Fatman, A. F., and Sugandi, M. 2020. Zonasi Distribusi Tanaman Hutan di Taman Nasional Gunung Semeru Berdasarkan Integrasi Nilai Indeks Vegetasi dan Digital Elevation Model. *Jurnal Geosains dan Remote Sensing* 1(2): 64–70.

Aripulis, S., and Sujadmiko, H. 2019. Keanekaragaman Lumut Di Lingkungan Sekolah Menengah Di Kabupaten Sleman, D.I.Y. Sebagai Penunjang Pembelajaran Biologi Aplikatif (1). 15(2): 1–12.

Azwad, R., Tavita, G. E., and Prayogo, H. 2020. Jenis-Jenis Lumut (Bryophyta) Di Hutan Sekunder Desa Sepandan Kecamatan Batang Lupar Kabupaten Kapuas Hulu. *Jurnal Hutan Lestari* 8(2): 230–238.

Azwir, Maulidia, Jaluddin, and Saputra, S. 2022. Infentarisasi Keanekaragaman Tumbuhan Lumut (Bryophyta) Di Hutan Kecamatan Mesjid Raya Kabupaten Aceh Besar Sebagai Media Pembelajaran Biologi. *Jurnal Biology Education* 10(2): 94–102.

Fanani, M., Afriyansyah, B., and Haerida, I. 2019. keanekaragaman Lumut (Bryophyta) di Bukit Muntai Kabupaten Bangka Selatan. *Jurnal Penelitian Biologi dan Pertanian* 1(13): 43–47.

Febriansyah, R., Setyoati, E., and Fauziah, A. 2019. Identifikasi Keanekaragaman Marchantiophyta Di Kawasan Air Terjun Parangkikis Pagerwojo Tulungagung. *Jurnal Biologi dan Pembelajarannya (JB&P)* 6(2): 17–21.

Gista et al. 2020. Pengembangan Ensiklopedia Lokal Melalui Identifikasi Bryophyta di Desa Munggut Kabupaten Madiun. *Prosiding Seminar Nasional SIMBIOSIS V* 28(1): 1–11.

Hilwan, I., and Wiraatmadja, A. P. 2021. Penyebaran Jenis Jirak (Symplocos fasciculata Zoll.) di Resort Kawah Ratu Taman Nasional Gunung Halimun Salak, Jawa Barat. *Journal of Tropical Silviculture* 12(1): 23–29.

Ivone, N. N., Irwandi, and Hartati, M. S. 2022. Jenis-Jenis Tumbuhan Lumut (Bryophyta) Pada Berbagai Substrat Di Desa Pasar Melintang Kota Bengkulu. *Prosiding Seminar Nasional Biotik* 9(2): 27.

Jayanti, U. N. A. D. 2020. *Keanekaragaman Tumbuhan: Modul Inkuiri Berbasis Potensi Dan Kearifan Lokal*. Ahlimedia Book, Malang.

Kartikasari, D., Widodo, G. A., Habibah, N., and Asna, R. Z. 2023. Jurnal Riset Biologi dan Aplikasinya. *Jurnal Riset Biologi dan Aplikasinya* 5(1): 43–51.

Krisnawati, Y., and Wardianti, Y. 2022. Jenis-Jenis Lumut Di Bukit Reli Kabupaten Musi Rawas, Sumatera Selatan. *Journal of Scientech Research and Development* 4(2): 130–137.

Lukitasari, M. 2019. *Mengenal Tumbuhan Lumut (Bryophyta) Deskripsi, Klasifikasi, Potensi Dan Cara Mempelajarinya*. CV. AE MEDIA GRAFIKA, Magetan.

Marhento, G., and Zaenab, C. 2021. Biodiversitas Lumut Epifit di Gunung Kendeng Dalam Kawasan Taman Nasional Gunung Halimun Salak Jawa Barat. *Seminar Nasional Perhimpunan Masyarakat Etnobiologi Indonesia* 78–82.

Mulyadi, H. 2014. *Botani Tumbuhan Rendah*. Syiah Kuala University Press, Banda Aceh.

Nadhifah, A. dkk. 2018. Keanekaragaman lumut (Musci) Berukuran Besar pada Zona Montana Kawasan Hutan Lindung Gunung Sibuatan, Sumatra Utara. *Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia* 4(2): 101–106.

Pratama, A. A., Kurniasih, S., and Prasaja, D. 2022. Keanekaragaman Bryophyta di Kawasan Pusat Pendidikan Konservasi Alam Bodogol. *Jurnal Penelitian Ekosistem Dipterokarpa* 8(2): 131–140.

Purbasari, Y., and Akhmadi, A. 2019. Keanekaragaman Bryophyta Di Dusun Candik Kabupaten Jember. *BIOMA* 84(10): 1511–1518.

Putri, S. E., Prayogo, H., and Wulandari, R. S. 2019. Inventarisasi Jenis-Jenis Lumut Di Kawasan Hutan Adat Bukit Benuah Kabupaten Kubu Raya. *Jurnal Hutan Lestari* 7(3): 1036–1047.

Putrika, A., Nisyawati, and Ariyanti, N. S. 2017. Keragaman Lumut Epifit di Hutan Kota dan Tepi Jalan Utama Kampus Universitas Indonesia. *Jurnal Bio-Site* 03(1): 25–38.

Raihan, C., Nurasiah, and Zahara, N. 2018. Keanekaragaman Tumbuhan Lumut (Bryophyta) di Air Terjun Peucari Jantho Kabupaten Aceh Besar. *Prosiding Seminar Nasional Biotik* 5(2): 439–451.

Roziaty, E., Agustina, P., and Rohmah, S. N. 2019. Inventory of Epiphytic Moss in the Tree Trunk Zonation of Jumog Waterfall Ngargoyoso Tawangmangu Karanganyar Central Java. *Biogenesis: Jurnal Ilmiah Biologi* 7(2): 73–79.

Salamah, Z., Sasongko, H., and Zulianti, E. 2019. Keragaman Lumut di Area Gua Selarong, Bantul, Yogyakarta Keragaman Lumut di Area Gua Selarong, Bantul, Yogyakarta. *Indonesian Journal of Biology Education* 2(1): 35–39.

Santi, R. 2021. Keanekaragaman jenis lumut (Bryophyta) di Bukit Nenek Taman Wisata Alam Gunung Permisan , Kabupaten Bangka Selatan The diversity of Bryophytes in Nenek Hills , Natural Tourism Park of Mount Permisan , South Bangka Regency. 25(2): 137–146.

Solihat, S. S., and Kurnia, M. F. 2021. Identifikasi Morfologi Marchantia polymorpha dan Leucobryum glaucum di Bojong Menteng, Kecamatan Cijeruk, Kabupaten Bogor, Jawa Barat. *Tropical Bioscience: Journal of Biological Science* 1(1): 33–33.

Sopacua, G., Tamaela, K. A., Sopratu, P., and Selehulano, K. 2020. Inventarisasi Tumbuhan Lumut di Kawasan Air Potang-potang Negeri Itawaka Kabupaten Maluku Utara. *Jurnal Ilmiah Wahana Pendidikan https://jurnal.unibrah.ac.id/index.php/JIWP* 6(3): 295–307.

Sujadmiko, H., and Vitara, Pantalea, E. 2021. *Tumbuhan Lumut di Kampus UGM*. Gadjah Mada University Press, Yogyakarta.

Susilo, F., Pasaribu, N., Syamsuardi, and Siregar, E. S. 2022. Diversity and distribution of liverworts in Mount Sibuatan, North Sumatra, Indonesia. *Biodiversitas* 23(9): 4539–4548.

Wati, T. K., Kiswardianta, B., and Sulistyarsi, A. 2016. Keanekaragaman Hayati Tanaman Lumut (Bryophitha) Di Hutan Sekitar Waduk Kedung Brubus Kecamatanpilang Keceng Kabupaten Madiun. *Florea : Jurnal Biologi dan Pembelajarannya* 3(1): 46.

Yohendri, S., Fafdinal, R., and Zakiah, Z. 2021. Inventarisasi Lumut Daun (Kelas Musci) di Kecamatan Entikong Kabupaten Sanggau Kalimantan Barat. *Jurnal of Biotechnology and Conservation in Wallacea* 01(01): 42–56.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Diversity of Ferns (Pteridophyta) in the Montana Zone, Samiran Village, Selo District, Boyolali Regency, Central Java Province

Indah Rahmawati[1] and Santhyami[1,2*]
[1] Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
[2]Environmental Study Centre, Universitas Muhammadiyah Surakarta, Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: san915@ums.ac.id

KEYWORDS:
Ferns
Montana Zone
Abiotic
Samiran Village
Diversity

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Ferns (Pteridophyta) are one of the Indonesian flora groups with high diversity and wide distribution, one of which is in the montana zone, an ecosystem zone at an altitude of 1500-2400 m asl. Samiran Village is located in the District of Selo, Boyolali Regency, between two mountains, namely Mount Merapi and Mount Merbabu. This type of research was conducted at an altitude of 1600 m asl to 1800 m asl in Samiran Village, Selo District, Boyolali Regency. This study aims to determine the types of ferns and their distribution in the montane zone of Samiran Village, Selo District, Boyolali Regency. The method used is purposive sampling, a data collection technique based on points determined deliberately with a distance of 10 meters with a total of 21 points carried out in the Montane zone of Samiran village. Fern (Pteridophyta) that have been found in the montana zone of Samiran Village, are group into 2 families of 6 species consisting of *Adiantum raddianum* C. Presl, *Notholaena copelandii* c.c. Hall, *Adiantum hispidulum* Sw., *Pityrogramma austroamericana* Domin, *Cyathea arborea* L. Sm, *Antrophyum sessilifolium* (Cav.) Spr. The Diversity value (H') is 1.22, a category as relatively low. Ferns are most commonly found on soil hosts. The most abundant species were dominated by *Adiantum raddianum* C. Presl with 107 individuals at 14 out of 21 points. This species is one type of terrestrial fern that is also often found growing between rocks, pool walls, fences, wells, ditches, river banks other damp places. Therefore, this location is a suitable environment for the growth of *Adiantum raddianum*.

1. INTRODUCTION

Ferns (Pteridophyta) are a type of Indonesian plant that have a diverse range of species (Kurniawati et al., 2016). In addition to flourishing in moderate regions, woodlands, and streams, this plant is frequently seen in tropical rainforests. Additionally, this plant can be found in water (hydrophytes), adhering to other plants (epiphytes), and growing on plant remains (saprophytes) (Hutasuhut & Febriani, 2019). Ferns in the montana zone are exposed to a lot of sunlight so that their fast growth and assisted by the right environmental factors can encourage the growth of ferns so that many variations are found.

Generally speaking, ferns take the shape of herbs, bushes that resemble trees, spores in clustered sporangia, and immature spores that are typically green in color and dispersed or small. On the underside or edge of the leaf, spores are communally living organisms. Whether solitary or complex, ferns have dark green leaves. In most cases, the stems grow on the ground, creep on trees as epiphytes, or float freely in the water; they are rarely visible. The spores' morphological characteristics serve as ferns' defining characteristics. One of the criteria for identifying ferns is

based on their spores (Pranita et al., 2017). Ferns (Pteridophyta) are an important component of biodiversity as a plant community that aids in the development of soil and serves as a cover for vegetation for organisms in the forest. Another function of ferns is as germplasm, as well as food and medicine (Mowata et al., 2020).

The montana zone is an ecological zone located between 1500 and 2400 meters above sea level. Smaller diameter stems vegetation, and lots of mosses and ferns are characteristic of the region. Compared to the submontane zone, this montana zone has lower tree heights. The diversity of tree species in the montana zone is not very high. Exposure to direct sunlight on forest soil can encourage the growth of grass and other plants. The montana zone has shorter trees than the submontane zone. In the mountainous zone, trees are 8–20 m high and have fewer species than the area beneath, the irregular shape of the trunks and low tree density create a lot of bare soil. Plants also became scarce and were replaced by lichens, lichens, bamboo, and shrubs (Anesta et al., 2020) such as needle leaf plants (*Dacrycarpus imbricatus* and *Podocarpus neriifolius*) and puspa plants (*Schima wallichii*) whose species diversity decreases with increasing soil altitude (Supriatna, 2014).

A village called Samiran is located between 1500 and 1800 meters above sea level. Samiran Village is specifically located in Selo District, flanked by Mount Merapi and Mount Merbabu. According to PPID Boyolali, this district experienced quite high rainfall in 2011, with a total of 4.232 mm and 229 rainy days. In general, the Selo sub-district has a moist type C climate that is suitable for the growth of ferns in the region. There are numerous locations and varieties where this fern grows and spreads. Cool environments are ideal for ferns to flourish. Ferns can also be found close to running water, and they have a substrate that is rooted to the ground. Numerous fern species, including those from the tribes Lycopodiaceae, Nepenthes, and Hymenophyllaceae, as well as Coniogramme, Dipteris, Gleichenia, and Blechnum, can be found in the montana zone (Muhaimim et al., 2018).

Ferns were chosen as the subject of the study because they are crucial to the humus-forming process, shield the soil from erosion, and preserve soil moisture. It is vital to conduct a study on ferns in the montana zone of Samiran Village because there is little data and knowledge about the different kinds of ferns there. The purpose of this study is to identify the fern species that can be found in the montana zone, specifically in Samiran Village, Selo District, and Boyolali Regency.

2. MATERIALS AND METHODS

Sampling Location and Sampling

This research was conducted in the montana zone of Samiran Village, Selo District, Boyolali, Central Java (Figure 1). The research was conducted in the montana zone of Samiran Village at an altitude of 1,600–1,800 m asl, with an average air temperature of 20–30 °C and an average humidity of 75–90%. The research was conducted in February - March 2023. The tools used included a thermohygrometer, altimeter, GPS, Lux meter, and soil tester. The materials used are ferns that live in the montana zone (1.600m asl, up to 1.8000m asl) in Samiran Village, Selo District, Boyolali District, Central Java.

The procedures used include 1) Determining stations and points; 2) Measuring location altitude, temperature, air humidity, soil pH, light intensity, and location coordinates; 3) Exploring; 4) Identifying and recording the types of ferns found.

This study used a survey method with a purposive sampling technique. This method was used in the montana zone of Samiran Village in the Selo District of the Boyolali Regency of the Central Java Province. Purposive sampling, which means a data gathering technique based on points that are determined intentionally with a distance of 10 meters and a total of 21 points.

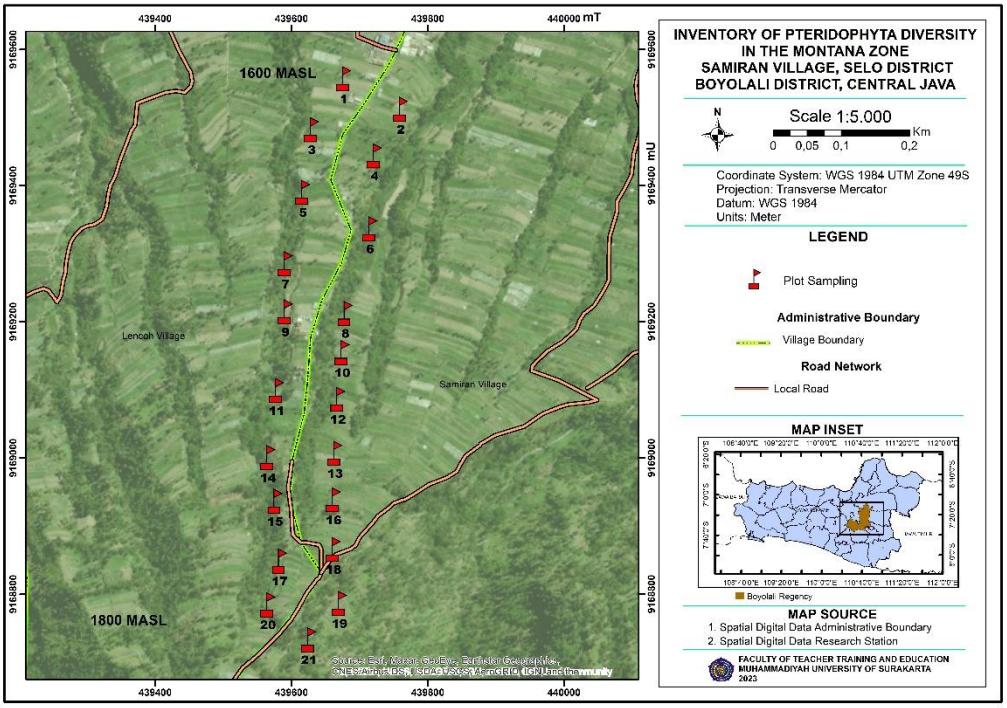


Figure 1. Research map

Specimen Collection and Identification

Collected specimens were identified in the Biology Laboratory Universitas Muhammadiyah Surakarta. Identification was carried out by observing using a monocular microscope and desk study based on the book Flora (Steenis, C.G.G.J., 2013) and Plant Taxonomy (Schizophyta, Thallophyta, Bryophyta, Pteridophyta) by Tjitrosoepomo (1989).

Data Analysis

To determine the distribution, use the Species Diversity Index (Shannon & Wiener 1963) to calculate the value of diversity by dividing the number of individuals of a species by the total number of individuals. Then divide into three groups H<1.5 is low, 1.5<H<3.5 is moderate, or H>3.5 is high (Magurran, 1988).

3. RESULT AND DISCUSSION

From 21 points of the sampling site, we found two families of ferns, namely Pteridaceae and Cyatheaceae (Table 1). The most abundant species was from Pteridaceae. This is due to the fact that certain Pteridaceae fern species may grow at a particular height from open, dry areas to damp, shaded locations (Muswita et al., 2013).

Table 1. Types of Ferns (Pteridophyta) In Montana Zone, Selo District, Boyolali Regency

Num	Species	Family	Number of Individuals	Habitats	Altitude (m asl)	Literature
1	*Adiantum raddianum* C. Presl**	Pteridaceae	107	Land and rock	250 – 2000	Perwati, L. K (2009)
2	*Notholaena copelandii* c.c . Hall	Pteridaceae	87	Land	300 – 1500	Flora Komite Editorial Amerika Utara (1993)

Num	Species	Family	Number of Individuals	Habitats	Altitude (m asl)	Literature
3	*Adiantum hispidulum* Sw	Pteridaceae	39	Land and roc	1345	Taslim, E (2019)
4	*Antrophyum sessilifolium* (Cav.) Spr	Pteridaceae	6	Tree	1836 – 2270	Astuti (2017)
5	*Pityrogramma austroamericana* Domin	Pteridaceae	10	Land	876	Yuskianti, (2018)
6	*Cyathea arborea* L.Sm*	Cyatheaceae	5	Land	1836	Astuti (2017)

Note:
** : The highest number of individuals found
* : The lowest number of individuals found

In the Pteridaceae family, five species have been identified based on the findings of the identification process, including *Adiantum raddianum* C. Presl, *Notholaena copelandii* C.C. Hall, *Adiantum hispidulum* Sw., *Pityrogramma austroamericana* Domin, and *Antrophyum sessilifolium* (Cav.) Spr. However, only one species, *Cyathea arborea* (L) Sm, has been recognized within the Cyatheceae family.

Based on the sorus shape, plant height, and host site, these species are divided into 6 species. The section of the spore that is found in the space between the leaf veins is known as *Cyathea arborea* (L) Sm, and *Pityrogramma austroamericana* Domin. On the leaf's margin is *Adiantum raddianum* C. Presl, *Notholaena copelandii* c.c. Hall, and *Adiantum hispidulum* Sw. Meanwhile, plants that do not have spores are *Antrophyum sessilifolium* (Cav.) Spr. Leaf dots on ferns are signs that a sporangium, or spore box, is present. Ferns produce spores in their sporangium as a way of reproduction (Ulum & Dwi, 2015). Spore morphological traits can be detected by the form, size, and kind of spore laesura. Fern sporangium is found on the underside of the leaf and forms a brown or black circle (Yunita et al., 2021). Sofiyanti et al (2020) investigated spore properties, identifying ferns as having two types of spore laesura, namely monolete and trilete with round, kidney, elliptical, and triangle shapes.

There is also a difference in the growth of these six plants, which is the height of the plants. *Cyathea arborea* L.Sm. is a tall plant that can reach heights of nearly 2-5 meters. *Adiantum raddianum* C. Presl, *Notholaena copelandii* c.c. Hall, *Adiantum hispidulum* Sw, *Pityrogramma austroamericana* Domin, and *Antrophyum sessilifolium* (Cav.) Spr. are among the plants that grow tiny. The tallest ferns, including those in the genus Cyathea, may grow to heights of several meters (Tjitrosoepomo, 2011).

The area where growth is split into three areas, namely land, rocks, and trees. *Notholaena copelandii* c.c. Hall, *Pityrogramma austroamericana* Domin, and *Cyathea arborea* L.Sm. live on the land. The plant's *Adiantum raddianum* C. Presl and *Adiantum hispidulum* Sw. occupy the soil and rock locations. Meanwhile, only *Antrophyum sessilifolium* (Cav.) Spr. grows at the tree location. The soil's habitus, which has a wide canopy form, allows for enhanced humidity and lower solar intensity, resulting in a low temperature and relatively damp zone under the canopy. The amount of ferns that grow is also affected by the height of the ground surface (Nainggolan, 2014). This fern thrives on flat soil, ditches, cliffs, and other types of habitat. The quantity of fern species and individuals present in the soil shows that the soil is an appropriate area to act as a host. This is connected to epiphytic plant spores that fall on appropriate places and can result in the formation of new epiphytic individuals (Darma et al., 2018).

When compared to other fern species, *Adiantum raddianum* ferns have the most individuals. From the 21 locations that were observed spots, 14 points of this variety of fern were discovered at altitudes ranging from 1600 to 1800 meters above sea level. The location is ideal for the growth of a few fern species. This is a terrestrial fern that is commonly found growing among rocks. Their preferred habitats include pond walls, fences, wells, ditches, river banks, and other wet areas (Lestari, 2011). *Adiantum raddianum* is a fern found from the lowlands to the mountains.

Adiantum raddianum grows wild on the sides of rocks or cliffs in chilly mountain environments. When kept in the lowlands, growth barriers exist (Ramndana et al., 2023).

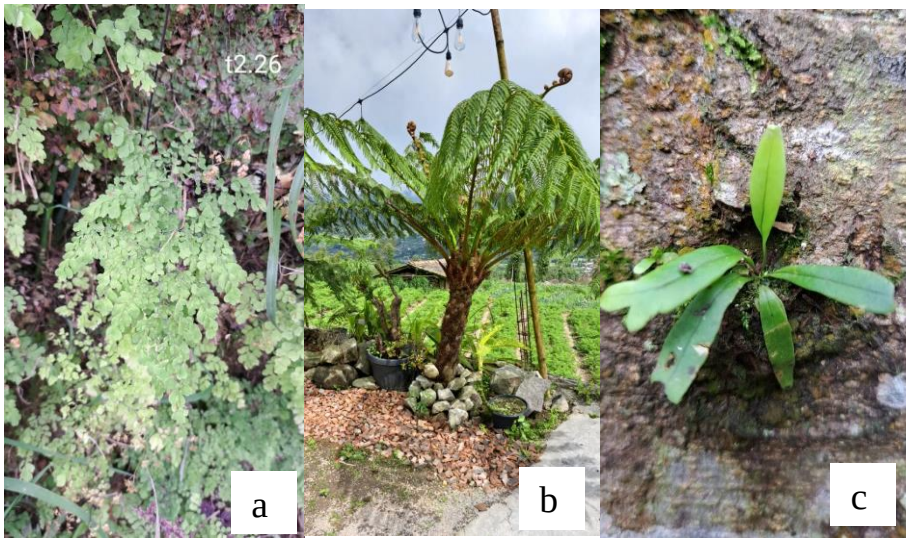


Figure 2. a. *Adiantum raddianum* C. Presl; b. *Cyathea arborea* L.Sm; c. *Antrophyum sessilifolium* (Cav.) Spr

The species diversity index (H') can be used to assess the diversity of fern species. It is possible to observe the H' value derived from each observation location. The H' value takes place between 1600 m asl to 1800 m asl and is 1.22. The criterion for identifying the level of diversity is H'<1.5, which indicates a low level of species diversity, 1.5<H<3.5 which indicates a moderate level of species diversity, and H'>3.5 which indicates a high level of species diversity (Magurran, 1988). According to Indriyanto (2006), if the diversity of species in a community is low, this is due to an area dominated by only a few species. According to Zulkarnain (2004), a community has high species diversity if several species are reasonably uniformly dispersed. However, if a community is made up of only a few species with an unequal number of members, the community has low diversity. Diversity can be used to assess the stability of a community. The size of the Diversity Index is related to environmental circumstances. The unequal distribution of individuals has an impact on species diversity, which is now deemed low.

Table 2. Abiotic factors of ferns in the Montana Zone in the Selo Region, Boyolali, Central Java

Abiotic Factors	Altitude Point (m asl)	
	1.600	**1.800**
Air Temperature (ºC)	28,7	21,3
Humidity (%)	57	73
Soil pH	6	6
Atmospheric pressure (atm)	835,4	815,6
Light Intensity (Cd)	18200	2180

The environment is a collection of numerous abiotic and biotic components that interact with one another to dramatically influence the conditions in which plants, particularly ferns, thrive (Nasrandi et al., 2022). Based on the table of abiotic parameters (Table 2) above, it is known that the altitude of 1600 m asl - 1800 m asl has a little temperature difference. At a height of 1600 m asl, the average temperature is 28.7 °C, while at 1800 m asl, the temperature drops to 21.3 °C. The average temperature at each elevation is ideal for the growth of ferns. According to Hoshizaki & Moran (2001), ferns that grow in the tropics require a temperature range of 21-27 °C to thrive. Many varieties of ferns spread in tropical forest environments due to ideal temperature conditions. Types of nails that reside in a temperature range of 27°C are often more tolerant of dim and bright environmental conditions.

Abiotic variables including soil pH influence Pteridophyta (ferns). The results of the research on soil pH ranged from 6 which means it is acidic. A pH of 6 indicates that the soil is acidic, however, fern rock regions require a more alkaline pH, precisely 7-8. Ferns (Pteridophyta) prefer chilly temperatures and high humidity, and soil pH should be between 6-7. If the pH of the soil is less than 7, it is acidic if the pH is greater than 7, it is alkaline (Permana, 2017). According to Lestari et al (2019), environmental conduciveness permits more plant species to grow in locations with a pH close to neutral and lower temperatures.

Soil moisture also affects the growth of Pteridophyta (ferns). Pteridophyta (ferns) in the montana zone of Samiran Village is classified as normal and good, with air humidity ranging from 57% to 73%. Each height has a pretty high average humidity because the research site is in a tropical rainforest with high rainfall and is at an altitude ranging from 1600 to 1800 meters above sea level, where the air temperature is lower. Because air temperature lowers with increasing altitude, humidity is highly influenced by it. The lower the temperature, the more air available. Because this humidity range is favorable for fern growth, it contributes significantly to the proliferation of ferns in this area. According to Hoshizaki & Moran (2001), the appropriate relative humidity for the growth of ferns normally varies from 60 to 80%.

The intensity of sunlight is also one of the environmental parameters examined in this study. The light intensity is 2180-18200 lux at an altitude of 1600-1800 m asl. According to Imaniar (2017), light intensity affects air humidity, the larger the light intensity, the faster the evaporation rate. According to Rizky et al (2018), canopy cover and clouds influence the high and low intensity of sunlight. Ferns prefer shady environments or those that are shaded by the intense sun. This variety of terrestrial fern requires moist climatic circumstances, thus it tends to form groups in the shade where the light intensity is lower (Katili, 2013).

Several types of ferns can only be found in the montana zone area, one of which is a plant of the Cyatheaceae family at an elevation of 1700 m above sea level. According to Astuti et al. (2017), *Cyathea* sp. lives at an elevation of 1836 m above sea level. This fern is commonly found in terrestrial environments, where it prefers moist conditions (Sengka et al., 2022). According to Suin (2022), stating the ideal humidity and temperature might cause specific types to thrive and reproduce properly. The largest ferns, such as those in the genus Cyathea, can grow to be several meters tall (Adlini et al., 2021). This is owing to the poor level of mastery over environmental variables in the fight for nutrients and growth space for the survival of this fern species.

4. CONCLUSIONS

From these findings, it was concluded that there are 2 families of ferns consisting of 6 species in the montana zone, Samiran village, Selo sub-district, Boyolali district, consisting of *Adiantum raddianum* C. Presl, *Notholaena copelandii* c.c. Hall, *Adiantum hispidulum* Sw., *Pityrogramma austroamericana* Domin, *Cyathea arborea* L.Sm, and *Antrophyum sessilifolium* (Cav.) Spr. The Diversity Index (H') is low, with a value of 1.22. The low diversity score is due to an imbalance in the number of individuals in each live fern species. *Adiantum raddianum* C. Presk had the most individuals from 14 points, with 107. The majority of ferns grow in dirt. Abiotic parameters at the study site include air temperature ranging from 21°C to 28°C, which is considered normal, air

humidity of 57%-73%, which is ideal for fern development, and soil pH of 6, which is acidic. The growth of the fern *Adiantum raddianum* in Samiran Village is highly influenced by diversity and abiotic conditions.

5. SUGGESTIONS

The author expresses gratitude to Biological Laboratory, Universitas Muhammadiyah Surakarta, which has provided tools and locations to aid the author's research, and to the manager of the New Selo tourist area, who has granted permission to research.

6. REFERENCES

Adlini, M. N., Hartono, A., Khairani, M., Tanjung, F. I., & Khairuna. (2021). Identifikasi Tumbuhan paku (Pteridophyta) di Universitas Islam Negeri (UIN) Sumatra Utara. *Jurnal Ilmuah Ilmu-Ilmu Hayati*, *6*(2): 87–94.

Anesta, A. F., Fatman, A. F., & Sugandi, M. (2020). Zonasi Distribusi Tanaman Hutan di Taman Nasional Gunung Semeru Berdasarkan Integrasi Nilai Indeks Vegetasi dan Digital Elevation Model. *Jurnal Geosains Dan Remote Sensing*, *1*(2): 64–70.

Astuti, F. K., Murningsih, & Jumari. (2017). Keanekaragaman Jenis Tumbuhan Paku (Pteridophyta) di Jalur Pendakian Selo Kawasan Taman Nasional Gunung Merbabu Jawa Tengah. *Jurnal Biologi*, *6*(2): 1–6.

Darma, I. D. P., Lestari, W. S., Priyadi, A., & Iryadi, R. (2018). Paku Epifit Dan Pohon Inangnya Di Bukit Pengelengan, Tapak Dan Lesung, Bedugul, Bali. *Journal Penelitian Hutan Dan Konservasi Alam*, *15*(1): 41–50.

Hoshizaki, & Moran. (2001). *Botani Pteridophyta*. IPB.

Hutasuhut, M. A., & Febriani, H. (2019). Keanekaragaman Paku-pakuan Terestrial di Kawasan Taman Wisata Alam Sicike-Cike. *Jurnal Biolokus*, *2*(1),:146–157.

Imaniar, R., Pujiastuti, & Murdiyah, S. (2017). Identifikasi Keanekaragaman Tumbuhan Paku di Kawasan Air Terjun Kapas Biru Kecamatan Pronojiwo Kabupaten Lumajang seta Pemanfaatan Sebagai Booklet. *Jurnal Pendidikan Biologi*, *6*(3): 337–345.

Indriyanto. (2006). *Ekologi Hutan*. Bumi Aksara.

Katili, A. S. (2013). Deskripsi Pola Penyebaran dan Faktor Bioekologis Tumbuhan Paku (Pteridophyta) di Kawasan Cagar Alam Gunung Ambang Subkawasan Kabupaten Bolaang Mongondow Timur. *Sainstek*, *7*(2): 1–13.

Kurniawati, E., Wisanti, & Rachmadiarti, F. (2016). Keanekaragaman Pteridophyta di Kawasan Hutan Wisata Air Terjun Girimanik Kabupaten Wonogiri. *LenteraBio*, *5*(1): 74–78.

Lestari, I., Murningsih, & Utami, s. (2019). Keanekaragaman Jenis Tumbuhan Paku Epifit di Hutan Petungkriyono Pekalongan, Jawa Tengah. *Journal of Tropical Biology*, *2*(2): 14–21.

Lestari, W. S. (2011). *Warta Kebun Raya*. UPT Balai Konsevasi Tumbuhan.

Magurran, A. E. (1988). *Ecologycal Methodology*. Harper Collins Publishers Inc.

Mowata, J., Hendrik, A. C., & Daud, Y. (2020). Kelimpahan Tumbuhan Paku (Pteridophyta) di Hutan Desa Tanglapui, Kecamatan Alor Timur, Kabupaten Alor. *Bio-Edu: Jurnal Pendidikan Biologi*, *5*(2): 75–86.

Muhaimim, M., Lailaty, I. Q., & Hidayat, I. W. (2018). Keragaman Tumbuhan di Kawasan Hutan Lindung Gunung Tanggamus, Lampung dan Upaya Konsevasinya. *Pros Sem Nas Masy Biodiv Indon*, *4*(2): 144–150.

Muswita, P. M., Indama, & Sanjaya, M. E. (2013). Studi Keanekaragaman Jenis Tumbuhan Paku di Taman Nasional Bukit Duabelas Provinsi Jambi. *Jurnal Prosiding Semirata FMIPA Universita Lampung*: 1–6.

Nainggolan, F. A. (2014). *Keanekaragaman Jenis Paku Epifit dan Pohon Inangnya di Kawasan Kampus IPB DARMAGA Bogor Jawa Barat*. IPB Bogor.

Nasrandi, D., Kolaka, L., & Munir, A. (22 C.E.). Keragaman Tumbuhan Paku Terestrial (Pteridphyta) di Kawasan Kebun Raya Kota Kendari (Kajian Materi SMA Keanekaragaman Hayati Kelas X). *Jurnal Alumni Pendidikan Biologi*, *6*(4): 186–190.

Permana, N. E. P. (2017). *Identifikasi Keanekaragaman Divisi Pteridophyta (Paku) di Kawasan Bukit Sulap Kota Lubuklinggau.* (Skripsi). STKIP PGRI Lubunglinggau.

Pranita, H. sukma, Mahanal, S., & Sari, M. S. (2017). Karakteristik Spora Tumbuhan Paku Asplenium kawasan Hutan Raya R.Sperjo. *Jurnal Pendidikan*, *2*(4): 454–468.

Ramndana, Mas'anah, Aini, Q., Sumarni, T., Marlina, I., Az-zahra, M., Kamukillah, Maemunah, Nurgamala, Juliati, E., Intan, Tusa'diah, N., Irawanto, D., Arham, Ernawati, Azmin, N., & Nasir, M. (2023). Identifikasi Tumbuhan Paku (Pteridophyta) di Wisata Air Terjun Desa Riamau Kabupaten Bima. *Jurnal Sains Dan Terapan*, *2*(1) :61–67.

Rizky, H., Primasari, R., Kurniasih, Y., & Vivanti, D. (2018). Keanekaragaman Jenis (Spesies) Tumbuhan Paku Terestrial di Kawasan Hutan Dengan Tujuan Khusus (KHDTK) Banten. *Jurnal Biologi Dan Pendidikan Biologi*, *3*(1): 6–12.

Sengka, R., Yani, A., & Sahriah. (2022). Eksplorasi Keanekaragaman Tumbuhan Tingkat Rendah sebagai Materi Pengembangan Modul Plantae Berbasis Kontekstual. *Jurnal Biologi Science and Education*, *11*(1):56–70.

Sofiyanti, N., Afni, A. M., Rissan, S., & Syafroni, P. (2020). Jenis-jenis Tumbuhan Paku di Pulau Rangsang Kepulauan Meranti Riau dan Karakteristik Morfologi-Palinologi. *Jurnal Biologi Tropis*, *20*(1): 102–110.

Suin, N. M. (2022). *Metode Ekologi*. Universitas Andalas.

Supriatna, J. (2014). *Wisata Alam di Taman Nasional*. Yayasan Pustaka Obor Indonesia.

Tjitrosoepomo, G. (2011). *Morfologi Tumbuhan*. Gadjah Mada University Press.

Ulum, F. B., & Dwi, S. (2015). Tumbuhan Paku (Pteridophyta) Epifit di Gunung Raung, Banyuwangi, Jawa Timur, Indoneisa. *Jurnal Ilmu Dasar*, *10*(3): 7–12.

Yunita, I., Nurma, Ibrahim, & Andalia, N. (2021). Identifikasi Jenis-jenis Tumbuhan paku (Pteridophyta) yang Tumbuh di Desa Uning Pune Kecamatan Putri Betung Kabupaten Gayo Lues. *Jurnal Biology Education*, *9*(1): 51–66.

Zulkarnain. (2004). *Identifikasi Keanekaragaman Pteridphyta di Daerah Sukamade Taman Nasional Maeru Betiri Kabupaten Kabupaten Banyuwangi* (Skripsi). Universitas Muhammadiyah Malang.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Solid Organic Fertilizer from Moringa Leaves and Peanut Shells with Banana Peel Bioactivator

Nur Afifah Mustikasari, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Banana peel
Bioactivator
Moringa leaves
Peanut shells
Solid organic fertilizer

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Fertilizer is a material added to the soil to meet the needs of plant growth and production. Moringa leaves and peanut shells can be used as solid organic fertilizer with the addition of banana peel bioactivator. The purpose of this study was to determine the quality of solid organic fertilizer from moringa leaves and peanut shells with banana peel bioactivator through observation of sensory properties and testing nutrient content. This study used an experimental research method with a complete randomized design (CRD) with a factorial pattern. The first factor was the ratio of ingredients (K_1 = 300 g of moringa leaves and 200 g of peanut shell soil; K_2 = 200 g of moringa leaves and 300 g of peanut shells). The second factor was dose of banana peel bioactivator (B_1 = 25 ml, B_2 = 30 ml). The K_1B_2 treatment had the characteristics of mature organic fertilizer. K_1B_1 and K_1B_2 treatments have the highest pH, which is 7. The K_1B_1 treatment has the best nutrient content with 3.42% nitrogen, 0.11% phosphorus, and 0.22% potassium. The study can be concluded to be that quality organic fertilizer is in accordance with SNI 19-7030-2004.

1. INTRODUCTION

Fertilizer is a material added to the soil to meet the needs of plants for growth and production. Based on the constituent materials, fertilizers are divided into organic and inorganic fertilizers. Currently, farmers still utilize a lot of inorganic fertilizers to supply the nutrients plants need. However, the use of inorganic fertilizers will have a negative impact. The long-term use of inorganic fertilizers will damage the soil, plants, and environment. To avoid the negative impact of using of inorganic fertilizers, switching to organic fertilizers is necessary.

Organic fertilizers function to meet the needs of plants for nutrients. The advantages of organic fertilizers are the availability of more balanced elements, increased soil biological activity, and increased soil organic matter content. Fertilizer is classified based on its form. Solid organic fertilizers and liquid organic fertilizers are the two categories of organic fertilizers. Solid organic fertilizer is a type of fertilizer made from solid organic ingredients. Solid organic fertilizer can be used as an alternative to inorganic fertilizers. Solid organic fertilizers can help improve soil structure, which was initially hard or dense to loosen. Solid organic fertilizer can use organic materials such as moringa leaves and peanut shells, with banana peel waste as a bioactivator.

Moringa leaves contain high levels of nitrogen, phosphorus, and potassium, so they can be used to make organic fertilizers. Based on the results of research by Adiaha (2017), the phytochemical content of Moringa leaves is nitrogen (N) 4,02%, phosphorus (P) 1,17%, and potassium (K) 1,80%. In addition, moringa leaves contain essential minerals such as Ca, Na, Mn, Zn, Fe, Mg, and Cu. One combination of ingredients that can be used is peanut shells. So far, peanut shells have yet to be utilized by the public, even though peanut shells contain nutrients that are good for plants. According to Torkashvand (2015), the phytochemical content of peanut shells was 0.87% N,

1.87% P, and 1.19% K. Therefore, the nutrient content in peanut shells is quite high, so they have the potential to be processed into organic fertilizer.

In the manufacture of solid organic fertilizers, bioactivators can be added to speed up the fermentation process. Bioactivators function as activating agents in the form of microorganisms and help start the process of transforming an organic material into a different product by causing changes in its physical and chemical properties. In addition to bioactivators that are already on the market, bioactivators can be made yourself with organic material waste, such as banana peel waste. The addition of bioactivators can speed up the fermentation process because there are microorganisms contained in them. According to Ozabor (2020), the microorganisms found on banana peel are *Pseudomonas* sp. and *Bacillus* sp.

Based on the explanation of the background above, it can be formulated how quality is determined from solid organic fertilizer made from moringa leaves and peanut shells with the addition of bioactivator made from banana peels through sensory tests and nutrient content (nitrogen, phosphorus, and potassium) based on SNI 19-7030-2004. This research aims to determine the quality of solid organic fertilizer from moringa leaves and peanut shells by adding bioactivators from banana peels through sensory tests and nutrient content (nitrogen, phosphorus, and potassium) based on SNI 19-7030-2004.

This research is expected to provide information and benefits to: 1) society regarding the use of moringa leaves, peanut shells, and banana peel waste processed as solid organic fertilizer. 2) Other researchers can add new knowledge about the benefits of moringa leaves, peanut shells, and banana peel waste and how to process them as solid organic fertilizers.

2. MATERIALS AND METHODS

This research was conducted in Tlangu, Bulan Village, Wonosari District, Klaten Regency for the manufacture of organic fertilizers and sensory tests. Test the content of nitrogen, phosphorus, and potassium, carried out at the Soil and Plant Nutrition Laboratory of the Agrotechnology Study Program at Universitas Muhammadiyah Yogyakarta used the Kejdahl method for testing nitrogen content and the wet ashing method with HNO_3 and $HClO_4$ for phosphorus and potassium content. The research took place on February 4–March 11, 2023.

Tool materials used in the manufacture of fertilizers include plastic, scales, chopping machines, knives, cutting boards, measuring cups, stationery, pH sticks, and pH indicators. Tools used in testing levels of N, P, and K include measuring cups, beakers, measuring flasks, digestion tubes, hot plates, Erlenmeyer dropper pipettes, spatulas, spectrophotometers, and test tubes. Materials used to manufacture fertilizers include moringa leaves, peanut shells, banana peels, rice washing water, and granulated sugar. Materials used in testing the levels of N, P, and K include distilled water, 40% NaOH, concentrated H_2SO_4, 60% $HClO_4$, 65% HNO_3, H_3BO_3, and methyl red indicators.

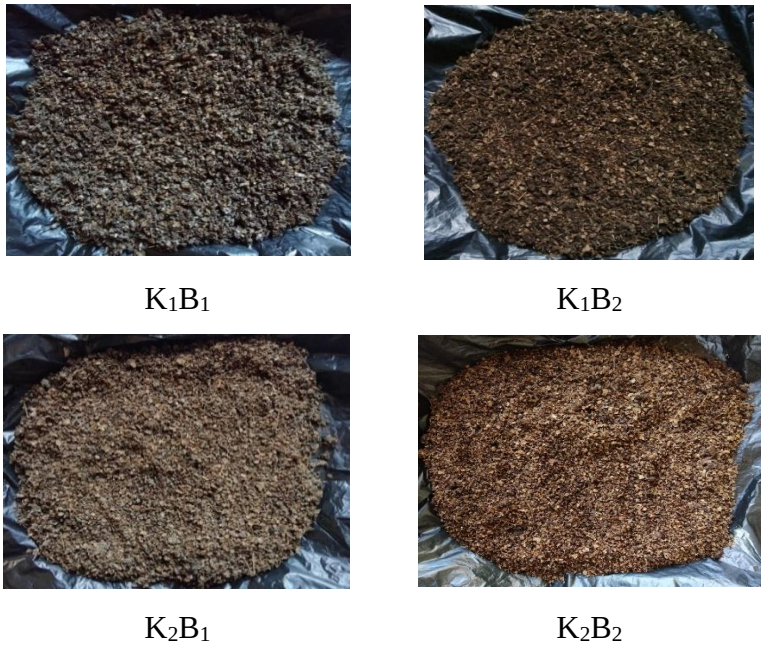
The research procedures include: 1) Preparation of tools and materials; 2) Manufacturing banana peel bioactivators 3) Making solid organic fertilizer: preparing 12 plastic bags labeled with a treatment combination. Put the moringa leaves and peanut shells in plastic according to the treatment combination. Added banana peel bioactivator, 25 ml and 30 ml, according to the treatment label. 4) Sensory test. Making sensory observations on the results of solid organic fertilizer in the form of color, aroma, texture, and pH. 5) Test nutrient content. Conduct a nutrient content test on the results of solid organic fertilizer, including nitrogen (N), phosphorus (P), and potassium (K).

This study used an experimental research method with a complete randomized design (CRD) with a factorial pattern. The treatment factors were as follows: The first factor was the ratio of ingredients (K_1 = 300 g of moringa leaves and 200 g of peanut shell; K_2 = 200 g of moringa leaves and 300 g of peanut shells). The second factor was dose of banana peel bioactivator (B_1 = 25 ml, B_2 = 30 ml). Data analysis used descriptive qualitative analysis and quantitative statistical analysis.

3. RESULTS AND DISCUSSION

3.1. Result

Documentation of the results of solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator can be seen as follows:



K_1B_1 K_1B_2

K_2B_1 K_2B_2

Figure 1. Documentation of color sensory observations on solid organic fertilizer.

Based on the results of research on the use of moringa leaves and peanut shells as solid organic fertilizer with the addition of banana peel waste as a bioactivator, the results of sensory testing (color, smell, texture, and pH) are obtained in table 1.

Table 1. Sensory test (color, smell, texture, and pH) on solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator

Num.	Treatment	Average Observation Results			
		Color	Smell	Texture	pH
1	K_1 B_1	Blackish brown	Less stinging	Rather subtle	7
2	K_1 B_2	Blackish brown	Earthy smell	Crumb	7
3	K_2 B_1	Brown	Sting	Rather subtle	6
4	K_2 B_2	Brown	Less stinging	Crumb	6

Notes:
Color: 1 = Light Brown, 2 = Brown, 3 = Blackish Brown, 4 = Very Black
Smell: 1 = Sewage smell, 2 = Sting, 3 = Less stinging, 4 = Earthy smell
Texture: 1 = Rough, 2 = Rather Rough, 3 = Rather Subtle, 4 = Crumb
K_1 B_1 : 300 g of moringa leaves and 200 g of peanut shell with 25 ml banana peel bioactivator.
K_1 B_2 : 300 g of moringa leaves and 200 g of peanut shell with 30 ml banana peel bioactivator.
K_2 B_1 : 200 g of moringa leaves and 300 g of peanut shell with 25 ml banana peel bioactivator.
K_2 B_2 : 200 g of moringa leaves and 300 g of peanut shell with 30 ml banana peel bioactivator.

Based on the results of research on the use of moringa leaves and peanut shells as solid organic fertilizer with the addition of banana peel waste as a bioactivator, the results of chemical testing (nitrogen, phosphorus, and potassium content) are obtained in table 2.

Table 2. Results of nitrogen, phosphorus, and potassium content in solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator.

Num.	Treatment	The Average Yield of Macro-nutrient Content		
		N (%)	P (%)	K (%)
1	$K_1 B_1$	3,42**	0,11**	0,22**
2	$K_1 B_2$	2,28*	0,10	0,19
3	$K_2 B_1$	2,93	0,09*	0,20
4	$K_2 B_2$	3,05	0,10	0,19*

Notes:
* = Lowest Value, ** = Highest value
$K_1 B_1$: 300 g of moringa leaves and 200 g of peanut shell with 25 ml banana peel bioactivator.
$K_1 B_2$: 300 g of moringa leaves and 200 g of peanut shell with 30 ml banana peel bioactivator.
$K_2 B_1$: 200 g of moringa leaves and 300 g of peanut shell with 25 ml banana peel bioactivator.
$K_2 B_2$: 200 g of moringa leaves and 300 g of peanut shell with 30 ml banana peel bioactivator.

3.2. Discussion

3.2.1. Color Parameter Sensory Test

Based on table 1 and figure 2. the results of sensory observations on solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator obtained the color on each treatment sample is different. Of the four treatments, the best result were obtained from the treatment K_1B_1 and K_1B_2 with blackish brown fertilizer color. Discoloration of solid organic fertilizer brown and blackish brown due to the presence of active microorganisms work during the fermentation process. According to Andriany (2018), the physical properties of the compost change the color of the compost from brownish yellow to blackish brown due to the process of fermentation or decomposition carried out by microorganisms. The blackish-brown color indicates that the fertilizer has matured.

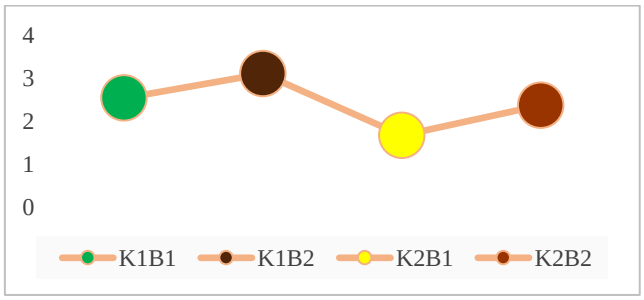


Figure 2. The results of observations of the color of solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator.

The change in color of the fertilizer to blackish brown occurs due to microorganisms decomposing organic matter into simpler ones. Research shows that the color shift happens as a result of microorganisms converting organic matter with a complicated C arrangement to a simple C arrangement during the decomposition process (Kumalasari, 2016). So that the end result is a solid organic fertilizer for moringa leaves and peanut shells with a blackish brown color in accordance with the standard provisions (SNI No. 19-7030-2004), which state that solid organic fertilizer that has matured will have a blackish color.

3.2.2. Smell Parameter Sensory Test

Based on table 1 and figure 3, the results of sensory observations on solid organic fertilizer made from moringa leaves and peanut shells with the addition of shell waste banana as a

bioactivator showed that among the four treatments, the fertilizer that smelled the best was the K_1B_2 treatment, which smelled of earth.

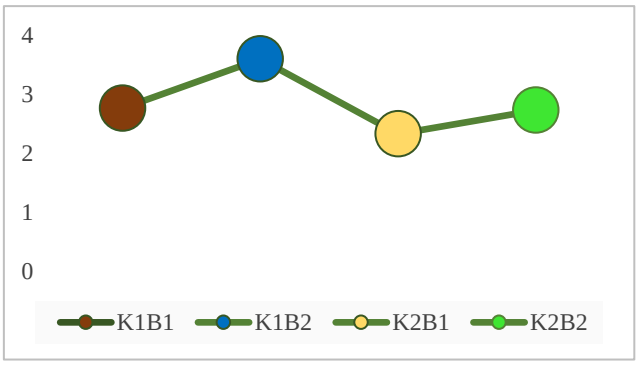


Figure 3. The results of observations on the smell of solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator.

In the K_1B_1 treatment, initially, it had a smell like fertilizer ingredients, which at the end of the fermentation turned into a less stinging one. The K_1B_2 treatment has an initial smell like fertilizer ingredients, which turns into an earthy smell at the end of the fermentation process. In the K_2B_1 treatment, the initial smell was like fertilizer ingredients, which turned into a sting at the end of the fermentation process. Also, there is the K_2B_2 treatment, which has an initial smell like fertilizer that turns into less stinging at the end of the fermentation process. This is in accordance with the fertilizer quality standards based on the national standard agency (SNI 19-7030-2004), which state that mature fertilizer will smell of earth.

The smell of the fertilizer is a sign that decomposition activity has occurred among microorganisms. Unripe fertilizer can be characterized by a pungent odor. According to Nafis (2021), during the decomposition process, the fertilizer smells pungent because the decomposition of the material releases gas in the form of NH_3 (ammonia). This pungent smell is getting longer and will decrease and be replaced with an earthy smell, indicating that the compost has been composted ripe. This is in accordance with the opinion of Zain (2022), which states that at the end of the process of decomposition of organic matter, mature fertilizer produces an earthy odor. The smell of earth on mature fertilizer occurs because the material it contains already resembles soil. According to Puryanto (2022), good compost does not emit a strong, pungent smell but gives off an odor like the smell of earth or the smell of humus.

3.2.3. Texture Parameter Sensory Test

Based on table 1 and figure 4, the results of sensory observations on solid organic fertilizer of Moringa leaves and peanut shells with the addition of shell waste banana as a bioactivator showed that among the four treatments, the texture of the fertilizer was the best in the K_1B_2 and K_2B_2 treatments, namely crumbs.

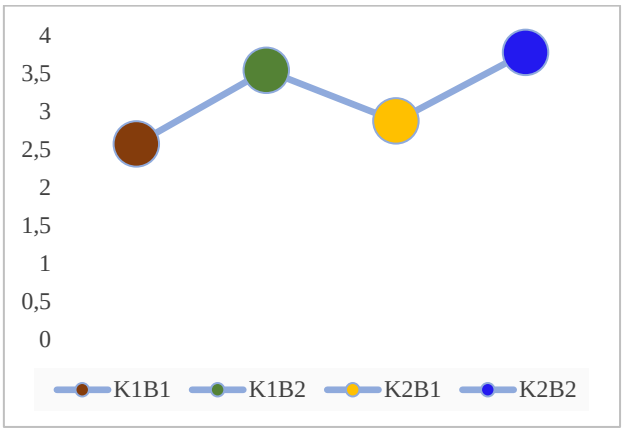


Figure 4. The results of observations on the texture of solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator.

In this study, the peanut shell material was chopped beforehand to simplify the decomposition process. The particle size of the fertilizer is related to its level of maturity. According to Natsir (2022), the more mature the fertilizer, the fewer fibers will result and the particle size will be smaller. The texture of the fertilizer changes due to the decomposition by microorganisms in the fertilizer. This is in accordance with research by Suwatanti (2017), who found that a good fertilizer texture is when the final fertilizer no longer resembles its initial form because it has been destroyed due to natural decomposition by microorganisms living in the fertilizer.

The sensory results of texture parameters show that fertilizer has resulted with small particles. This is in accordance with government regulations regarding quality standards for compost, namely 0.55–25 mm (SNI-19-7030-2004). In the K_1B_2 and K_2B_2 treatments, there was a crumb texture, which was considered good fertilizer characteristic. Crumb texture will make the process of absorbing water into the soil easier, thereby preventing erosion.

3.2.4. pH Parameter Sensory Test

Based on table 1 and figure 5, the results of sensory observations on solid organic fertilizer of moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator showed that among the four treatments, the pH of the fertilizer was the best in the K_1B_1 and K_1B_2 treatments, namely 7.

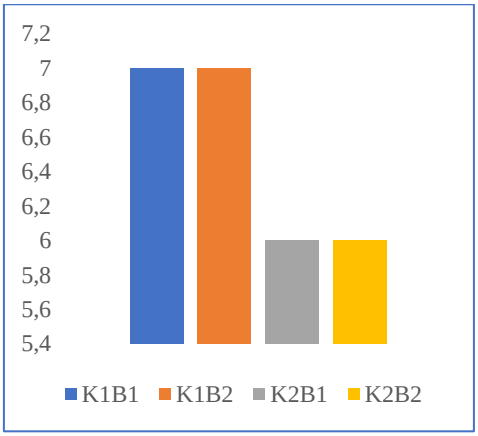


Figure 5. The results of observations on the pH of solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator.

The figure 5 shows the results for each treatment with a different pH value. Different pH values can be affected by the ratio of ingredients used. From the results obtained, it can be said that the pH level is good because it has a pH content range of 6-7. This is reinforced by SNI 19-7030-2004, which states that fertilizer's pH range is 6.80–7.49. The stable pH value can be said to be good for the growth of decomposing microorganisms. This is in accordance with research by Subula (2022), who found that if the pH value is too high, the nitrogen in the fertilizer material will turn into ammonia. Conversely, if the pH is too low, the microorganisms will die.

Different pH values for each treatment indicate that decomposition has taken place. According to Aditya (2015), the decomposition activity that occurs in fertilizers is the overhaul of complex compounds such as carbohydrates, proteins, and fats into simpler compounds to produce organic acids. The K_1B_1 and K_1B_2 treatments had a pH of 7, indicating that the pH is neutral. The neutral pH value of solid organic fertilizer will be easy to determine for used plants. This is in accordance with research by Setyawati (2021), who found that the pH value of solid organic fertilizers that are in neutral range will be easily absorbed and used by plants and is useful for reducing soil acidity. Based on the research results, it is known that the pH content of solid organic fertilizers for moringa leaves and peanut shells with the addition of banana peel waste is a good bio activator because it meets pH quality standards.

3.2.5. Nitrogen Content

Based on table 2 and figure 6, results of nitrogen content in organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator showed that the K_1B_1 treatment had the highest nitrogen content of 3.42%, and the lowest nitrogen content was found in fertilizer with the K_1B_2 treatment of 2.28%.

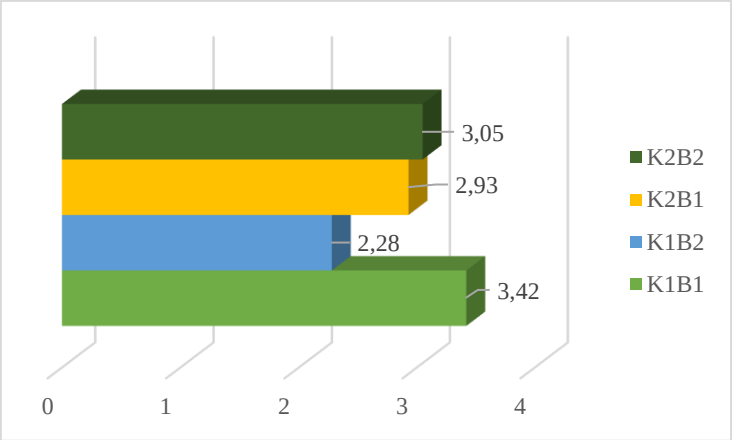


Figure 6. The results of the nitrogen content of solid organic fertilizer for moringa leaves and peanut shell soil with the addition of banana peel waste as a bioactivator.

Based on the figure 6, the nitrogen content formed after undergoing a fermentation process with the raw materials of moringa leaves and peanut shells with banana peel bioactivator has a different nitrogen content in each treatment. A comparison of ingredients and the amount of bioactivator can affect the difference in nitrogen content.

Based on the results of the two-way ANOVA test for nitrogen content, the comparison of ingredients and the amount of bioactivator shows a probability value (sig.) of 0.00 < 0.05, which means there is an effect of the ratio of ingredients and the amount of bioactivator on nitrogen content. This can be seen by the significant difference in the average nitrogen content of each treatment (Fig. 6).

The high nitrogen content in solid organic fertilizers is caused by the fact that moringa leaves have a high nitrogen content. This is in accordance with research by Adiaha (2017), who found that the phytochemical content of moringa leaves is nitrogen (N) 4.02%, phosphorus (P) 1.17%, and potassium (K) 1.80%. In addition to moringa leaves, peanut shells can increase the nitrogen

content of solid organic fertilizer. This is in accordance with research by Khomami (2015), which states that peanut shell compost contains N 2.43%, P 0.67%, K 1.19%, Ca 33.6%, and C/N 9.80.

The addition of banana peels as a bioactivator is also able to increase nitrogen content in solid organic fertilizers because banana peels contain *Bacillus* sp. *Bacillus* sp. is able to fix N_2 so as to increase the availability of nitrogen in the soil. Low nitrogen content can be affected by microbial activity in the decomposition process. According to research by Rosalina (2020), microbes are very active in the decomposition process and use a lot of nitrogen, which causes nitrogen content to drop. Based on the results of the study, the results of the nitrogen (N) content obtained are good and meet SNI 19-7030-2004 because the nitrogen content is above the minimum limit of 0.40%.

3.2.6. Phosphorus Content

Based on table 3 and figure 7, the results of the phosphorus content in organic fertilizer from Moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator showed that the K_1B_1 treatment had the highest phosphorus content of 0.11% and the lowest phosphorus content was found in fertilizer with the K_2B_1 treatment of 0.09%.

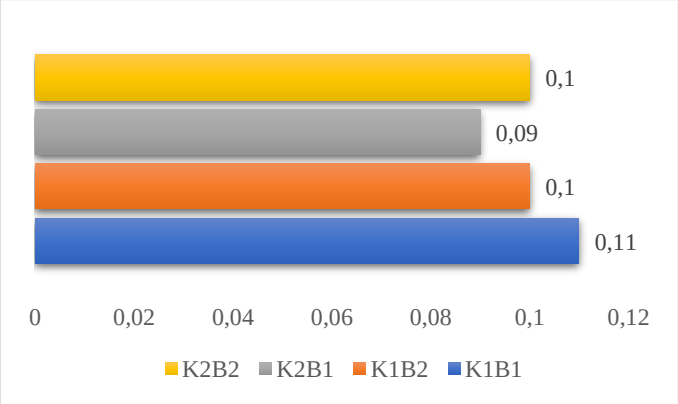


Figure 7. The results of the phosphorus content of solid organic fertilizer for moringa leaves and peanut shell soil with the addition of banana peel waste as a bioactivator.

Based on figure 7, the proportion of moringa leaves to peanut shells and the amount of bioactivator used can both have an impact on the phosphorus content. The highest phosphorus content was obtained in the K_1B_1 treatment using 300 g of moringa leaves and 200 g of peanut shells with the addition of 25 ml of banana peel bioactivator.

Based on the results of the two-way ANOVA test for phosphorus content , the comparison of ingredients and the amount of bioactivator shows a probability value (sig.) of 0.227 > 0.05, which means there is no effect of the ratio of ingredients and the amount of bioactivator on phosphorus content. This can be seen by the average phosphorus content of each treatment (Fig. 7), which shows no significant difference.

Phosphorus content in solid organic fertilizers from moringa leaves and peanut shells and the addition of banana peel as a bioactivator showed different results. Differences in phosphorus content in fertilizers can be affected by *Pseudomonas* sp., which is contained in banana peel bioactivators. According to Asril (2020), several groups of bacteria, such as *Pseudomonas*, *Bacillus*, and *Rhizobium*, have the highest phosphate solubilizing potential. The *Pseudomonas* bacteria group was found to be the best phosphate-solubilizing bacteria. Pseudomonas sp. helps break the chain of other compounds that bind to phosphate elements.

Microorganisms really need phosphorus to build their cells. The decomposition of organic matter and the assimilation of phosphorus occur due to the presence of phosphatase enzymes produced by microorganisms. According to research by Tumimbang (2016), if there is a shortage of compost microorganisms, the process of decomposition of organic matter and assimilation of phosphate will be reduced, so that phosphorus is not used, and if the number of microorganisms

in the fertilizer is sufficient, the decomposition of organic matter takes place perfectly. Based on the results of the study, the phosphorus (P) content in the K_1B_1, K_1B_2, and K_2B_2 treatments complied with SNI 19-7030-2004 because the nitrogen content was above the minimum threshold of 0.10%. Meanwhile, the content of phosphorus (P) in the K2B1 treatment did not meet SNI 19-7030-2004 because the potassium content was below the minimum limit of 0.10%.

3.2.7. Potassium Content

Based on table 3 and figure 10, the results of potassium content in organic fertilizer from leaves of moringa and peanut shells with the addition of banana peel waste as a bioactivator showed that the K_1B_1 treatment had the highest potassium content of 0.22%, and the lowest potassium content was found in fertilizers with K_1B_2 and K_2B_2 treatments of 0.19%.

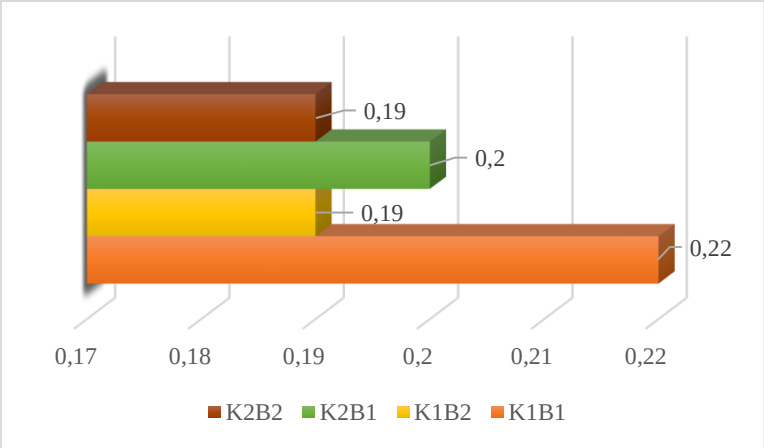


Figure 8. The results of the potassium content of solid organic fertilizer for moringa leaves and peanut shell soil with the addition of banana peel waste as a bioactivator.

Potassium content is formed after experiencing a fermentation process with raw moringa leaves and peanut shells, with the addition of banana peel waste as a bioactivator. Each treatment has a different potassium content. A difference in potassium value can be caused by the comparison of fertilizer ingredients and the number of different bioactivators. The results showed that the addition of 25 ml of banana peel bioactivator could result in higher potassium content. This can be interpreted as meaning that the amount of potassium in the best banana peel bioactivator to get high potassium levels is 25 ml.

Based on the results of a two-way ANOVA test for potassium content on the ratio of ingredients and the number of bioactivators show a probability value (sig.) 0.122 > 0.05, which means there is no effect of the ratio of ingredients and the amount of bioactivator on potassium content. Although the amount of bioactivator has a probability value of 0.009 < 0.05, which means there is an effect of the amount of bioactivator on potassium content, the effect that occurs is not significant and does not affect the potassium content. This can be seen in the average potassium content of each treatment (Fig. 8), which did not show a significant difference.

The potassium content of solid organic fertilizer is influenced by the activity of microorganisms that decompose organic matter. According to research by Bachtiar (2019), the difference potassium content can be caused by differences in the speed at which microorganisms carry out the decomposition process of organic matter during the fermentation process. In essence, potassium is already present in organic stuff, but because it is still complicated, plants cannot directly absorb it. According to research by Worotitjan (2022), during the decomposition process, complex organic waste will break down into simpler organic matter, creating potassium that plants can absorb.

Potassium content below the minimum standard can be caused by microorganisms need for potassium in the decomposition process of organic matter. According to Trivana (2017), which

states that potassium is used by microorganism as a catalyst, the presence of bacteria and their activity will greatly affect the increase in potassium content.

The results showed the potassium (K) content in the K_1B_1 and K_2B_1 treatments were good and fulfilled SNI 19-7030-2004 because of the potassium content above the minimum limit of 0.20%. Meanwhile, the content of potassium (K) in the K_1B_2 and K_2B_2 treatments does not meet SNI 19-7030-2004 because the potassium content is below the minimum limit.

4. CONCLUSIONS

Based on the results of research, solid organic fertilizer from moringa leaves and peanut shells with the addition of banana peel waste as a bioactivator average has good quality in terms of sensory observations and tests of nutrient content (nitrogen, phosphorus, and potassium) according to SNI 19-7030-2004. This solid organic fertilizer study did not show a significant difference in each treatment. The K_1B_2 treatment (300 g of moringa leaves and 200 g of peanut shells with 30 ml of banana peel bioactivator) had the characteristics of mature organic fertilizer, namely blackish brown in color, a crumbly texture, and an earthy aroma. The K_1B_1 treatment (300 g of moringa leaves and 200 g of peanut shells with 25 ml of banana peel bioactivator) and the K_1B_2 treatment (300 g of moringa leaves and 200 g of peanut shells with 30 ml of banana peel bioactivator) had the highest pH, namely 7. The K_1B_1 treatment has the best nutrient content with 3.42% nitrogen, 0.11% phosphorus, and 0.22% potassium. The results of the study can be concluded to be that the quality organic fertilizer is in accordance with SNI 19-7030-2004. Suggestion from researchers are: 1) It is hoped that further testing will be carried out on the application of solid organic fertilizers made from moringa leaves and peanut shells with banana peel bioactivator on plants. 2) It is hoped that in future studies, variations will be made on bioactivators other than banana peels.

5. ACKNOWLEDGMENTS

The author would like to thank Allah, my parents, Mrs. Aminah Asngad, and the Biology Education Study Program who have helped so that this research and paper can be completed.

6. REFERENCES

Adiaha, M. S. (2017). *Potential of Moringa oleifera as nutrient – agent for biofertilizer production*. *10*, 101–104.

Aditya, S., Suparmi, & Edison. (2015). Studi Pembuatan Pupuk Organik Padat dari Limbah Perikanan. *Jurnal Online Mahasiswa*, *1*, 1–11.

Andriany, Fahruddin, & Abdullah, A. (2018). *Pengaruh Jenis Bioaktivator Terhadap Laju Dekomposisi Seresah Daun Jati Tectona grandis L.f., di Wilayah Kampus UNHAS Tamalanrea*. *3*(2), 31–42.

Asril, M., & Lisafitri, Y. (2020). Isolasi Bakteri Pelarut Fosfat Genus Pseudomonas dari Tanah Masam Bekas Areal Perkebunan Karet di Kawasan Institut Teknologi Sumatera. *JurnalTeknologiLingkungan*, *21*(1), 40–48.

Bachtiar, B., & Ahmad, A. H. (2019). Analisis Kandungan Hara Kompos Johar Cassia siamea Dengan Penambahan Aktivator Promi. *Bioma: Jurnal Biologi Makassar*, *4*(1), 68–76.

Khomami, A. M. (2015). The Possibility Using the Composted Peanut Shells in the Growth of Marigold and Viola tricolor Plants. *Journal of Ornamental Plants*, *5*(1), 61–66.

Kumalasari, R., & Zulaika, E. (2016). *Pengomposan Daun Menggunakan Konsorsium Azotobacter*. *5*(2), 7–9.

Nafis, D., Allaily, & Yaman, M. A. (2021). *Pengaruh Lama Fermentasi pada Pembuatan Kompos dari Bahan Liter Ayam, Limbah Serbuk Kayu Pinus dan Eceng Gondok Terhadap Kualitas Fisik*. *6*(3), 70–78.

Natsir, M. F., Amqam, H., Sulfiana, Purnama, D. R., Syamsurijal, V. A. D., & Amir, A. U. (2022). *Analisis Kualitas Kompos Limbah Organik Rumah Tangga Berdasarkan Variasi Dosis Mol Tomat*. *12*(2), 155–163.

Ozabor, T., Ojokoh, A. O., Wahab, A. A., & Aramide, O. O. (2020). *Effect Of Fermentation On The Proximate and Antinutrient Composition Of Banana Peels*. *9*(2), 105–117. https://doi.org/10.18488/journal.57.2020.92.105.117

Puryanto, C. (2022). *Menambah Income dari Pupuk Organik*. Pusat Pengembangan Pendidikan dan Penelitian Indonesia.

Rosalina, Pracahyani, R., & Ningrum, N. P. (2020). *Uji Kualitas Pupuk Kompos Sampah Organik Rumah Tangga Menggunakan Metode Aerob Effective Microorganisms 4 (EM4) dan Black Soldier Fly (BSF)*. *44*(2), 9–21.

Setyawati, H., Sari, S. A., K, D. N., & A, N. Z. (2021). *Pengaruh Variasi Jenis Limbah Sayuran (Kubis. Sawi, Selada) dan Kadar EM4 pada Pembuatan Pupuk Kompos dengan Proses Fermentasi*. *02*(02), 1–7.

Subula, R., Uno, W. D., & Abdul, A. (2022). *Kajian Tentang Kualitas Kompos yang Menggunakan Bioaktivator EM4 (Effective Microorganism) dan MOL (Mikroorganisme Lokal) dari Keong Mas*. *4*(2), 56–64.

Suwatanti, E., & Widiyaningrum, P. (2017). *Pemanfaatan MOL Limbah Sayur pada Proses Pembuatan Kompos*. *40*(1), 1–6.

Torkashvand, A. M., Alidoust, M., & Khomami, A. M. (2015). The reuse of peanut organic wastes as a growth medium for ornamental plants. *International Journal of Recycling of Organic Waste in Agriculture*, *4*, 85–94. https://doi.org/10.1007/s40093-015-0088-0

Trivana, L., & Pradhana, A. Y. (2017). Optimalisasi Waktu Pengomposan dan Kualitas Pupuk Kandang dari Kotoran Kambing dan Debu Sabut Kelapa dengan Bioaktivator PROMI dan Orgadec Time Optimization of the Composting and Quality of Organic Fertilizer Based on Goat Manure and Coconut Coir Dust usi. *Jurnal Sain Veteriner*, *35*(1), 136–144.

Tumimbang, M., Tamod, Z. E., & Kumolontang, W. (2016). *Uji Kualitatif Kandungan Hara Kompos Campuran Beberapa Kotoran Ternak Peliharaan*. *22*(3), 123–133.

Worotitjan, F. D., Pakasi, S. E., & Kumolontang, W. J. N. (2022). Teknologi Pengomposan Berbahan Baku Eceng Gondok (Eichhornia crassipes) Danau Tondano. *Jurnal Agroteknologi Terapan*, *3*(1), 1–7.

Zain, M. M. (2022). *Seribu Manfaat Tanaman Tebu Inovasi Limbah Tebu yang Wajib Anda Ketahui*. Deepublish Publisher.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Liquid Organic Fertilizer Peanut Shells and Tofu Dregs With Banana Stems as Bioactivator

Muhammad Rizal Kahfi, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Banana Steams
Fertilizer Quality
Liquid Organic Fertilizer
Peanut Shells
Tofu Dregs

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Liquid organic fertilizer is nutrition given to plants to improve the supply of nutrients so that plants can grow well. The utilization of peanut shells and tofu dregs has the potential as liquid organic fertilizer and banana stems as a bioactivation. This study aimed to determine the quality of liquid organic fertilizer, a combination of peanut shells and tofu dregs, adding moles of banana stems as a bioactivator. This study used experimental methods and a Completely Randomized Design (CRD) consisting of 2 factors and 4 combinations with 3 repetitions. Factor 1 combines peanut shells and tofu waste K1 = 100 ml: 200 ml and K2 = 120 ml: 180 ml. Factor 2 is the local microorganism concentration, namely M1 = 100ml and M2 = 200ml. Data were analyzed using descriptive qualitative and quantitative. The results showed that the fertilizer had a yellowish brown and light brown color, a slightly pungent fermented to not overpowering, and a pH of 4. The highest N was in K1M1 combination of 0,57%, the highest P in K1M1 and K2M1 was 0,05%, and the highest K in K1M1 of 0,08%. It can be concluded that liquid organic fertilizer has good quality complies with SNI 19-7030-2004.

1. INTRODUCTION

Plants need nutrients to support their growth. The addition of ingredients with sufficient nutrients will make the plants grow well. Using fertilizers can improve and add nutrients required for plants to grow. Fertilizers are materials added to growing media or plants to meet the nutrients plants need to grow correctly. In fertilizers, the availability of anions for plant growth, such as nitrate, phosphate, borate, and chloride, as components function to increase nutrients for plant needs is one of the functions of fertilizer use. Fertilizers are divided into inorganic fertilizers (chemical) and organic fertilizers (natural).

Organic fertilizers are materials added to improve the supply of nutrients for plants and consist of organic materials derived from plants or animals that have undergone a fermentation process and are used as a source of plant nutrition. Organic fertilizers are divided into solid and liquid forms. Liquid organic fertilizer is a solution containing one or more soluble carriers of the elements needed by plants, and solid organic fertilizer is organic matter in solid form from plant residues or animal waste. Liquid organic fertilizer has the advantage of being able to provide nutrients according to plant needs more easily and quickly evenly distributed because of its liquid form. According to Roidah (2013), liquid organic fertilizer can use organic materials such as animal manure, animal body parts, and plants. Waste can also be used to make liquid organic fertilizer, namely peanut shell waste, leri water, tofu dregs, and others.

In general, peanuts are only used for seeds for consumption and food purposes, while the skin produces waste and has not been widely used. Peanut shell waste is a waste that is often found in the surrounding environment and is simply thrown away. Peanut skin has an essential substance

for the fulfillment of plant nutrients. According to Sihite (2020), peanut shell waste contains several nutrients: N 2.64%, P2O5 3.56%, K2O 1.67%, and organic C 4.93.

Other materials are needed to manufacture liquid organic fertilizer so that the nutrients required by plants can be fulfilled. One of the ingredients that is easily found around us is tofu dregs. Tofu dregs are solid waste from the tofu processing industry, which is underutilized. Discarded tofu waste can pollute the environment. One effort to overcome this is by utilizing tofu waste as fertilizer. Tofu dregs contain 8.66% protein, 3.79% fat, 51.63% water, and 1.21% ash (Kusumaningtyas et al., 2020). Sunarsih et al. (2018) found that tofu dregs contained nutrients namely N 0.09%, phosphorus 0.062%, and K 1.82%.

Liquid organic fertilizer production occurs anaerobically or does not require oxygen and is fermented without sunlight. The manufacture of organic fertilizers requires MOL (local microorganisms). Local microorganism is a bioactive component that can break down organic matter. Specifically, bioactive agents are purified microbial isolates that uniquely digest organic materials, including cellulose fibers. Hadi (2019) stated that adding local microorganism to manufacture liquid organic fertilizer can accelerate the fermentation process. Local microorganism can be obtained by utilizing household waste or crop residue, vegetables and fruits, animal waste, etc. Local microorganism that can be used as a decomposer is local microorganism which contains many decomposing microorganisms, such as the local microorganism of banana stems.

Banana stems can be used as an alternative to making organic local microorganism. Banana stems can be used as ingredients for local microorganisms that can increase soil fertility. Local microorganisms can help accelerate the fermentation process. These decomposing bacteria help make compost faster, easier, and of better quality. Yuliansari & Endina (2020) stated that in banana stems, there is the bacterium *Pseudomonas* sp. and *Citrobacter freundii* which can speed up the fermentation process. This shows that banana stem is one of the ingredients that can be used as a local microorganism or activator.

Based on the background above, the problem is: How is the quality of liquid organic fertilizer combined with peanut shells and tofu dregs with adding banana stems as a bio activator? This study aims to determine the quality of liquid organic fertilizer combined with peanut shells and tofu dregs with the addition of banana stem local microorganism as a bio activator in terms of sensory characteristics (color, aroma, and pH) and nitrogen, phosphorus, and potassium content.

The benefits of the results of this study are expected to provide information to 1). Providing information to the general public about using peanut shells, tofu dregs, and banana stems as liquid organic fertilizer. 2). Provide information to fertilizer makers about the quality, content, and content of good plant nutrients. 3). Farmers and materials for consideration for the Government regarding alternatives to making organic fertilizer using peanut shells and tofu dregs with adding banana stem bio activators as a substitute for chemical fertilizers.

2. MATERIALS AND METHODS

This research was conducted at the UMS Biology Laboratory Greenhouse. This study used 16L jars, 5L jars, blenders, basins, digital scales, analog scales, wooden stirrers, basins, stoves, filters, 250ml measuring cups, 1000ml measuring cups, knives, pH indicators, and bottles. At the same time, the materials used in this study included peanut skins, tofu dregs, banana stems, water, brown sugar, molasses, leri water, groundwater, bran, pH stick, raffia, and label paper.

The research procedures include: 1). Making the bioactivation: chopping and grinding 3 kg of banana stems into a jar, adding 3 liters of leri water, coconut water, and 800 grams of brown sugar, stirring until homogeneous, and fermenting for two weeks. 2). Extracting peanut shells: Grind 3 kg of peanut skins with 3 liters of water, filter the crushed material, and extract it. 3). Making tofu dregs flour: 3kg of tofu dregs is heated in a pan on the stove for 45 minutes and pureed with 1 liter of water. 4) Manufacture of fertilizer: the extract and local microorganism of banana stems are put into a jar according to the treatment, 5). add 90 ml of molasses and 90 gr of bran in each jar, then

homogenize, close the jar, ferment for 14 days, and do sensory observations every three days (Nasution and Rizka 2022).

The method used was an experimental method and completely randomized design (CRD) with two factors: the composition of peanut shells with tofu pulp waste and adding a banana stem bioactivation. This study used 4 treatments with 3 repetitions, and the data analysis technique used was descriptive qualitative and quantitative analysis.

3. RESULT AND DISCUSSION

3.1 Result

3.1.1 Sensory Test

After going through fermentation for 14 days, and sensory tests were carried out on ten panelist to test of sensory characteristic, the results of the liquid organic fertilizer combined with peanut shells and tofu dregs and the addition of banana stems as a bio activator can be seen as follows:

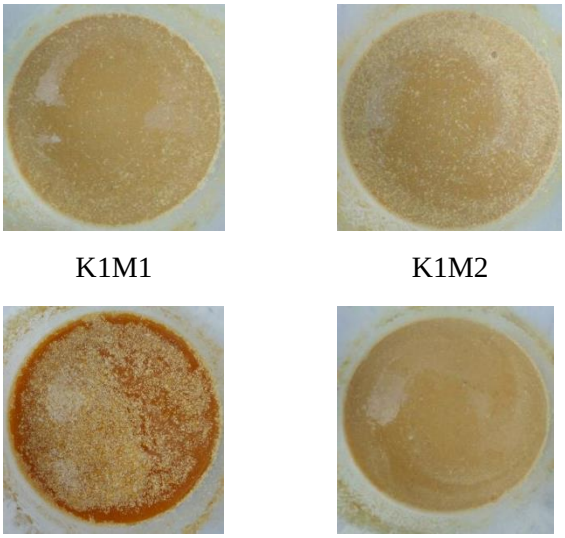


Figure 1. Liquid organic fertilizer result

The results of sensory observations that have been made regarding the color, aroma, and degree of acidity (pH) in the liquid organic fertilizer combination of peanut shells and tofu dregs with the addition of banana stems as a bioactivator can be seen in the following table:

Table 1. Sensory test results of liquid organic fertilizer combination of peanut shells and tofu dregs with the addition of banana stems as a bioactivator

Combination	Sensory Observation Result		
	Color	Aroma	pH
K1M1	Light brown	Fermentation smell not overpowering	4
K1M2	Light brown	Fermentation smell not overpowering	4
K2M1	Yelloowish-brown	Slightly pungent fermented smell	4
K2M2	Light brown	Fermentation smell not overpowering	4

Noted:
K1 M1 = Liquid organic fertilizer with a concentration of 100 ml of peanut shell extract and 200 g of tofu dregs with 100 ml local microorganism of banana stem.
K1 M2 = Liquid organic fertilizer with a concentration of 100 ml of peanut shell extract and 200 g of tofu dregs with 150 ml local microorganism of banana stems.
K1 M2 = Liquid organic fertilizer with a concentration of 120 ml of peanut shell extract and 180 g of tofu dregs with 100 ml local microorganism of banana stems.
K2 M2 = Liquid organic fertilizer with a concentration of 120 ml of peanut shell extract and 180 g of tofu dregs with 150 ml local microorganism of banana stems.

Based on the results of the table analysis above, it can be seen that sensory observations of all samples have a light brown and yellowish brown color with a pH of 4 and a slight difference in aroma.

3.1.2 N, P and K Content

Based on the results of laboratory tests regarding the macro-nutrient content including nitrogen (N), phosphorus (P), and potassium (K) in the liquid organic fertilizer combination of peanut shells and tofu dregs with the addition of banana stems as a bioactivator, it can be seen from the test results for the content in following table:

Table 2. The content of N, P, and K in liquid organic fertilizer a combination of peanut shells and tofu dregs with the addition of psiang stems as a bioactivator

Combination	Analysis Result		
	N (%)	**P (%)**	**K (%)**
K1M1	0,55	0,05**	0,08 **
K1M2	0,57 **	0,04 *	0,07
K2M1	0,52	0,05	0,06 *
K2M2	0,48 *	0,04	0,06

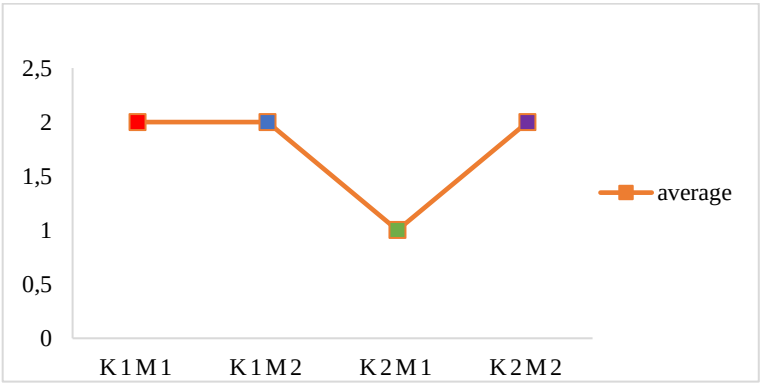
Where: (*) lowest yield
(**) highest yield

The analysis of N, P, and K content in Table 2 shows that the highest nitrogen (N) content was found in the K1M2 combination of 0.57%. In contrast, the lowest nitrogen content was found in the K2M2 combination, which was 0.48%. the highest phosphorus content was in the combination K1M1 and K2M1, namely 0.05%, while the lowest phosphorus content was in the combination K2M1 and K2M2, namely 0.04%. The highest potassium (K) content was found in the K1M1 combination, 0.08%, and the lowest in the K2M1 combination, 0.06%.

3.2 Discussion

3.2.1 Color parameters

After sensory observations on liquid organic fertilizer from peanut shells and tofu dregs with the addition of banana stems as a bioactivator, it showed that each treatment sample had the slight different color. Then the data can be presented in the form of a bar chart as follows:



Description: 1 = yellowish brown; 2 = light brown; 3 = dark brown; 4 = blackish brown

Figure 2. Color parameter of liquid organic fertilizer

Color is one of the determining factors for the quality of liquid organic fertilizer and determining the maturity of liquid organic fertilizer. It can be seen from the results of the average color observation of liquid organic fertilizer peanut shells and tofu dregs with the addition of banana stems as a bio activator that there is no significant difference in color. In the treatment combinations K1M1, K1M2, and K2M2, the POC was light brown, while in the K2M1 treatment combination, the color was yellowish brown.

The color change in liquid organic fertilizer can be affected by the color of the ingredients used. The ingredients used in this fertilizer are light brown extracted banana stems, white tofu dregs flour, brownish white banana stem MOL, and other additives such as molasses, rice bran, coconut water, and leri water, which can also affect the color of the fermented product liquid organic fertilizer. The activity of microorganisms from adding banana stem bio-activators accelerated the change of the liquid organic fertilizer color from each treatment. Its relevant research by Situmorang (2018) states that adding a bio activator in the manufacture of liquid organic fertilizer can cause a color change from blackish brown to brown due to the activity of microorganisms during the decomposition process. This also follows research by Siregar (2016) which states that microorganism activity can affect the color change in liquid organic fertilizer during fermentation.

Mixing all these ingredients makes the resulting liquid organic fertilizer a yellowish-brown color at first; after being fermented, it produces a light brown color. It is appropriate Tsaniya's research (2021) that in SNI 19-7030-2004, physical indicators of fertilizer maturity in color are between brown and blackish brown.

3.2.2 Aroma Parameters

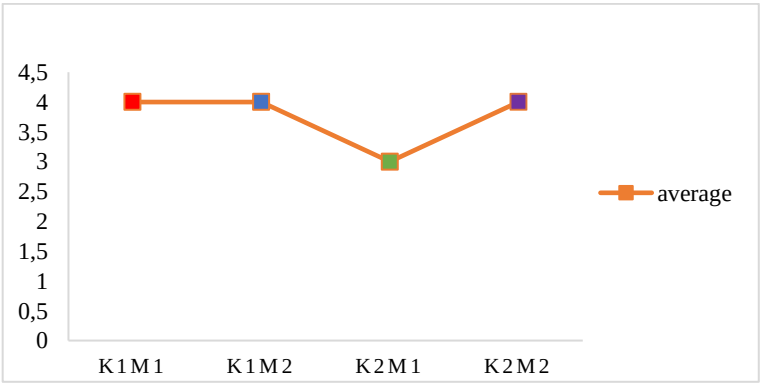


Figure 3. Aroma parameter liquid organic fertilizer

Description: 1 = bad smell; 2 = pungent fermented odor; 3 = slightly pungent fermented smell; 4= fermentation smell not overpowering

The results showed that the four treatment samples had a non-stinging aroma. At the beginning of the fermentation process, the aroma is like the aroma of peanut butter. This is due to the raw material used, peanut shells, and the addition of bran and molasses as a source of nutrition for microorganisms to decompose organic materials. On the 3rd to 12th day of observation, the fertilizer gave off a change in aroma to fermented tape, which over time, was pungent. However, on the 14th day of observation, the fertilizer did not show a pungent odor.

During 14 days of making fertilizer, there is a fermentation process by microorganisms present in liquid organic fertilizer with the help of a banana stem bioactivator. The decomposition activity of the material by microbes causes the smell of tape. The pungent smell of tape or alcohol indicates microbial activity that is currently active, and a smell that gradually decreases indicates microbial activity that has started to become inactive or that the fertilizer is ripe. It is appropriate with research by Lestari et al. (2019), which states that liquid organic fertilizer fermented for 7-14 days will smell like tape. So the liquid organic fertilizer produced is of good quality.

3.2.3 pH Parameters

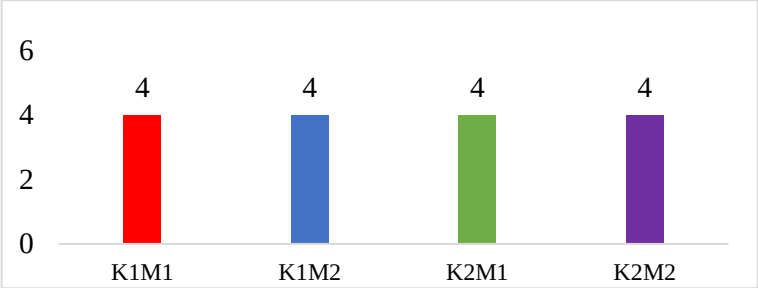


Figure 4. pH parameter of liquid organic fertilizer

After conducting sensory observational research on liquid organic fertilizer, a combination of peanut shells and tofu dregs with the addition of banana stems as a bio activator, it was shown that there was a similarity in pH value in each treatment. The pH of the treatment sample indicated that the pH of the fertilizer was 4. At the beginning of the fermentation process, the pH of the four treatments was acidic, namely, 5. The activity of actively developing bacteria could affect the decrease in acidity. It is according in Kurniawan's research (2017) that the degree of acidity in fertilizers that is experiencing an increase or decrease is caused by bacterial activity.

This shows that the pH of the liquid organic fertilizers in this study was still in the acidic pH category, so they were still suitable for the growth of microbes that decompose organic matter in liquid fertilizers. The advantage of pH, which tends to be acidic, can produce many nitrogen elements and kill the nymphs or eggs of pathogenic organisms (Setyaningsih et al. 2017). Too high a pH increases oxygen consumption and damages the environment. Conversely, if the pH is too low, some microorganisms will die. This pH value follows the requirements for liquid organic fertilizer from the Decree of the Minister of Agriculture of the Republic of Indonesia concerning Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers, and Soil Improvement, which states that the pH value of Liquid Organic Fertilizer is between 4-9 (Tsaniya et al. 2021).

3.2.4 N, P dan K Content

Based on the results of laboratory tests regarding the macro-nutrient content, including nitrogen (N), phosphorus (P), and potassium (K) in the liquid organic fertilizer combination of peanut shells

and tofu dregs with the addition of banana stems as a bioactivator, it can be seen from the test results for the content in following diagrams:

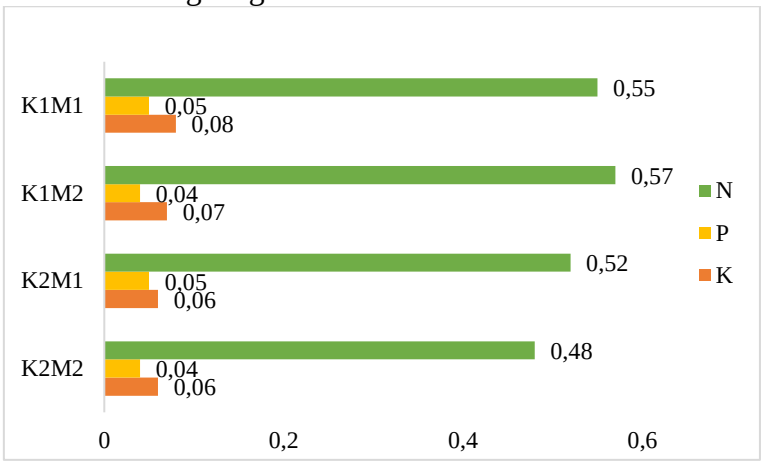


Figure 5. NPK content

3.2.4.1 Nitrogen Levels (N)

The test results for the N, P, and K content in Figure 5 shows that the nitrogen content has a higher percentage content than the P and K content. The highest average nitrogen content found in the K1M2 combination of 0.57%, while the average content is the lowest nitrogen average found in the K2M2 combination, namely 0.48%. It follows the results of statistical tests (means) that the highest average nitrogen content is in the K1M2 combination, and the lowest is in K2M2.

The statistical analysis by two way anova showed significant results with a significance level of less than 0.05, namely 0.011, which meant significant differences between the four liquid organic fertilizer treatment combinations. The fermentation process can influence the difference in nitrogen levels. Following research by Mulyadi et al. (2013), the nitrogen content of each treatment combination was different because the speed of the microbes in decomposing the fermented material was different. According to Meriatna et al. (2019), the nitrogen content decreased after the 16th day of fermentation. The decreasing nitrogen level was also caused by the reaction of N with water, which produced NO3- and H+ (Trivana et al. 2017).

The quality of Nitrogen can decrease quite drastically. It is presumably because the element nitrogen can evaporate together with the evaporation of water. The quality of liquid organic fertilizer can decrease during storage; even though it has been appropriately stored, nutrients can still evaporate and become unavailable, so the longer it is stored, the lower the fertilizer quality can be (Nurlaila et al. 2017). The nitrogen (N) content in liquid organic fertilizer combined with peanut shells and tofu dregs with adding banana stems as a bio activator has met the Indonesian National Standard regarding BSN (Badan Standarisasi Nasional) 2004 standard liquid organic fertilizer. Good fertilizers have a total N parameter that is at a percentage of more than 0.40%.

3.2.4.2 Phosphorus Levels (P)

The observations showed that the highest average phosphorus content was in the combination of K1M1 and K2M1, namely 0.05%, while the lowest average phosphorus content was in the combination of K1M2 and K2M2, 0.04%. The four treatment combinations did not show a significant difference. It follows the results of statistical tests (means) that the highest average phosphorus content is in the combination of K1M1 and K2M1, and the lowest phosphorus content is K2M1 and K2M2. The two way anova statistical analysis did not show a significant difference between the four treatments. This also follows the significance test, which shows a sig value (1) >

0.05, so there is no significant difference between the four liquid organic fertilizer treatment combinations.

The phosphorus content in liquid organic fertilizer combined with peanut shells and tofu dregs with adding banana stems as a bio activator does not meet the minimum standard because phosphorus is less than 0,10%. This can be caused by a need for phosphorus nutrient content in the essential ingredients of liquid organic fertilizer. Nur et al. (2016) in their experiments reported that each waste or waste has a different level of phosphorus and can affect the speed of the fermentation process. Phosphorus-decomposing microorganisms also affect the phosphorus content, whereas in the banana stem, bio activator, there is a phosphorus-decomposing bacteria, namely Citrobacter freundii, which will increase phosphorus levels. The minimum nutrient content in the fertilizer is due to the activity of microorganisms which, apart from breaking down phosphorus, also use it for living activities. This is also because the decomposing microorganisms have reached the death phase before the fermentation process ends.

The fermentation time also affects the final yield of phosphorus content in liquid organic fertilizer. Kusumadewi et al (2019) explained that the longer the fermentation time, the more nutrients will be used for the activities of microorganisms, and over time, the availability of nutrients will be exhausted, and the activity of microorganisms in breaking down organic compounds will decrease. The resulting phosphorus content will be less. The high N content in liquid organic fertilizer can cause a high P content. This is according to research by Situmorang (2018) that the high content of phosphorus is influenced by the high content of nitrogen, where the higher the nitrogen content, the activity of microorganisms that break down phosphorus will increase, causing the phosphorus content in liquid organic fertilizer to increase.

3.2.4.3 Potassium Levels (K)

Based on observations of the results, the highest average potassium level was in the K1M1 combination, which was 0.08%, and the lowest was in the K2M1 and K2M2 combination, which was 0.06%. From the research results, the potassium content in liquid organic fertilizer combined with peanut shells and tofu dregs with the addition of banana stems as a bio activator in the four combinations showed that the results did not meet SNI 2004 because the K content had a percentage of less than 0.20%.

The results of statistical analysis by two way anova showed a significance value of 0,644 > 0,05. These statistical results indicate no significant difference between the four treatment combinations because the significance results are more than 0,05. The K content is affected by the nutrient content in the raw materials for peanut shells and tofu dregs used to manufacture liquid organic fertilizer. The nutrient content of potassium contained in peanut shells can be seen from research by Sihite et al. (2020) which is equal to 1.67%, while the potassium content in tofu dregs is seen from research by Sunarsih et al (2018) at 1.82%. Microorganisms use potassium as a catalyst, and the activity of microorganisms dramatically influences the increase in potassium levels. The higher the activity of microorganisms, the higher the potassium level. The low potassium content in liquid organic fertilizer is also because the microorganisms in it have yet to develop optimally. The organic matter in liquid organic fertilizer has not entirely decomposed, and the microorganisms are still in adaptation (Sulfianti et al. 2021).

The low potassium content in liquid organic fertilizer is also because the microorganisms in it have yet to develop optimally. The organic matter in liquid organic fertilizer has not been wholly decomposed, and the microorganisms are still in the adaptation phase (Sulfianti et al. 2021).. From the K content in the peanut shell, it can be concluded that the greater the material used, the more potassium nutrient content is obtained. The content of nutrient elements contained in organic fertilizers is usually relatively small for N, P, and K. However, the amount available for each element can be quite a lot, of the concentration of materials in organic fertilizers is higher (Mustamu 2020).

4. CONCLUTIONS

Based on the research results, peanut shells and tofu waste, adding banana stems as activators can be used as liquid organic fertilizer. It can be seen from the observations of sensory characteristics, namely the color of yellowish brown and light brown, slightly pungent to not overpowering fermented aroma and a pH of 4. So liquid organic fertilizer from peanut shells and tofu dregs with local microorganism banana stems as a bioactivation has good quality. Furthermore, meet the sensory requirements of SNI 19-7030-2004. The percentage of nitrogen (N), phosphorus (P), and potassium (K) content of liquid organic fertilizer combined with peanut shells and tofu dregs with the addition of local microorganism of the banana stem as a bio activator with N content complies with SNI 19-7030-2004 and shows a significant difference in treatment. At the same time, P and K did not meet or show a significant difference in treatment. Suggestions that the author can convey are it is necessary to test the content of each ingredient before making liquid organic fertilizer, and further tests regarding applying liquid organic fertilizer, a combination of peanut shells and tofu dregs waste with banana stems as a bioactivator.

5. ACKNOWLEDGMENTS

The author would like to thank the head of the laboratory, Green House Laboratory of the Biology Education Department, Universitas Muhammadiyah Surakarta, for research support.

6. REFERENCES

Hadi, R. . 2019. Pemanfaatan mol (mikroorganisme lokal) dari materi yang tersedia di sekitar lingkungan. *Agroscience* 9(1): 93–104.

Kurniawan, E., Ginting, Z., and Nurjannah, P. 2017. Pemanfaatan Urine Kambing Pada Pembuatan Pupuk Organik Cair Terhadap Kualitas Unsur Hara Makro (NPK). *Seminar Nasional Sains dan Teknologi* 1(2): 1–10.

Kusumadewi, M. A., Suyanto, A., and Suwerda, B. 2019. Kandungan Nitrogen, Fosfor, Kalium dan pH Pupuk Organik Cair dari Sampah Buah Pasar Berdasarkan Variasi waktu. *Sanitasi: Jurnal Kesehatan Lingkungan* 11(2): 92–99.

Kusumaningtyas, R. D., Hartanto, D., Triwibowo, M. M., Kusuma, A. M. H., Fidyawati, Mezaki, N. M., Mutaqin, A. M., and Loveyanto, R. O. 2020. The Processing of industrial Tofu Freg Waste into Animal Feed in Sumurrejo Village Semarang. *Jurnal Penerapan Teknologi dan Pembelajaran* 18(2): 36–41.

Lestari, S. U., Mutryarny, E., and Susi, N. 2019. Uji Komposisi Kimia Kompos Azolla mycrophylla dan POC Azolla mycrophylla. *Jurnal ilmiah pertanian* 15(2): 121–127.

Meriatna, M., Suryati, S., and Fahri, A. 2019. Pengaruh Waktu Fermentasi dan Volume Bio Aktivator EM4 (Effective Microorganisme) pada Pembuatan Pupuk Organik Cair (POC) dari Limbah Buah-Buahan. *Jurnal Teknologi Kimia Unimal* 7(1): 13. DOI: 10.29103/jtku.v7i1.1172

Mulyadi, Y., Sudarno, and Sutrisno. 2013. Studi Penambahan Air Kelapa pada Pembuatan Pupuk Cair dari Limbah Cair Ikan Terhadap Kandungan Hara Makro C, N, P, dan K. *Jurnal Teknik Lingkungan* 2(4): 1–14.

Mustamu, N. E. 2020. *Sludge Biogas*. Literasi Nusantara, Malang.

Nasution, N. E. A., and Rizka, C. R. 2022. Production of Liquid Compost with EM4 Bio Activator Volume Variation from Vegetable and Fruit Waste. *META: Journal of Science and Technological Education* 1(1): 87–99.

Nur, T., Noor, A. R., and Elma, M. 2016. Pembuatan Pupuk Organik Ciar dari Sampah Organik Rumah Tangga dengan (Effective Microorganisme). *Konversi* 5(2): 44–51.

Nurlaila, Maesaroh, S., and Novitasari. 2017. Degradasi kandungan nitrogen pada pupuk organik cair selama dalam penyimpanan. *Buletin Loupe* 14(2): 13–18.

Roidah, I. S. 2013. Manfaat Penggunaan Pupuk Organik Untuk Kesuburan Tanah. *Jurnal Universitas Tulungagung* 1(1).

Setyaningsih, E., Astuti, D. S., and Astuti, R. 2017. Kompos daun solusi kreatif pengendali limbah. *Bioeksperimen: Jurnal Penelitian Biologi* 13(2): 45–51.

Sihite, M., Nugrahini, Y. L. R. E. dan Simanjuntak, E. M. 2020. Efektivitas Ekstrak Kulit Kacang Tanah Dan Bakteri *Lactobacillus acidophilus* Sebagai Sinbiotik *Jurnal Nutrisi Ternak Tropis dan Ilmu Pakan* 2(4): 225–233.

Siregar, E. P. 2016. Kualitas Pupuk Organik Cair (Biourin) yang Difermentasi Dengan Penambahan Starter Effective Microorganism 4 (EM4). *12345678*, 1(1), 1-2

Situmorang, M. S. 2018. Pengaruh Penambahan Effective Microorganisme 4 (EM4) Terhadap Kandungan Hara Pupuk Organik Cair Berbahan Dasar Kotoran Kambing dan Bonggol Pisang. *Skripsi Fakultas Peternakan, Universitas Jambi, Jambi.*

Sulfianti, Risman, and Saputri, I. 2021. Analisis NPK Pupuk Organik Cair dari Berbagai Jenis Air Cucian Beras dengan Metode Fermentasi yang Berbeda. *Agrotech* 11(1): 36–42.

Sunarsih, F., Hastiana, Y., and Aseptianova. 2018. Respon Pupuk Organik Ampas Tahu dengan bioaktibvator Terhadap Pertumbuhan Ipomea reptans. *Bioeksperimen* 4(2): 1–9.

Trivana, L., Yudha, A., and Pradhana, Y. 2017. Optimalisasi Waktu Pengomposan dan Kualitas Pupuk Kandang dari Kotoran Kambing dan Debu Sabut Kelapa. *Jurnal Sain Veteriner* 35(1).

Tsaniya, A. R., Dewi, E. N., and Anggi, A. D. 2021. Characteristics of Liquid Organic Fertilizer from Different Composition Types of Seaweed between Gracilaria sp. and Sargassum sp. *Journal of Physics: Conference Series* 1943(1).

Yuliansari, D., and Endina, F. 2020. Uji Lanjutan Isolasi Dan Identifikasi Bakteri Pada Bioaktivator Dari Limbah Bonggol Pisang (Mol) Dalam Proses Pengomposan Sampah Organik Rumah Tangga. *Bioscientist.* 8(2): 276–283.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Quality of Infrastructure Facilities and the Readiness of Biology Laboratories to Support Learning in High School

Mei Renni Sholikhah, Lina Agustina*
Biology Education Department, Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Central Java, Indonesia
*Corresponding Author. E-mail address: la263@ums.ac.id

KEYWORDS:
Readiness
Quality of infrastructure
Laboratory
Biology Learning

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Biology learning is the mastery of collecting knowledge information in concepts, principles, and facts, as well as learning and comprehending how the process of acquiring knowledge is achieved directly through the practicum. Physical and social skills can be developed through the use of practicum activities as a learning supplement. The implementation of practicum activities must be supported by a high-quality laboratory infrastructure. The laboratory equipment and infrastructure of Cal must comply with the laboratory requirements outlined in Permendiknas Number 24 of 2007. The research aimed to determine the quality of infrastructure facilities and the readiness of biology laboratories to support learning at SMA Negeri 1 Cawas. This research is qualitative descriptive research through observation, interviews and documentation. The results showed that the quality of biological laboratory infrastructure based on Permendiknas Number 24 of 2007 was included in the perfect category with an average percentage of 95%. Meanwhile, laboratory readiness obtained an average readiness percentage value of 92%, including in the ready category, so the biology laboratory in this school is ready to be used to support learning.

1. INTRODUCTION

In a learning environment, learning is the process of interaction between participants, instructors and learning resources. Education give learning so that the process of obtaining knowledge can occur (Suardi, 2018). Biology is a discipline of study that examines the variety and interdependence of all living organisms on Earth. Thus, biology is among the sciences that contribute considerably to the growth of science (Susilawati & Bakhtiar, 2018). As a field of study, biology stands out due to the investigation of all living things, the theme of problems affecting biological objects that arise in nature, and the use of scientific methods to resolve concerns. Biology education is impacted by the characteristics of biology as a science (Trianto, 2010).

Learning biology involves not only mastery of the collection of knowledge information in the form of concepts, principles, and facts, but also learning and comprehension of how knowledge is acquired. Biology education should stress direct experiential learning in order to give students with meaningful learning in the cognitive, psychomotor, and affective domains. Biology education teaches and comprehends how knowledge is acquired through practical actions (Daba et al., 2017). Practical activities in biology learning are carried out to arouse student learning motivation, develop basic skills in conducting experiments, and as a promoter of the delivery of teaching materials, hence biology education and practicum are linked (Neji et al., 2014). This demonstrates the importance of laboratories in aiding biology teaching and accomplishing educational goals (Kalsum et al., 2018). Practical activities can take place well when the availability of the means and facilities of the biological laboratory in supporting the practice is available in a good condition

and a sufficient amount, it must comply with the Permendiknas Number 24 of 2007 standard on the medium and facility of high school or madrasah aliyah (SMA or MA), so that the laboratory is one of the most important facilities in support of biological practice (Poedjiadi, 2007).

A laboratory is a location where observations, scientific research, experiments, and other scientific endeavors are conducted. The laboratory is one of the most important components for supporting biology education in schools, needing confirmation between theory and reality (Daud & Pratiwi, 2017). Through problem solving, educators can also strengthen their critical thinking abilities in a laboratory. Without a school laboratory, it will be difficult to develop the competence and quality standards of educators therefore, it is necessary to have a laboratory with quality infrastructure in accordance with Permendiknas Number 24 of 2007 that is managed professionally, as laboratory infrastructure is one of the most essential laboratory resources and should not be neglected (Gusnani et al., 2019).

To facilitate practicum activities, students must be laboratory ready in order to cultivate scientific attitudes and promote learning. Aspects of laboratory preparedness, such as laboratory room design, laboratory administration, storage of laboratory material instruments, and well-managed laboratory management, will give students with a genuine laboratory experience (Russel et al., 2018). The establishment of standardized biology laboratories will facilitate the optimal operation of the laboratory-dependent learning process and the attainment of educational objectives (Rahmiyati, 2018).

In support of the school's vision and goal, SMA Negeri 1 Cawas develops numerous facilities that can be utilized by all school components. One of the school's facilities is the biology laboratory. Based on observations and interviews, it has been determined that the biology laboratory at this school has been utilized actively to enhance learning. To yet, there has been no research on the quality of infrastructural facilities and the readiness of biological laboratories. Even though SMA Negeri 1 Cawas is one of the state schools and holds the title of Adiwiyata for his many accomplishments, the research aims to provide information on the description of the quality of infrastructure facilities and the readiness of laboratories biology to support learning, so that it can be used as evaluation material for all parties involved.

2. RESEARCH METHODS

2.1. Types of Research

This qualitative descriptive research aims to provide an overview of the quality of infrastructure facilities and the readiness of biological laboratories to support learning at SMA Negeri 1 Cawas.

2.2. Place and Time of Research

This research was carried out in the biology laboratory of SMA Negeri 1 Cawas, which is based on Jl. Tembus Cawas-Pedan, Tugu, Cawas, Klaten, Central Java 57463. The study will be conducted from February 2023 to May 2023 and calculated from submitting titles to reporting research results.

2.3 Data and data sources

Data is collected in the form of laboratory rooms, laboratory furniture, experimental tools and materials, educational media, consumables, and other equipment for the aspect of biological

laboratory infrastructure quality, while data is collected in the form of laboratory room design, laboratory administration, laboratory management, storage of tools and materials, and completeness of equipment for the aspect of biological laboratory readiness. Laboratory management instructors and laboratory spaces are the sources of the data for both elements.

2.4 Data Collection Techniques

2.4.1 Observation

Observation in this study aims to determine the quality of facilities and infrastructure and the readiness of biological laboratories. This is done using non-participatory techniques. Namely, researchers are not involved in the learning process but only as observers. Hence, researchers make direct observations to see and observe laboratory rooms, furniture, experimental tools and materials, educational media, consumables, teaching aids and other equipment based on the standards listed in Permendiknas Number 24 of 2007.

2.4.2 Interview

To gather information about the standard of infrastructure facilities and the readiness of biological laboratories, this study interviewed laboratory management teachers. To determine laboratory readiness, interviews are conducted in closed settings with a restricted number of response options such as always, frequently, never, and sometimes and in open settings with unlimited response options.

2.4.3 Documentation

Documentation is done in biological laboratories to provide tangible proof of observations. According to Permendiknas Number 24 of 2007, the information was obtained in the form of images or photographs related to laboratories.

2.5 Research Procedure

The process in this study begins with the stage of preparation, which takes the form of problem formulation, draft question preparation, instrument validation submission, and practice of research licensing letter. The second stage is implementation, which entails doing research on the infrastructure facilities' quality and biological laboratories readiness to assist learning while using predetermined data collection methods and documenting all study findings. The last stage is when data processing, inference, and compilation are completed.

2.6 Data Analysis Techniques

Data obtained from observations of the quality of infrastructure facilities and closed interviews of biological laboratory readiness are then analyzed. There is an observation of the quality of infrastructure facilities obtained compared with the standards written in Permendiknas Number 24 of 2007. The results of the study can be calculated by the percentage formula (Agustina & Ningsih, 2017):

$$P = \frac{n}{N} \times 100\%$$

Information:

P: percentage
n: the number of scores obtained
N: maximum number of scores
The percentage results are interpreted based on their respective criteria:

a. Quality of laboratory infrastructure

81% – 100% : Excellent
61% – 80% : Good
41% – 60% : Good enough
21% – 40% : Not Good
0% – 20% : Very Not Good
(Agustina et al., 2019)

b. Laboratory Readiness

76% – 100% : Ready
56% – 75% : Simply Ready
41% – 55% : Less Prepared
≤ 40% : Not Ready
(Sugiyono, 2013)

3. RESULTS AND DISCUSSION

3.1. Quality of Laboratory Facilities and Infrastructure In Supporting Learning

The laboratory has a crucial role in learning biology in schools, especially at the high school level, because the activities there can support the achievement of competencies and learning objectives related to psychomotor and actual experience in the field. Facilities and infrastructure in educational institutions are supporting factors for teaching and learning in schools, and one of them is the laboratory. Standardizing the caliber of optimum infrastructure and facilities for biological laboratories alludes to Permendiknas Number 24 of 2007 (Jannah & Sontani, 2018).

The observation results regarding the quality of biological laboratory facilities and infrastructure refer to the Permendiknas Number 24 of 2007 standards. This standard is used as a reference for minimum research standards regarding the quality of biological laboratory facilities and infrastructure at SMA Negeri 1 Cawas. According to standardizing natural laboratory infrastructure must meet predetermined criteria, including laboratory space, furniture, teaching aids, experimental tools and materials, educational media, consumables, and other equipment in the laboratory. Data on the quality of biological laboratory infrastructure are presented in Table 1.

Table 1. Quality of Biology Laboratory Infrastructure Facilities SMA Negeri 1 Cawas

No	Observed aspects	Percentage	Category
1.	Laboratory Room	100%	Excellent
2.	Furniture	100%	Excellent
3.	Props	96%	Excellent
4.	Experimental Tools and Materials	97,2%	Excellent
5.	Educational Media	100 %	Excellent
6.	Consumables	92,3 %	Excellent
7.	Other Equipment	80%	Good
	Average	95%	Excellent

Based on Table 1, it is known that the quality of biological laboratory infrastructure in supporting learning in the school shows an average score of 95%, which is included in the category of high school even though it has not 100% satisfied the requirements of Permendiknas Number 24 of 2007 while also supporting practical activities to aid in the school's biology curriculum. The indicators given below show that each aspect noticed has a distinct percentage of the value:

3.1.1. Laboratory Room

The laboratory room is used to carry out practicum or research activities supported by complete facilities. According to Permendiknas Number 24 of 2007, a good laboratory room can accommodate at least one study group with a minimum ratio of 2.4 m^2 /student for a study group of fewer than 20 students, a minimum laboratory area of 48 m^2 including storage and preparation space of 18 m^2, and the minimum width of the laboratory is 5 m, with the laboratory room having adequate lighting facilities for reading books and observing experimental objects. The laboratory room must also be clean water available. The observations on the laboratory room indicator obtained a percentage value of 100%, indicating that the laboratory room aspect is included in the perfect category and meets the standards.

The biology laboratory room in this school has met the minimum ratio of space, with a room area of 100 m² and a biology laboratory width of 9 m, with a group of 36 students. The laboratory room is spacious, so students are free when doing a practicum. The laboratory room is neat, clean, comfortable and organized. The laboratory room is divided into two parts: the practicum and separate storage rooms for tools and materials. The storage room is in front of the practicum room with an area of 20 m². Research Kurniawan (2021), the separation of practice rooms from tool and material rooms is intended so that students and teachers have no difficulty finding tools and materials. Besides, it aims to prevent practicum tools and materials from being damaged due to accidents in practicum activities in the laboratory.

Figure 1. Biology laboratory room at SMA Negeri 1 Cawas

This school's biology lab provides good lighting, which makes it simpler for students to read textbooks and carefully inspect experimental objects. The laboratory has a fan inside and numerous vents at the top of each window, which improves air circulation and adds to the comfort of the pupils. Ample clean water is also available in the lab space from sinks located on the west and east sides of the student desks. Research Maharani & Sasi (2019), the environmental conditions of biological laboratories also need to be considered, among others, with adequate air circulation and ventilation systems, adequate water needs, and room temperatures that are maintained constant and safe from interference.

3.1.2. Furniture

Furniture is equipment items that function to support the course of practicum. According to Permendiknas Number 24 of 2007, laboratory furniture facilities include chairs, student tables, demonstration tables, preparation tables, tool cabinets, material cabinets, and sinks. Based on observations about laboratory furniture at SMA Negeri 1, Cawas obtained a percentage value of 100%, included in the perfect category, where aspects of furniture in the biological laboratory have met the minimum standards.

The biological laboratory equipment consists of nine student desks that are large enough to accommodate groups of students, one presentation table, and 50 seats, divided into 46 student chairs and four teacher chairs that are sturdy, stable, safe, and easy to move. There are two long preparation tables so that they can add all the necessary tools and materials to be used. The trail is in the front, the table is extended to accommodate the materials tools to be used, spacious, strong, suitable for use, and adequate height, allowing students to observe the experiment demonstrated. Next to the wall and perpendicular to the sink is the prep table. Tool cabinets and materials that are large enough and plentiful enough to hold all tools are not readily corroded, closed, and lockable. For practicum activities, six sinks have smooth, clear water faucets. According to research Rahman (2017), laboratory water installations are utilized to wash hands after practicum if they become unclean or are exposed to dangerous substances.

3.1.3. Props

Teaching aids are learning aids and objects used to demonstrate learning materials. Based on the observation of teaching aids in the biology laboratory of SMA Negeri 1, Cawas obtained a percentage of 96%, indicating that the teaching aids facilities of the biology laboratory in this school are included in the perfect category even though they have not 100% met the standards of the Ministry of National Education Number 24 of 2007. The teaching aids facilities listed by Permendiknas Number 24 of 2007 consist of 25 types of tools namely: human skeleton models, human body models, various preparations, chromosome images, DNA images, RNA images, Mendelian inheritance images, plant examples drawings from multiple divisions, animal examples drawings from different species, drawings or models of various systems in animals and humans, and draw the evolution tree. Of the 25 types of props observed, 24 kinds of equipment follow the standard, namely having good conditions, suitable for use, and ratios and descriptions that follow the norm. The thing that causes teaching aids not to meet 100% of the standards of the is that there is no image of an evolutionary tree, so it is necessary to strive for a picture of an evolutionary tree that can provide more insight to students about evolutionary material more efficiently.

But since the teaching materials in the school's biology lab are thorough, they are helpful for the learning that takes place there. Students will be better able to understand the material given that there is complete educational equipment available and a variety of tools that adhere to the requirements. This is supported by Trisianawati (2020), that the state of complete practicum tools and materials will make teachers maximize the use of laboratories in supporting the implementation of learning and students will be easier to understand and learn the principles and Natural Sciences, so that they can be used in everyday life.

3.1.4. Experimental Tools and Materials

Before practicum, tools and materials are necessary since research or training cannot be conducted without tools and experimental materials. The comprehensiveness of tools and materials

facilitates the success and simplicity of practical activities, hence facilitating the accomplishment of educational objectives. This study observed 36 types of experimental instruments and materials, including microscopes, thermometers, balance sheets, test tubes, measuring pipettes, watch glasses, funnels, Petri dishes, universal clamps, tricycles, measuring cups, stopwatches, and other material tools that support practicum operations.

Based on the observation results of experimental tools and materials obtained a percentage value of 97,2%, which indicates that the facilities of biological laboratory practical tools and materials at SMA Negeri 1 Cawas are included in the perfect category even though they have not 100% met the standards of the Permendiknas Number 24 of 2007, but have been able to support the process of implementing biology practicum activities in supporting learning. The availability of useful tools and materials is what prevents experimental tools and materials from meeting norms. There are still some ratios, though, that do not adhere to the standards. For instance, there aren't enough long and short stative rod devices; the norm calls for six sets each lab. In order to make it simpler for students to use the instrument, it is important to try to add a static rod device to satisfy a predetermined ratio. Research Hayati (2020), the availability of experimental tools and materials in a laboratory is the basis for achieving good practices.

3.1.5. Educational Media

Educational media can deliver learning materials to attract students' attention, interests, thoughts and feelings in learning activities to achieve specific learning goals (Sumiharsono & Hasanah, 2017). Educational media contained in the biology laboratory is a whiteboard with a standard of 1 piece per laboratory with a minimum size of 90 cm x 200 cm placed in a position that allows all students to see it. The whiteboard is an essential object in the teaching and learning process, one of whose functions is as a medium for writing learning materials.

Based on the results of observations of educational media in the biology laboratory, SMA Negeri 1 Cawas obtained a percentage of 100% which indicates that the educational media facilities in the biology laboratory are included in the perfect category and have met the standards of the Permendiknas Number 24 of 2007. The blackboard contained in the biology laboratory at this school follows the minimum requirements of the biology laboratory, which is one piece measuring 120 cm x 200 cm with good conditions and suitable for use. The whiteboard is placed at the front so students can see clearly. There are other educational media in the biology laboratory room, namely LCD projectors teachers use to explain material when using laptop media. Research Mastika (2014), which shows that the whiteboard facilities in the Science/Biology laboratory room at SMA Negeri Kota Denpasar obtained 100% data, indicating that the furniture facilities at SMA Negeri Kota Denpasar mean that they meet the minimum standards listed in Permendiknas Number 24 of 2007.

3.1.6. Consumables

Consumables are materials that are used and run out quickly or are not durable. The consumables listed in Permendiknas Number 24 of 2007 are Sulfuric Acid, HCL, Acetokarmin, Eosin, Ethanol, Glucose, Universal Indicators, Iodine, KOH, $MnSO_4$, NaOH, Vaseline, and filter paper. Based on the observation of consumables at the biology moratorium of SMA Negeri 1, Cawas obtained a percentage value of 92,3%, indicating that the consumables of the biology laboratory at this school are included in the perfect category. However, they have not 100% met

the standards of the Permendiknas Number 24 of 2007 but have been able to support the process of implementing biology practicum activities so that they can support learning in the laboratory.

According to the findings of observation sheets used in the biology lab at SMA Negeri 1 Cawas, the reason why experimental instruments and materials don't meet criteria is because consumables are still available but don't have the right ratio of them. The balance established by Permendiknas Number 24 of 2007 is four rolls/lab, however these consumables, universal indicators, are only offered in four rollers/lab. The supplies used in the biology lab at SMA Negeri 1 Cawas are all in good shape and kept in durable glass cabinets made of wood. As a result, they do not rust easily, and all consumables are excellent for usage because both solid and liquid materials have a long shelf life. The government has lately provided this school with funding for a substantial quantity of consumables that meet the requirements of Permendiknas Number 24 for the of 2007.

3.1.7. Other Equipment

Other equipment is additional equipment to support practicum learning in biology laboratories. Biological laboratory facilities in the aspect of other equipment consisting of electrical sockets, fire extinguishers, P3K, trash cans, and wall clocks at SMA Negeri 1 Cawas obtained a percentage of 80% which indicates that other equipment facilities in the biology laboratory at this school are included in the excellent category even though they have not 100% met the standards set in Permendiknas Noumber 24 of 2007.

According to the findings of observation sheets in this school's biology lab, the availability of alternative equipment is what prevents experimental tools and materials from meeting criteria. However, several still fall short of the ratios and description requirements for the measurements. Another piece of equipment is an electrical socket; there are only four electrical outlets available for the nine desks that students are assigned, and the electrical socket is faulty and dangerous to use. As a result, given that the electric socket ratio is one of the laboratory's major supporters, improvement and expansion are required. According to research Adilah (2021), water facilities are used to wash hands if filthy or exposed to toxic chemicals, and to wash dirty practicum equipment after usage. Electrical installation facilities are necessary for voltage sources in carrying out practicums that require electricity. Additionally, pure water can be used in laboratories. Because mishaps during practicum can happen at any time, biological laboratories must have P3K equipment and fire extinguishers available to cope with incidents in the lab.

3.2. Readiness of Biology Laboratory in Supporting Learning

Laboratory administration, facility completion, equipment and material storage, and room design are all important factors. Planning, organizing, structuring, maintaining, and overseeing are some of the components of laboratory management (Candra & Hidayati, 2020). With adequate laboratory readiness, it will also affect the biology learning process that requires a laboratory.

Based on research that has been conducted on the readiness of biology laboratories in supporting learning at SMA Negeri 1 Cawas from the results of closed interviews with laboratory management teachers and observations of the completeness of laboratory material equipment facilities referring to the standards of the Permendiknas Number 24 of 2007. Each question item has a short answer, such as never, sometimes, often and consistently, so a short but definite answer is obtained. The four answers have their value weight. Data on the readiness of biological laboratories are presented in Table 2.

Table 2. Readiness of Biology Laboratory of SMA Negeri 1 Cawas

No	Indicators	Percentage	Category
1.	Laboratory Room Design	85%	Ready
2.	Laboratory Administration	95%	Ready
3.	Laboratory Management	88%	Ready
4.	Storage of Tools and Materials	95%	Ready
5.	Completeness of tools and materials	96,5%	Ready
	Average	92%	Ready

Based on Table 2, it can be seen that the readiness of the biology laboratory to support learning in this school shows an average score of 92%, which is included in the ready category even though it has not reached a percentage of 100%. Where each aspect observed has a different ratio of value, it can be seen from the indicators described as follows:

3.2.1. Laboratory Room Design

From the results of closed interviews, the laboratory room design obtained a readiness percentage value of 85%, indicating that the creation of the biology laboratory room at SMA Negeri 1 Cawas was included in the ready category. However, it had not yet reached the percentage of 100% value. The design of the biology laboratory room at this school was prepared to be used in supporting practicum activities. Questions regarding the design of laboratory rooms, made referring to the standards of the Permendiknas Number 24 of 2007, such as the area of laboratory space, laboratory layout, setting the distance between experimental and storage rooms, specifying the number of students to maintain student comfort during the practicum process, availability of water, and sufficient lighting. The interview results show that the biology laboratory in this school has been designed following standards, namely the distance between the laboratory and other buildings is about 4 m, with an area of 100 m to allow 36 students to enter, the availability of water is adequate as evidenced by the presence of 6 sinks in the room complete with water faucets and three pieces outdoors in front before entered the laboratory.

The biology laboratory is equipped with a good light source, making it easier for students to conduct experiments or activities because there is no lack of lighting. This is in line with Research Mastika (2014), that the distance between the laboratory and other buildings is at least equal to the height of the nearest building ± 3 meters so that the room can be optimal in getting direct lighting from sunlight and not located in the wind direction, to avoid air pollution. Almost all criteria referenced in the biological laboratory design readiness assessment are met. Only a few aspects have not been met by some high schools, namely: lack of the number of electric sockets, because many electric sockets have broken and do not function, so it is necessary to improve and add sockets to support the learning process better.

3.2.2. Laboratory Administration

The readiness of laboratory administration is indicated by criteria stating that in the laboratory, several aspects need to be administrated, including Administration of biological laboratory rooms, Administration of biological laboratory facilities, Administration of experimental tools and materials, Administration of personnel and Administration of activities laboratory. From the results of closed interviews regarding laboratory administration, the readiness value of 95% indicates that the biology laboratory administration at SMA Negeri 1 Cawas is

included in the ready category. Although it has not yet reached the percentage of 100% marks, the laboratory administration carried out by the manager is classified as ready where the school Always make an inventory of tools and materials, both new and old, makes a list of material equipment needs every semester, record all material tools that have been damaged both after and before practicum begins, make inventory data on the receipt of material tools both from schools and the government and do all inventories associated with other biological laboratories. Everything related to Administration is neatly arranged in soft files and complex files booked.

It will be simpler for the school to know the state of the lab and make future changes with good administration. Research Rahmiyati (2018), effective administration helps with planning for the purchase of equipment or materials, monitoring the effectiveness of budget use, facilitating the implementation of activities, presenting reports objectively, facilitating supervision, and protecting laboratory wealth, which is one of the costly investments made by the government in the education sector.

3.2.3. Laboratory Management

Laboratory management, or laboratory management, is an activity to plan, maintain, secure and administer to develop the laboratory efficiently and effectively to achieve a goal (Astuti, 2017). From the results of closed interviews regarding laboratory management, a readiness percentage value of 88% was obtained, indicating that the management of the biology laboratory at SMA Negeri 1 Cawas was included in the ready category. However, it had not yet reached the percentage of 100% marks. The management of the biology laboratory at the school was prepared to support learning.

Almost all criteria referenced in the readiness assessment of the management aspect of biological laboratories are met. Only some elements have not been met, such as periodic chemical maintenance following the way and place of storage. That is because the laboratory staff is minimal. In contrast, the biology laboratory in this school only amounts to 1 person who doubles as a subject teacher, so the time to carry out maintenance is irregular.

3.2.4. Storage of Tools and Materials

Storage of tools and materials consists of giving codes, names and specifications on practicum tools and materials, storing hazardous materials separately from other materials, storing tools and practicum materials based on function and use, storage of practicum tools is carried out in the form of sets, avoiding tools and materials from harmful environmental influences. The results of closed interviews regarding the readiness of storage of tools and materials obtained a readiness percentage value of 95% which indicates that the storage of biological laboratory tools and materials at SMA Negeri 1 Cawas is included in the ready category. However, it has not reached the percentage of 100% value. The storage of tools and materials carried out follows the standards in this study.

Storage of tools and materials is placed in cabinets whose doors can be closed tightly but are still easy to reach to facilitate the retrieval of glass tools are also placed in the same cabinet, making it easier to supervise. Equipment that is three dimensional such as a torso, is stored in a glass cupboard and separated from other tools. Therefore, this school's laboratory equipment and materials storage aspect is ready to support learning. Research Maharani & Sasi (2019), tools that are often used are usually placed in separate cabinets with instruments made of glass grouped or

stored in one cupboard. In addition, there is a cabinet to store tools made of glass and tools used to store microscopes. The chemicals used for practicum are also stored in a separate cupboard to make it easier to prepare for practicum activities. Likewise, three dimensional props such as the human torso and its constituent organs are stored in a joint cabinet.

3.2.5. Completeness of Tools and Materials

The completeness of physical laboratory facilities and infrastructure is essential in smoothly implementing practicum activities following learning objectives. The available budget and laboratory arrangements support factors that support the entirety of practicum material equipment in the laboratory. From the observation of the completeness of experimental equipment and material facilities, obtaining a readiness percentage value of 96,5% indicates that the entirety of equipment and material facilities in the biology laboratory of SMA Negeri 1 Cawas is included in the ready category, even though it has not met 100% of the standards of the Permendiknas Number 24 of 2007 but has been able to support the process of implementing biology practicum activities so that it can support learning in this school. All equipment and material facili ties are in adequate condition and suitable for use. This is because all material tools are cared for by a laboratory worker assisted by subject teachers.

The completeness of equipment and material facilities observed in this study consisted of 82 observation items comprised of furniture, props, consumables, educational media, and other equipment to support the running of the practicum. Based on the results of observation sheets in biological laboratories, things that cause the completeness of laboratory equipment and material facilities are not 100% ready because there is some completeness of equipment and material facilities that do not exist or already exist but with ratios that are not following standards such as non-existent evolutionary tree images, lack of electric socket and lack of universal indicator ratios, so that there is still a need for improvement so that tools and materials are following standards which will also affect the learning process that is getting smoother, with that the purpose of learning will be easier to achieve. Research Agustina (2019), to create a good teaching and learning process and quality learning outcomes, the laboratory must have all the facilities and infrastructure needed and meet laboratory standards.

4. CONCLUSIONS

The quality of the biological laboratory infrastructure at SMA Negeri 1 Cawas is included in the perfect competition with a percentage value of 95%. Although it has not met 100% of Permendiknas Number 24 of 2007 standards, the quality of biological laboratory infrastructure is following standards. It can support learning as for the level of laboratory readiness included in the ready laboratory with a percentage value of 92% so that it is prepared to help with biology learning in the school. The level of laboratory readiness studied includes laboratory design, laboratory administration, laboratory management, completeness of laboratory material equipment facilities and storage of laboratory material equipment.

5. ACKNOWLEDGEMENTS

The author would like to thank the lecturers of FKIP Biology Education, University of Muhammadiyah Surakarta, who have helped with the process of publishing this article and also

thank a teacher for the biology laboratory manager of SMA Negeri 1 Cawas, who has helped a lot in completing this research.

6. REFERENCES

Adilah, M. (2021). Analisis Standarisasi Laboratorium Biologi SMA di Kota Pontianak. *Ilmiah Didaktika*, *21*(2), 195–207.

Agustina, P., & Ningsih, I. W. (2017). Observasi Pelaksanaan Praktikum Biologi di Kelas XI SMA Muhammadiyah 1 Surakarta T.A. 2015/2016 Ditinjau dari Standar Pelaksanaan Praktikum Biologi. *Bioeducation Journal*, *1*(1), 34–43.

Agustina, P., Saputra, A., Khotimah, E. K., Rohmahsari, D., & Sulistyanti, N. (2019). Evaluasi Pelaksanaan Praktikum Biologi di SMA Negeri di Klaten pada ditinjau dari Kualitas Laboratorium, Pengelolaan, dan Pelaksanaan Praktikum. *IBo-Pedagogi: Jurnal Pembelajaran Biologi*, *8*(2), 105–110.

Astuti, A. P. (2017). Jurnal Ilmiah Didaktika. *Jurnal Pendidikan Sains*, *5*(1), 47–55.

Candra, R., & Hidayati, D. (2020). Penerapan Praktikum dalam Meningkatkan Keterampilan Proses dan Kerja Peserta Didik di Laboratorium IPA. *Jurnal Kependidikan Dan Sosial Keagamaan*, *6*(1), 26–37.

Daba, T. M., Anbassa, B., Oda, B. K., & Degefa, I. (2016). Status of biology laboratory and practical activities in some selected secondary and preparatory schools of Borena zone , South Ethiopia. *International Conference on Teaching and Education (ICoTE)*, 11(17), 1709–1718.

Daud, M. H., & Pratiwi, N. Y. (2017). Efektivitas Pengelolaan Labortarium IPA Pada SMP Negeri 1 Mambroko Kabupaten Sumba Tengah. *Pendidikan Ekonomi*, *2*(1), 33–44.

Gusnani, Y., Chiar, M., & Sukmawati. (2019). Pengelolaan Laboratorium IPA di Madrasah Tsanawiyah. *International Conference on Teaching and Education (ICoTE)*, *2*(1), 135–141.

Hayati, A. (2020). Evaluasi Standar Sarana Dan Prasarana Labpratorium IPA Di Sekolah Model SMA Negeri 7 Bengkulu Selatan. *Jurnal Manajer Indonesia*, *14*(2), 70–83.

Jannah, S. N., & Sontani, U. T. (2018). Sarana dan Prasarana Pembelajaran Sebagai Faktor Determinan Terhadap Motivasi Belajar Siswa. *Jurnal Pendidikan Manajemen Perkantoran*, *1*(2), 63–70.

Kalsum, U., Mustami, M. K., & Ismail, W. (2018). Pengembangan Modul Pembelajaran Biologi Materi Ekosistem Berbasis Pendekatan Contextual Teaching and Learning (CTL). *Jurnal Lentera Pendidikan*, *21*(1), 97–109.

Kurniawan, R. A. (2021). Analisis Standarisasi Sarana, Prasarana dan Tenaga Laboratorium IPA MTs Negeri 8 Jember. *Edulab: Majalah Ilmiah Laboratorium Pendidikan*, *6*(1), 29–42.

Maharani, R. I., & Sasi, F. A. (2019). Analisis Cek List Bahan Laboratorium di Laboratorium Biologi FMIPA UNNES. *Jurnal Teknologi Dan Manajemen Pengelolaan Laboratorium (Temapela)*, *2*(1), 38–45.

Mastika, N., Adnyana, P. B., & Setiawan, A. N. G. A. (2014). Analisis Standarisasi Laboratorium Biologi dalam Proses Pembelajaran di SMA Negeri Kota Denpasar. *Journal Program Pascasarjana Universitas Pendidikan Ganesha*, *4*(1), 25–35.

Neji, Amba, H., Ukwetang, O, J., Nja, & O, C. (2014). Evaluating the Adequacy of laboratory facilities on students' academic Performance in Secondary School in Calabar, Nigeria. *Journal of Research & Method in Education*, 4(3), 11–12.

Permendiknas Number 24. (2007) Peraturan Menteri Pendidikan Nasional No 24 Tahun 2007 Tentang Standar Sarana dan Prasarana Untuk Sekolah Dasar/Madrasah Ibtidaiyah (SD/MI), Sekolah Menengah Pertama/Madrasah Tsanawiyah (SMP/MTS), dan Sekolah Menengah Atas/Madrasah Aliyah (SMA/MA).

Poedjiadi, A. (2007). *Ilmu Dan Aplikasi Pendidikan Bagian 3 Pendidikan Disiplin Ilmu*. Grasindo.

Rahman, M. S. (2017). Kajian Standarisasi Sarana Prasarana Laboratorium IPA Berdasarkan Permendiknas No. 24 Tahun 2007 di SMP N 4 Sumenep. *Jurnal Lensa (Lentera Sains)*, *7*(1), 1–11.

Rahmiyati. (2018). The Effectiveness of Laboratory Use in Madrasah Aliyah in Yogyakarta. *Jurnal Penelitian Dan Evaluasi Pembelajaran*, *1*(2), 23–36.

Suardi, M. (2018). *Belajar & Pembelajaran*. Depublish.

Sugiyono. (2013). *Metode Penelitian Pendidikan*. Alfabeta.

Sumiharsono, R., & Hasanah, H. (2017). *Media Pembelajaran*. Pustaka Abadi.

Susilawati, & Bakhtiar, N. (2018). *Biologi Dasar Terintegrasi*. Kreasi Edukasi.

Trianto. (2010). *Model Pembelajaran Terpadu Konsep, Strategi, Dan Implementasinya Dalam Kurikulum Tingkat Satuan Pendidikan (KTSP)*. Bumi Aksara.

Trisianawati, E., Ita, & Fitria. (2020). Analisis Kelengkapan Alat dan Bahan Laboratorium IPA Sekolah di Kota Pontianak. *Jurnal Pendidikan Sains Dan Aplikasinya (JPSA)*, *3*(2), 66–72.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Duck Manure Fertilizer and Paitan Leaves with the Addition of MOL Papaya Skin

Hana Khairunnisa, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Central Java, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Solid Organic Fertilizer
Duck Manure
MOL Papaya Skin
Paitan Leaf

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The use of organic materials for the manufacture of fertilizers is an alternative to reduce waste in the environment. Fertilizer can be made using duck manure and paitan leaves (Tithinia diversifolia) which produce high levels of nutrients.The purpose of this study was to determine the quality of N,P, and K as well as sensory test results which included color, texture, pH, and aroma of duck manure and paitan leaves with the addition of papaya peel bioactivator.This study used an experimental research method with a completely randomized design (CRD) with a factorial pattern.The treatment factors were: Factor 1 weight of duck manure and sick leaves (B1: 300g duck manure+200g paitan leaves, B2: 200g duck manure + 300g paitan leaves), Factor 2: Addition of papaya skin waste bioactivator (P1: 25ml MOL of papaya skin waste , P2: MOL of papaya skin waste 30ml) data analysis used a qualitative descriptive study.The results showed that the best quality was the N test, namely the B1P2 treatment (5.34%), the P test, namely the B2P2 treatment (0.15%),the K test, namely the B2P2 treatment (0.47%).The results showed that the best quality was B1P2 which produced black fertilizer, loose texture, earthy aroma and had a pH of 6.

1. INTRODUCTION

Indonesia is part of a country with a tropical climate, so it is easier for most people to grow crops. In terms of farming, land with adequate soil elements is needed. Please note that the tropical climate can fertilize the soil. Through fertilization, the plants will thrive well because of the nutrients provided. Unfortunately, fertilizers that are often used by the community are inorganic. Inorganic fertilizers have terrible impacts, such as environmental pollution, if used continuously. In addition, the price of inorganic fertilizers, which is too high, affects the quality of the farmers' crops. Overcoming this problem requires another alternative replacing inorganic fertilizers with fertilizers derived from organic materials.

Organic fertilizers can meet the needs required by the soil in meeting the needs of nutrients and improve the earth's physical, chemical, and biological properties (Ketut et al., 2019). The organic materials needed are used as solids and liquids from plant or animal waste. Organic fertilizers can be used as plant fertilizers in solid form. Solid organic fertilizers must contain macro and micronutrients such as Nitrogen, phosphorus, and Potassium. With organic matter in the form of duck manure, the nitrogen and phosphorus content needed by plants can be adequately fulfilled.

Duck manure is still a waste that the community needs to utilize more effectively. The utilization of duck manure includes quality organic matter as fertilizer. However, this requires processing that plant roots can absorb. This duck manure will be processed into fertilizer material that can provide fertility for the soil and plants. Based on research , Duck manure as an organic material can provide the nutrients needed by plants, including the elements of Nitrogen, phosphorus, and Potassium, so the more significant the content of duck manure N: 2.37%, P:

6.89% and K: 0.37%. Adding paitan leaves (Tithinia diversifolia) was carried out to increase the value of the quality of the nutrient content of the duck manure.

Paitan leaves contain active ingredients, especially in the leaves, namely: alkaloids, Flavonoids, saponins, tannins, terpenoids phenolic compounds(Syahputra et al., 2022). Therefore, this part of the leaf, which has bioactive properties, can be used as a plant insecticide. Paitan leaves are wild plants or invasive weeds usually found in tropical areas. According to researchAnnisa (2017), paitan contains N: 3.5%, P; 0.37%, and K 4.10%, so applying paitan compost can reduce inorganic fertilizer doses. Therefore, Paitan has the potential as an inorganic fertilizer supplement to support plant growth and production, reduce pollutants and reduce active P, Al, and Fe adsorption levels.

Papaya peels MOL contains microbes that degrade organic matter as protein decomposition (complex compounds) into more specific elements, including Nitrogen. According toDwiyogo et al. (2022), Nitrogen can be absorbed by plants in the form of ammonium ions or nitrate ions. Therefore, it can be utilized by plants; protein compounds must be broken down into more superficial elements. Microbes contained in MOL from papaya fruit skin are Pseudomonas, Bacillus, and Aspergillus niger. These microbes and fungi also act as phosphorus solvents in the organic matter (Fryatama, 2016). Therefore, the MOL manufacturing solid organic fertilizers also affect the nitrogen content produced.

Based on this background, the problems found with this research are: What is the nutrient content of N, P, and K, and what are the results of sensory observations, which include color, pH, texture, and aroma in solid organic fertilizer (POP) from duck manure and paitan leaves with the addition of papaya peel MOL bioactivator. Therefore, the objectives of this study were as follows: to determine the nutrient content of N, P, and K, to observe sensory input, including color, texture, pH, and aroma in solid organic fertilizer (POP) from duck manure and paitan leaves with the addition of papaya skin MOL bioactivation. This research is expected to provide benefits: 1). Providing innovations as materials for making solid organic fertilizer in the form of duck manure and paitan leaves; 2). Be an alternative organic fertilizer for farmers so that it is not at risk for long-term use.

2. MATERIALS AND METHODS

This research was conducted in Tlangu, Bulan, Wonosari, and Klaten to manufacture organic fertilizers and sensory tests. The Muhammadyah University, Yogyakarta, Faculty of Agrotechnology laboratory, conducted the N, P, and K elemental tests. The research took place from 12 February – 11 March 2023.

The tools used in this study were measuring cups, knives, cutting boards, basins, stirrers, plastic containers, blenders, spoons, label paper, rags, kjdahl flasks, destruction tools, distillation tools, titration tools, pipettes, kjdahl tablets, tubes reaction, volumetric flask, spectrophotometer, and beaker. In addition, the materials used in this study were papaya peel, rice washing water, granulated sugar, aqua dest, paitan leaves, and duck manure.

The research procedures included: 1) preparing four pieces of plastic, each labeled to mark the treatment combination. 2). Put 25 ml and 30 ml of papaya skin MOL bioactivator into the plastic according to the treatment combination. 3). Add 200g and 300g of duck manure into the plastic according to the treatment combination 4). Finally, put as much as 200g and 300g of paitan leaves into the plastic according to the treatment combination. 5). Stir all the ingredients that have been mixed until smooth. 6) Stir and open every three days.

This study uses experimental research methods in descriptive qualitative and quantitative methods Two Way Anova. This study used a completely randomized design (CRD) with a factorial pattern consisting of 4 treatments and three replications. The treatment factors are as follows: Factor 1 is the weight of the duck manure and pain leaves (B_1: 300g duck manure + 200g paitan leaves, B_2: 200g duck manure + 300g paitan leaves), Factor 2: Addition of papaya skin MOL bioactivation (P_1: MOL papaya skin 25 ml, P2: MOL papaya skin 30 ml).

3. RESULTS AND DISCUSSION

Based on the test results of each treatment in laboratory tests (N, P, and K) on the average test results of solid organic fertilizer duck manure and paitan leaves with the addition of MOL papaya skin bioactivator, presented as follows:

Table1. Average laboratory test results for N, P, and K on solid organic fertilizer from duck manure and paitan leaves with the addition of papaya peel MOL bioactivator

No	Treatment	N total (%)	P total (%)	K total (%)
1	B_1P_1	3.52	0.11	0.41
2	B_1P_2	5.34	0.14	0.47*
3	B_2P_1	4.01*	0.14	0.39
4	B_2P_2	3.92	0.15*	0.39

Description: * = Highest element value

3.1. Nitrogen

Nitrogen (N) levels based on Table 1 contained in solid organic fertilizer of duck manure and paitan leaves with the addition of papaya skin MOL bioactivation in four treatments, namely B_1P_1, B_1P_2, B_2P_1, and B_2P_2 after fermentation for four weeks are as follows:

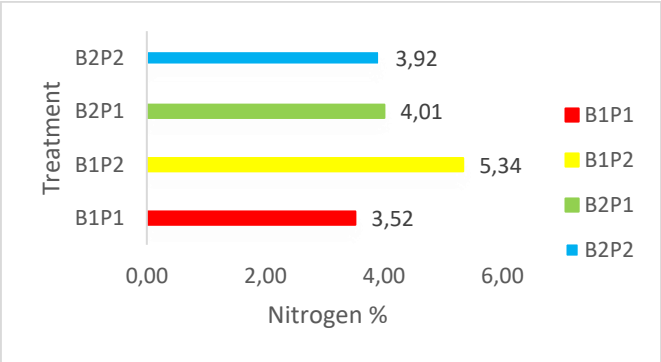


Figure 1. Elemental N test results

Nitrogenase nutrients are needed by plants in large quantities and are absorbed by plants in the form of ammonium (NH4) and nitrate (NO3); these ions come from the decomposition of compounds in the form of proteins by decomposer microorganisms. According to Mustofa (2022), ammonia is the nitrogen produced in the fermentation process. The amount of oxygen in the fermentation process is minimal, so the ammonia obtained in the fermentation process cannot be converted into nitrate, and nitrogen can be lost in the form of NH3 gas at high pH and temperature conditions. Nitrogen plays an essential role in stimulating plant vegetative growth. The research data results in Figure 2 shows that the highest nitrogen content was found in the B_1P_2 treatment, 5.34%, and the lowest nitrogen content was in the B_1P_1 treatment, 52%. The B_2P_1 treatment was 4.01%, and the B_2P_2 treatment was 3.92%. The observed data above shows that the N content in this organic fertilizer complies with the standard quality criteria for organic fertilizer, namely a minimum total N content of 0.40% (SNI-19-7030-2004). This is reinforced by conducting tests using Two Way Anova data analysis in the following table: From the observed data above, it shows that the N content in this organic fertilizer complies with the standard quality criteria for organic fertilizer, namely a minimum total N content of 0.40% (SNI-19-7030-2004). This is reinforced by conducting tests using Two Way Anova data analysis in the following table: From the observed data above, it shows that the N content in this organic fertilizer complies with the standard quality criteria for organic fertilizer, namely a minimum total N content of 0.40% (SNI-19-7030-2004). This is reinforced by conducting tests using Two Way Anova data analysis in the following table:

Table 2. Dependent Variable: Nitrogen Content

Tests of Between-Subjects Effects

Dependent Variable: Kandungan_N

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.629[a]	3	1.876	10722.714	.000
Intercept	211.428	1	211.428	1208160.429	.000
Bahan_Utama	.649	1	.649	3706.714	.000
Bioaktivator	2.245	1	2.245	12826.714	.000
Bahan_Utama * Bioaktivator	2.736	1	2.736	15634.714	.000
Error	.001	8	.000		
Total	217.059	12			
Corrected Total	5.631	11			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

On Two-Way Anova results in Table 2. The main ingredients are duck manure, and Paitan leaves in sig. i.e. 0.000<0.05. In bioactivators with sig. 0.000 <0.05, and the interaction between the main ingredient and the activator affects the nitrogen content. Due to the high N content in the duck manure, which is 2.37%, pain leaves at 3.5%, and the bacteria in the MOL of papaya skin, which causes the effect on nitrogen content. Based on this treatment, the high nitrogen content in solid organic fertilizer from duck manure and paitan leaves with the addition of MOL papaya peel bioactivator was due to the large composition of the main ingredients and additional ingredients given. The amount of concentration in this solid organic fertilizer's ingredients will affect the nitrogen yield. On the other hand, the low nitrogen content in solid organic fertilizers of duck manure and paitan leaves with the addition of the MOL papaya skin bioactivator in the B_1P_1 treatment was 3.52% because this treatment used less MOL of papaya skin, namely 25 ml; this is evidenced in table 1. The low nitrogen content is caused by also the loss of nitrogen levels in the form of ammonia gas during the fermentation process, characterized by the appearance of gas from the container during the fermentation of solid organic fertilizers when it is opened.

3.2. Phosphorus (P)

Test results Phosphorus (P) levels in Table 1 contained in solid organic fertilizer of duck manure and Paitan leaves with the addition of the papaya skin MOL bioactivator, which was carried out with four levels of treatment, namely B_1P_1, B_1P_2, B_2P_1, and B_2P_2 after four weeks of fermentation were as follows:

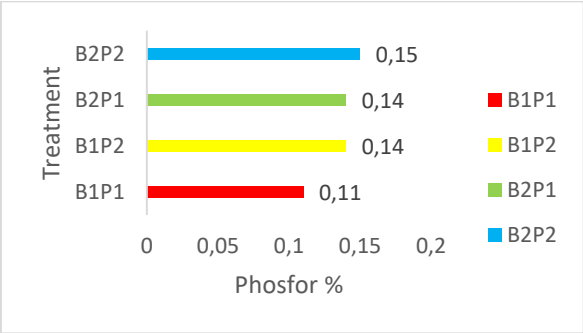


Figure 3. P element test results

Based on research data in Figure 3, it was found that the highest content of element P was in the B_2P_2 treatment with a value of 0.15%, and the treatment with the lowest value was in B_1P_1, namely 0.11%. The results were the same in the B_1P_2 and B_1P_2 treatments, namely 0.14%. The

results of the P content test were 0.11% - 0.15%. The observation data above show that the elemental content of phosphorus resulting from the treatment meets the criteria for solid organic fertilizer quality raw materials by SNI 1970-30-2004 with a minimum total requirement of 0.10%. The low content of P produced can be caused by the content of total N from papaya fruit skin is also low, which is 0.14% (Syahputriani, 2017). Because protein is a complex compound composed of elements C, H, O, and N, and sometimes P and S will be broken down into simpler compounds, and one of them is phosphorus. Therefore, based on the research data results, the nitrogen content is greater than the P element content because the P element in the chemical formula of protein is only a side chain. The P element content in fertilizers is related to the nitrogen element content in the material from the manufacture of fertilizers. The higher the nitrogen content in the material, the multiplication of microorganisms that will break down the P element will increase, and the P element content in fertilizers will increase along with the higher the P content in the material (Fryatbhanneet, 2016). According to Syahputriani (2017), the P content contained in papaya fruit skin is relatively small, namely 0. 02%, so the P element produced in this study was relatively small. This is by the data obtained in the Two Way Anova test as follows:

Table 3. Dependent Variable: Phosphorus Content

Tests of Between-Subjects Effects

Dependent Variable: Kandungan_P

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.003[a]	3	.001	2.400	.143
Intercept	.219	1	.219	583.200	.000
Bahan_Utama	.001	1	.001	3.200	.111
Bioaktivator	.001	1	.001	3.200	.111
Bahan_Utama * Bioaktivator	.000	1	.000	.800	.397
Error	.003	8	.000		
Total	.224	12			
Corrected Total	.006	11			

a. R Squared = .474 (Adjusted R Squared = .276)

Based on the Two-Way Anova test results for phosphorus elements in Table 3, the duck manure and Paitan leaves with sig. 0.111> 0.05, MOL papaya skin bioactivator with sig. 0.111> 0.05, and the interaction with the content of the element phosphorus has no effect. With this, the content of each ingredient, namely duck manure, is 6.89%, and pain leaves 0.37%, with the addition of a bio activator so that there is no effect or interaction between the ingredients and the activator. In the B_1P_1 treatment, with a bioactivator concentration of 25 ml, it was seen to produce a low phosphorus content. In contrast, compared to the B_2P_2 treatment, which used a bioactivator concentration of 30 ml, the phosphorus content was higher; this could happen because the 30 ml bioactivator contained microorganisms that were actively growing. This is in line with Kusumadewi's research (2019) that phosphorus-degrading microbes grow and spread the fastest, causing an increase in microbial activity in the decomposition of organic matter and contributing to an increase in phosphorus levels.

3.3. Potassium

ResultsTesting the levels of potassium (K) in Table 1 contained in solid organic fertilizer of duck manure and Paitan leaves with the addition of papaya skin MOL bioactivation in 4 treatments B_1P_1, B_1P_2, B_2P_1, and B_2P_2 after four weeks of fermentation were as follows:

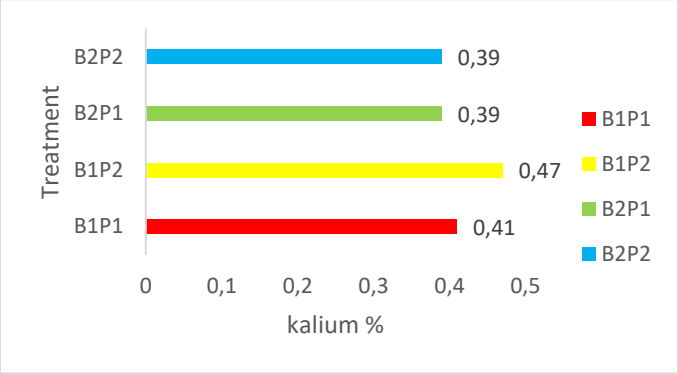


Figure 4. K-element test results

Based on the observational data in Figure 4, the Potassium test was found in the B_1P_2 treatment with the highest elemental yield of 0.47%, while the lowest treatment results were found in B_2P_1 and B_2P_2. In the B_1P_1 treatment, the result was 0.41%. The testing results on potassium levels obtained in this study were between 0.39% - 0.41%. The value of potassium content from the observations meets the criteria for organic fertilizer-quality raw materials according to SNI 1970-30-2004, which requires a minimum potassium content of 0.20%. Rahmawati (2020) states that the element potassium contained in potassium dioxide (K_2O) compounds in the substrate is used by microorganisms as a catalyst; this will affect the presence of bacteria and their activity in the fermentation process. Element K is stored and bound by bacteria and fungi in cells; potassium will be available again if it is degraded again by microorganisms. In another source Safitri et al. (2017), Potassium is an element produced from the process of bacterial metabolism; in bacteria, it will use free K+ ions contained in organic matter as a catalyst so that the potassium level will increase along with the increasing number of bacteria. According to Afiyah et al. (2021) that the activity that occurs in microorganisms during the process of degrading organic matter in the process of making fertilizer will cause the carbon chains in organic matter to break down into more specific elements so that it will cause an increase in the element of Potassium in the fertilizer produced. Potassium levels increase along with growing and increasing the number of bacteria. Reinforced by the data generated in the data analysis test using Two Way Anova, namely as follows:

Table 4. Dependent Variable: Potassium Content

Tests of Between-Subjects Effects

Dependent Variable: Kandungan_K

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.013[a]	3	.004	14.333	.001
Intercept	2.067	1	2.067	6889.000	.000
Bahan_Utama	.008	1	.008	25.000	.001
Bioaktivator	.003	1	.003	9.000	.017
Bahan_Utama * Bioaktivator	.003	1	.003	9.000	.017
Error	.002	8	.000		
Total	2.082	12			
Corrected Total	.015	11			

a. R Squared = .843 (Adjusted R Squared = .784)

Two-Way test results ANOVA in Table 4 of the potassium element in the dirt and pain leaves with a sig. 0.001<0.05, bioactivator with sig. 0.017< and the interaction between the main ingredient and the activator significantly affects the potassium element content. With this, the content of 0.70% duck manure and 4.10% pain leaves with the addition of MOL papaya skin causes an effect on potassium content. Potassium content in organic fertilizers in the combination of materials between treatments with the highest and lowest content yields has a different concentration composition, causing different potassium content results. The difference between

the highest and lowest treatment results is in the content of the materials used; it can affect the results of the potassium content.

Table 5. Average sensory testing (aromatic, texture, color, and pH) on fertilizer from duck manure and paitan leaves with the addition of papaya peel MOL bioactivator

No	Treatment	Observation result			
		Color	Texture	Aroma	pH
1	B_1P_1	Dark brown	Rather subtle	Land	6,6
2	B_1P_2	Very black	Crumb	Land	7
3	B_2P_1	Chocolate	Rather rough	Less stinging	6
4	B_2P_2	Chocolate	Rather rough	It stings enough	6,3

Information :

Color : 1 = Yellow, 2 = Brown, 3 = Dark Brown, 4 = Very Black

Texture : 1 = Coarse, 2 = Slightly Coarse, 3 = Slightly Smooth, 4 = Crumbly

Smell: 1 = Very pungent, 2 = Quite pungent, 3 = Less pungent, 4 = Smells of earth

B_1P_1 : 300 grams of duck manure and 200 grams of paitan leaves with the addition of 25 ml of MOL

B_1P_2 : 300 grams of duck manure and 200 grams of paitan leaves with the addition of 30 ml of MOL

B_2P_1 : 200 grams of duck manure and 300 grams of paitan leaves with the addition of 25 ml of MOL

B_2P_2 : 200 grams of duck manure and 300 grams of paitan leaves with the addition of 30 ml of MOL

B_1P_1

B_1P_2

B_2P_1

B_2P_2

Figure 5. Fertilizer sensory test results (aroma, texture, and color) on fertilizer from duck manure and paitan leaves with the addition of papaya skin MOL bioactivator

3.4. Color parameters

Based on Table 2. And figure 1. The results of observations on the sensory test with the color parameters of organic fertilizer from duck manure and paitan leaves with the addition of the papaya skin MOL bio activator showed that of the four treatments, the best results were obtained according to Figure 5, namely in the B_1P_2 treatment with fertilizer color, namely black on number 4.

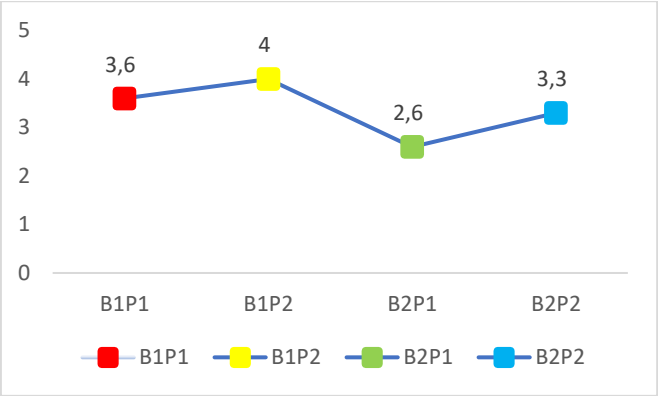


Figure 6. Average color test results

At the beginning of the fermentation, all treatments had the same color as the raw material, namely light brown. Until the end of the fermentation, there was a change in each treatment. Per Figure 5, the results of the color test on B_1P_1 are blackish brown, B_1P_2 is very black, B_2P_1 and B_2P_2 are brown. In the fermentation process, there is a decomposition of organic matter by microbes that take water, oxygen, and nutrients from organic matter, which will then undergo decomposition and release CO_2 and O_2. The color change in the fertilizer is due to organisms that work actively in the decomposition process, namely in the form of duck manure and pain leaves, which are present in each treatment. This is appropriate Abdullah, (2018) states that a color change during composting is caused by the decomposition process carried out by microbes. The color change in solid organic fertilizer is caused by comparing the materials used to manufacture solid organic fertilizer. These organic materials will be converted into nutrients to lose their color pigments which causes the color to turn black. This is in opinion Sarpong et al. (2019) state that the color change that occurs is due to the composting process, which changes organic matter with complex C chains into simple C forms. This process will cause the composted material to lose its color pigment, so the color turns black according to its constituent elements so that the final result of fermenting fertilizer with a black color is obtained according to the standard provisions (SNI No 19-7030-2004), which states that when solid organic fertilizer is ripe, it will have a black color like soil.

3.5. Texture Sensory Test

Based on the sensory observation test results of solid organic fertilizer from duck manure and Paitan leaves with the addition of papaya skin MOL bioactivator with texture parameters in Table 2. And figure 1. Shows that the texture of fertilizer in the B_1P_2 treatment has the best texture, namely crumb-like soil, compared to other treatments.

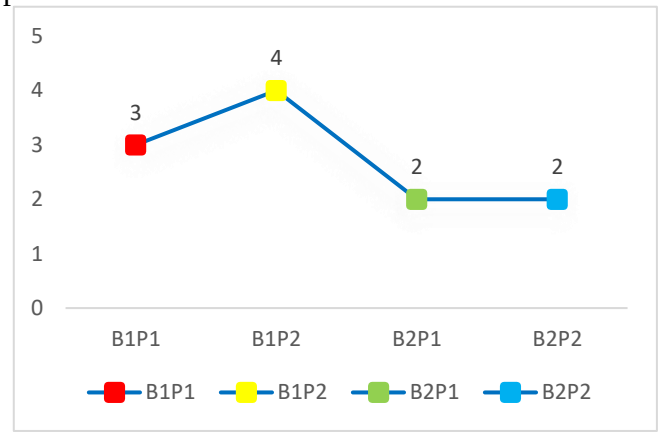


Figure 7. Average texture test results

Differences in texture in fertilizers are caused by the decomposition process using different combinations that affect the final fertilizer yield. The addition of decomposers to fertilizers aims to speed up the decomposition process of fertilizers. The smaller the available particles, the faster the decomposition process will be. The treatment with a rough texture because the decomposing organisms in the fertilizer cannot decompose organic waste quickly. The final results of the sensory parameters of the texture show that the fertilizer has resulted in small particles. Figure 6 shows the results for the B_1P_1 treatment with a rather fine texture at number 3 and the B_2P_1 and B_2P_2 treatments with a slightly rough texture at number 2. This is by government regulations in the form of compost quality standards, namely 0.55-25mm (SNI-19- 7030-2004). Fertilizers with a crumb texture, like soil, will be more easily absorbed by plants. So that the nutrient content in the fertilizer has decomposed, when it is applied, it will be directly absorbed by plant roots.

3.6. Aroma Sensory Test

Based on the sensory observation test results of organic fertilizer from duck manure and Paitan leaves with the addition of papaya skin MOL bioactivator with texture parameters in Table 2. And Figure 7. The aroma of fertilizer in the B_1P_1 and B_1P_2 treatments had the best aroma, namely an earthy smell.

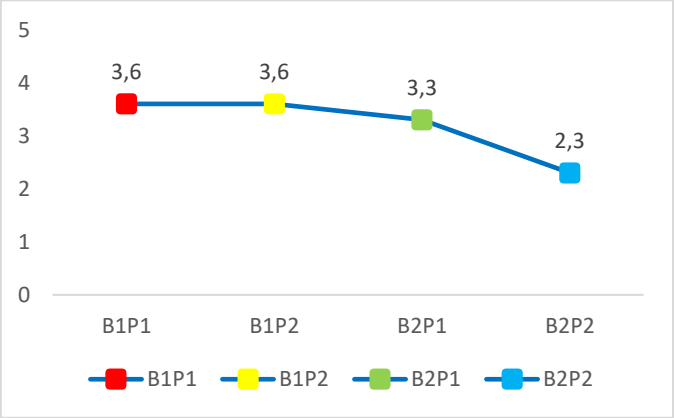


Figure 8. Average aroma test results

The aroma produced by the fertilizer is a sign of decomposition activity by decomposer organisms. The organisms used as decomposers will break down the organic matter into ammonia so that the gas produced can affect the odor present in the material. The odor generated can also come from materials that are too wet. The odor produced will decrease over time, and the pungent smell at first will be replaced with an earthy odor which indicates that the compost is ripe. In the B_2P_1 treatment, the results of a less pungent odor are shown in number 3.3, in the B_2P_2 treatment, the odor is quite pungent. This is by the opinionMentari et al. (2021), which states that the odor produced will decrease over time, and the rotten smell at the beginning of composting will be replaced by an earthy odor indicating that the compost is ripe. The unpleasant smell of compost is due to the process of forming ammonia from the organic matter due to decomposition activity by decomposer organisms where this compound is volatile. At the end of the fermentation, it was found that the fertilizer had an earthy aroma, which by the government decree stated that ripe compost would have an earthy smell (SNI No 19-7030-2004).

3.7. pH content

Based on Table 1. and Figure 4. Observations on the sensory test with the color parameters of organic fertilizer from duck manure and Paitan leaves with the addition of papaya skin MOL bioactivation show that of the four treatments, the pH results obtained can be said to be good because it has a susceptible pH content between 4-9. This is by the Minister of Agriculture

Regulation No. 70/Armenian/SR.140/10/2011 and is reinforced by stating that for good growth, the range of pH content is from 4 to 9 (SNI No 19-7030-2004).

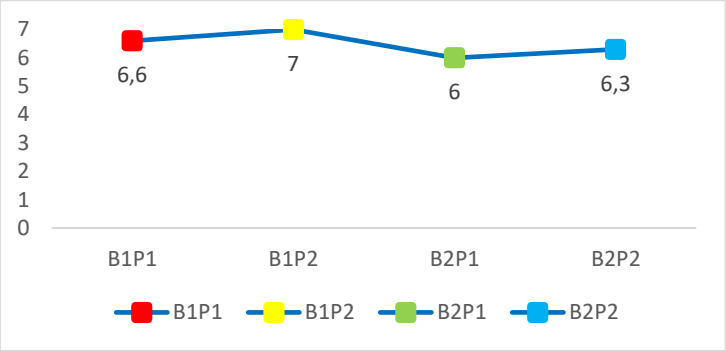


Figure 8. Average fertilizer pH test results

High and low pH can be affected by the activities of decomposing organisms due to the process of converting organic matter into organic acids. This is by research Suwatanti, (2017), which states that changes in pH that occur at the composting stage are thought to be due to the formation of acids by decomposing organisms. The process of decomposition of organic matter by these organisms produces lactic acid and other organic acids, which are weak. In addition, the experimental results showed that the pH was close to neutral, which was caused by mature compost. The increase in pH close to the neutral number can be due to the mineralization process. This is in line with the opinion that the pH of mature compost is usually close to a neutral pH. The increase in neutral pH is due to the addition of organic matter due to the mineralization of organic anions into CO2 and H2O or due to the alkaline nature of the organic matter. Duck manure and paitan leaves, with the addition of papaya peel MOL bioactivator, can be used as a solid organic fertilizer that provides macro-nutrients for plants. This solid organic fertilizer can provide alternatives to farmers as a substitute for chemical fertilizers.

4. CONCLUSIONS

Based on the results of the study, it was shown that the organic fertilizer from duck manure and Paitan leaves with the addition of papaya peel MOL bio activator had, on average good quality in terms of the quality of the elements N, P, and K, and quality tests in the form of color, texture, aroma, and pH by SNI No. 19-7030-2004. In the B_1P_2 treatment with the highest yield, namely the highest N element, namely 5.34%, Potassium element, namely 0.47%, and in the best organic fertilizer quality test, which had black fertilizer results, crumb texture, soil aroma with a pH of 7. The highest phosphorus test result was 0.15% in the B_2P_2 treatment. The limitations of the researchers in this study were obtaining fertilizer materials in large quantities. It is hoped that in the future, further research will be carried out on organic fertilizers for duck manure and paitan leaves with the addition of MOL papaya skin with a larger organic matter composition, and it is necessary to carry out further tests on the application of solid organic fertilizers It's in plants.

5. ACKNOWLEDGMENTS

This research went well thanks to the help of various parties, for researchers would like to thank to Universitas Muhammadiyah Surakarta who have provided good cooperation in this research.

6. REFERENCES

Abdullah, Adi. 2018. "The Effect of Bioactivator Types on the Decomposition Rate of Teak Tectona Grandis LF Leaf Litter, In the Unhas Tamalanrea Campus Area. Bioma : *Journal of Biology Makassar*. Vol. 3.

Andria, M., Abdurrahman, T., & Rahayu, S. (2019). Effect of Combination of NPK and Duck Manure on the Growth and Yield of Sorghum Plants in Peat Soil. Equator Agricultural Science Journal, 9(1). Mentari, F. Silvi Dwi, Yuanita, and Roby. 2021. "Making Sugarcane Bagasse Compost Using MOL Bamboo Shoots Bioactivator." Poltanesa Bulletin 22 (1). https://doi.org/10.51967/tanesa.v22i1.333.

Annisa, P., & Gustia, H. (2018). Response of growth and production of melon plants to Tithonia diversifolia liquid organic fertilizer. National Secretariat Proceedings, 104-114.

Dian Safitri, Adhis, Riza Linda, Biology Study Program, Faculty of Mathematics, Tanjungpura University, and Jl H Hadari Nawawi. 2017. "Application of Liquid Organic Fertilizer (POC) Fermented Goat Manure With EM4 on the Growth and Productivity of Cayenne Pepper (Capsicum Frutescents L.) Var. Bara." Vol. 6.

Fryathama, I., & Sukmiwati, M. (2017). Utilization Of The Visceral Organsof Catfish (Pangasius Hypoptalmus) Added To Banana Peel (Musa Acuminata Balbisiana) To Produce Liquid Organic Fertilizer. *Student Online Journal (JOM) in the Field of Fisheries and Marine Sciences*, 4(1), 1-10.

Indonesia, S. N. (2004). Specifications for compost from domestic organic waste. *SNI*: Jakarta

Ketut Putu Suniantara, I, I Gede Eka Wiantara Putra, Ni Putu Sri Ayuni, Jl Raya Puputan No, and Renon Denpasar - Bali. 2019. "National Seminar on Community Service Results 2019 SINDIMAS 2019 STMIK

Kusumadewi, M. A., Suyanto, A., & Suwerda, B. (2019). Content of Nitrogen, Phosphorus, Potassium, and pH of Liquid Organic Fertilizer from Market Fruit Waste Based on Time Variation. Sanitation: *Journal of Environmental Health*, 11(2), 92-99.

Mustofa M, and Fikri LS. 2022. Organic liquid fertilizer from bio-eranol waste and goat livestock waste: analysis of N, P, and K levels. *Journal of Social and Science.* 2(1): 210 - 218. Pontianak." Vol. 29.

Nirmala Afiyah, Delinda, Emelia Uthari, Dewi Widyabudiningsih, and Retno Dwi Jayanti. 2021. "Making and Testing Liquid Organic Fertilizer (POC) From Market Waste Using EM4 Bioactivators." Fullerene Journ. Of Chem 6 (2): 89–95. https://doi.org/10.37033/fjc.v6i2.325.

Sarpong, DE, Oduro-Kwarteng, S., Gyasi, SF, Buamah, R., Donkor, E., Awuah, E., & Baah, MK (2019). Biodegradation by composting of municipal organic solid waste into organic fertilizer using the black soldier fly (Hermetia illucens)(Diptera: Stratiomyidae) larvae. *International Journal of Recycling of Organic Waste in Agriculture*, 8, 45-54.

Suwatanti, EPS, & Widiyaningrum, P. (2017). Utilization of MOL of vegetable waste in the composting process. *Indonesian Journal of Mathematics and Natural Sciences*, 40(1), 1-6.

Syahputra, S., Rustam, R., & Salbiah, D. (2022). TEST OF SEVERAL CONCENTRATIONS OF BITTER LEAF FLOUR EXTRACT *(Tithonia diversifolia A. Gray*) ON MORTALITY OF CORN COB MOTORING LARVAE Helicoverpa armigera Hubner. AGRICULTURAL DYNAMICS , 38 (3), 277-284.

Wicaksono, GD, & Rachmawati, SH (2022). NPK Analysis of Liquid Organic Fertilizer from Tilapia Waste with the Utilization of Papaya Skin Local Microorganisms. *Fishtech Journal*, 11(1), 47-57.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Liquid Organic Fertilizer Combination Gamal Leaves and Tofu Dregs with Banana Stem Bioactivator

Feby Istifarini, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Banana stem
Bioactivators
Gamal leaves
Liquid organic fertilizer
Tofu dregs

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Liquid organic fertilizer is an effective solution to inorganic fertilizers. Gamal leaves and tofu dregs can be used to make fertilizer and banana stem bioactivator to speed up fermentation. The study aim to determine the quality of liquid organic fertilizer (LOF) from the combination of gamal leaves and tofu dregs with the banana stem bioactivators based on sensory properties parameters and N, P, K content. This research method used experimental method with a completely randomized design (CRD). It consists of two factors, As for factor 1, namely the combination of gamal leaves and tofu dregs, P1 = 100 ml : 200 ml, P2 = 120 ml : 180 ml. Factor 2 is banana stem bioactivator, B1 = 100 ml, B2 = 150 ml. Data analysis used descriptive qualitative and quantitative statistics used Two Way ANOVA. In observing the sensory indicators, the average fertilizer yield had a dark brown color, scent like soil, and a pH of 5. Meanwhile, in the content test, only the N content met SNI 19-7030-2004. Thus, it can be concluded that the quality of fertilizer can be used as fertilizer but the color parameters, P and K content do not meet the standards.

1. INTRODUCTION

Indonesia is a well-known agricultural nation in numerous sectors. One of them is the agricultural sector, which can only exist with plant fertilizers. Fertilizer is a substance used to provide essential nutrients to plants. Unfortunately, most farmers rely heavily on government-subsidized inorganic (chemical) fertilizers. In contrast, excessive use of inorganic (chemical) fertilizers damages soil components and kills decomposing microorganisms. Therefore, an effective solution to this issue is transitioning from inorganic (chemical) to organic (natural) fertilizers, readily available in the local environment.

Organic fertilizers are fertilizers derived from a combination of natural or organic materials that contain large amounts of nutrients in small amounts and, in addition to supplying plants with the elements they require, can also improve the biological, physical, and chemical activities of the soil (Rahma et al., 2014). Liquid fertilizer has the advantage of being able to eliminate nutrient deficiencies in plants more rapidly than solid fertilizers. Liquid organic fertilizer contains plant nutrients such as N by 3-6%, P_2O_5 by 3-6%, and K_2O by 3-6%, and its pH ranges from 4 to 9 (Regulation of the Minister of Agriculture, 2011).

Liquid organic fertilizer requires a mixture of supporting organic materials. Two distinct substances can be combined with the intention of enhancing the availability of plant-required nutrients. Gamal leaves are one of the organic materials that can be used as liquid organic fertilizer and are derived from leguminose plants. Due to a lack of knowledge regarding the composition and benefits of gamal leaves, they are typically reserved for animal fodder. The composition of gamal leaves is rich in macro and micronutrients, with Nitrogen by 3.15%, Phosphorus by 0.22 %, Potassium by 2.65 %, Calsium by 1.35 %, and Magnesium by 0.41 %. The content of essential nutrients in gamal leaves can satisfy the high nutrient needs of plants (Novriani et al., 2019).

To meet the need for low phosphorus content in gamal leaves, it is necessary to add tofu dregs, which have a high phosphorus content and is used to make liquid organic fertilizer. Tofu dregs are solid refuse resulting from the tofu factory industrys residual processing of soybeans into tofu. According to Jupry (2020), utilization of tofu dregs has the availability of nutrients needed by plants. The content of essential nutrients needed by plants in tofu dregs is N by 1.24%, P_2O_2 by 5.54 %, K_2O by 1.34%, and C-Organic by 5.803%.

The production of liquid organic fertilizer necessitates using of a bioactivator, which is employed to speed up fermentation. In addition, the bioactivator in the fermentation of liquid organic fertilizer serves as a decomposer or decomposer of organic substances within the material. Banana stems are one form of bioactivator that can be utilized. Bioactivators or local microorganisms (MOL) derived from naturally occurring banana stems contain micro and macro elements as well as bacteria that decompose organic matter. According to research Tuhuteru et al., (2021), the microbial content of banana stems includes nutrient suppliers such as *Lactobacillus*, *Actinomycetes*, Phosphate solvent, and *Saccharomyces*. Banana stem bioactivator or MOL also contains the hormones gibberellin and cytokinin, which function to divide plant tissue in order to accelerate plant growth, including plant height, root dry weight, and leaf area.

Based on the preceding context, the research problems are as follows: How is the quality of liquid organic fertilizer (LOF) derived from the combination of gamal leaves and tofu dregs with the addition of banana stem bioactivator as measured by sensory properties parameters (color, scent, pH) and indicators of Nitrogen (N), Phosphorus (P), and Potassium (K). This study aims to determine the quality of liquid organic fertilizer (LOF) from combination of gamal leaves and tofu dregs with the addition of a bioactivator derived from banana stems based on sensory properties parameters (color, scent, pH) and indicators of nitrogen (N) content, phosphorus (P) content, and potassium (K) content.

In the meantime, it is hoped that the results of this study will provide information for the following purposes: 1) Researchers will acquire additional knowledge and insight regarding the use of organic matter in the production of liquid organic fertilizer. 2) The community is aware of the application and composition of gamal leaves and tofu dregs as liquid organic fertilizer (LOF) with banana stem bioactivator.

2. MATERIALS AND METHODS

This research was conducted from February and April 2023 at the Green House Laboratory of the Faculty of Teacher Training and Education at Universitas Muhammadiyah Surakarta to produce liquid organic fertilizer and conduct sensory evaluations (Color, Scent, pH). Tests of Nitrogen (N) content by using the Kjeldahl method, Phosphorus (P) content, and Potassium (K) content by using wet ashing with HNO_3 and $HCIO_4$ were conducted at Universitas Muhammadiyah Yogyakarta Soil and Plant Nutrition Laboratory, Agrotechnology Study Program.

The tools used in the manufacture of liquid organic fertilizer from the combination of gamal leaves and tofu dregs with the addition of banana stem bioactivators are jars, blenders, basins, digital scales, analog scales, wooden stirrers, stoves, filters, measuring cups, knives, pH indicators, distillation, titration, test tubes, spectrophotometer, flamephotometer, stationery, documentation tools, gloves. Meanwhile, the materials used for making fertilizer are gamal leaves, tofu dregs, banana stems, water, brown sugar, molasses, coconut water, leri water, ground water, bran, pH stick, raffia rope, H_2SO_4 concentrated, distilled water, salt, N_2OH 45%, Zn, H_3BO_3 4%, HCL 0,1 N, HNO_3 concentrated, $HCIO_4$ concentrated, HNO_3 2N, ammonium heptamolybdate vanadate, concentrated extract to P.

The research procedures includes: Preparing Tools and Materials, Make Stock of Banana Stem Bioactivator by conducting sensory observations once every 3 days with stirring before observation. Then, make Tofu Dregs Flour Stock. The next step is to make stock of Gamal leaf extract. Then, make Liquid Organic Fertilizer with prepared materials such as gamal leaf extract, stock of tofu dregs flour, and banana stem bioactivator according to the concentration. Then, observing the sensory properties of each fertilizer every 3 days according to the indicator

parameters of color, scent, pH. Then, after the fertilizer has been fermented, tests for the content of N, P, K include the N Test (Kjeldahl Method), P Test (Wet Ashing with HNO_3 and $HCIO_4$), and K test (wet ashing with HNO_3 and $HCIO_4$).

This research method used an experimental research type with a Completely Randomized Design (CRD) consisting of 2 factors with 4 combinations and 3 repetitions. The first factor is the use of a combination of the basic ingredients of gamal leaves and tofu dregs, namely P_1 : 100 ml : 200 ml, P_2 : 120 ml : 180 ml. Factor 2 is the addition of MOL or banana stem bioactivator, namely B_1 : 100 ml, B_2 : 150 ml. There are 2 data analyzes used, namely descriptive qualitative and quantitative statistics using two-way analysis of variance (Two Way ANOVA).

3. RESULTS AND DISCUSSION

3.1 Sensory Observation

The results of sensory research involving liquid organic fertilizer combined with gamal leaves and tofu dregs with the addition of banana stem bioactivator, conducted using a sensory questionnaire on 10 farmer panelists from four combination samples with three replications, are as follows:

Table 1. sensory observations on liquid organic fertilizer a combination of gamal leaves and tofu dregs with the addition of banana stem bioactivator.

Treatment	Indicator		
	Color	**Aroma**	**pH**
P_1B_1	Dark Brown	Scent Like Soil	5
P_1B_2	Dark Brown	Scent Like Soil	5
P_2B_1	Greenish Brown	Non-pungent Fermentation Odor	5
P_2B_2	Greenish Brown	Scent Like Soil	5

Notes:

P_1B_1 : liquid organic fertilizer with a concentration of 100 ml of gamal leaf extract and 200 ml of tofu dregs with the addition of 100 ml of banana stem bioactivator.

P_1B_2 : liquid organic fertilizer with a concentration of 100 ml of gamal leaf extract and 200 ml of tofu dregs with the addition of 150 ml of banana stem bioactivator.

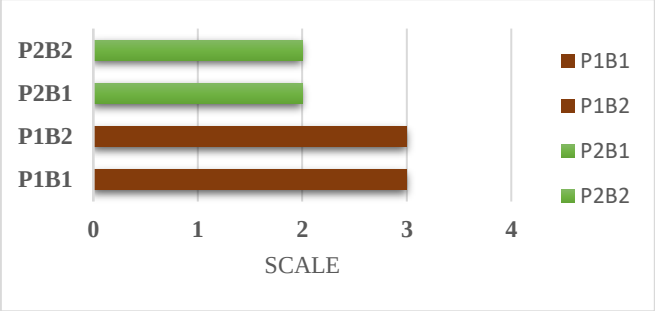
P_2B_1 : liquid organic fertilizer with a concentration of 120 ml of gamal leaf extract and 180 ml of tofu dregs with the addition of 100 ml of banana stem bioactivator.

P_2B_2 : liquid organic fertilizer with a concentration of 120 ml of gamal leaf extract and 180 ml of tofu dregs with the addition of 150 ml of banana stem bioactivator.

The Sensory Observations on liquid organic fertilizer include the following parameters:

3.1.1 Color Parameters

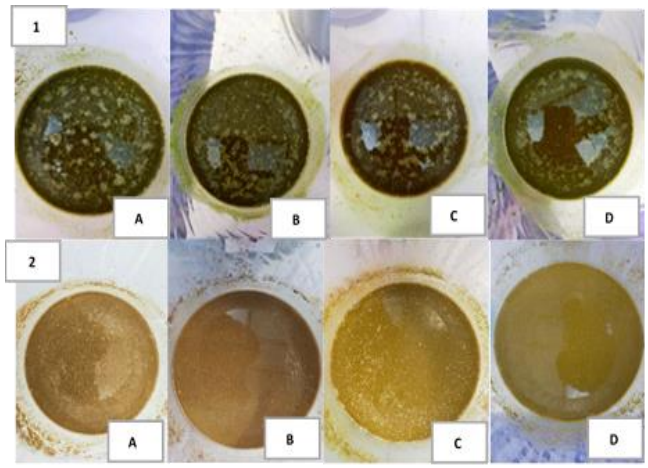
The color parameter is a physical property-based indicator of fertilizer quality based on physical properties. The color change of the fertilizer is a result of the combined ingredients (Fangohoy, 2017). The following bar chart shows the color parameters based on sensory observation research findings:



Note: 1=yellowish brown; 2=greenish brown; 3=dark brown; 4=slightly dark brown

Figure 1. The color of liquid organic fertilizer

Four samples of liquid organic fertilizer are shown in Table 1 and Figure 1. During production, the color of the liquid organic fertilizer is greenish brown; however, after 14 days of fermentation, the color of each treatment varies. In the treatment of P_1B_1 and P_1B_2, the fertilizer color is dark brown; in the treatment of P_2B_1 and P_2B_2, the fertilizer color is greenish brown, as shown in Figure 1. Fertilizer color can be shown in the following figure:



Notes: 1= Early fermentation 2=Final fermentation; A=P_1B_1, B=P_1B_2, C=P_2B_1, D=P_2B_2

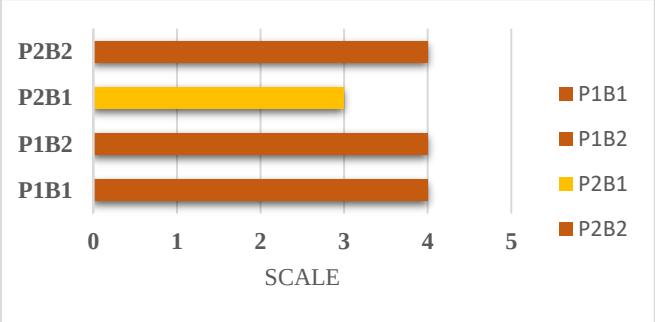
Figure 2. Sensory observation of liquid organic fertilizer

The maturation of liquid fertilizer can be determined by its transformation from its original color to brown. If the color remains the same as when it was first produced, the fermentation time is still too rapid (Sari et al., 2022). The average brown color was generated by the four fertilizer treatment. According to Yuliatin et al., (2018), The transformation of liquid fertilizer color to brown after the fermentation process indicates the fertilizer effectiveness.

In this study, the average color of liquid organic fertilizer combined with gamal leaves, tofu dregs, and banana stem bioactivator did not meet SNI 19-7030-2004 specifications. The requirements of SNI 19-7030-2004 for the maturation of liquid organic fertilizer are dark brown. This is due to the fourth color combination of liquid organic fertilizer based on the used constituent mixture. In accordance with Arifan et al., (2020) finding that the color change produced in liquid organic fertilizer is influenced by the main ingredients used, the color produced from each ingredient can be used as an indicator of the success of making liquid organic fertilizer.

3.1.2 Scent Parameter

Liquid organic fertilizer is successful based on its scent. The scent parameters can be represented as follows in a bar chart based on the research findings:



Notes: 1 = Bad scent; 2=Strong Fermentation scent; 3=Non-pungent Fermentation Scent; 4=Scent Like Soil

Figure 3. The scent of liquid organic fertilizer

In Table 1 and Figure 3, the P_2B_1 treatment produces a non stinging fermented odor. In contrast, when P_1B_2, P_1B_2, and P_2B_2 are treated, an earthy odor is produced. In accordance with research Indrayani et al., (2019), liquid organic fertilizer at maturity will scent of fermentation and not sting and scent like soil. According to Triyanto (2021), the level of maturity of liquid organic fertilizer can be determined by observing the reduction of odor and heat.

During the 14-day fermentation of liquid organic fertilizer, bioactivators derived from banana stems aid the microorganisms activity. During the 14-day fermentation process of the banana stem bioactivator, the odors of tape and alcohol are released. According to the findings of Heryan et al., (2022), the scent that indicates a fermentation process caused by active microorganisms has a fresh sour aroma or a distinct tape scent and does not smell unpleasant. This demonstrates that liquid organic fertilizer satisfies the requirements of SNI 19-7030-2004 for the scent parameter. Because the organic matter in the fertilizer was properly fermented and the nutrients were properly formed, a mature fertilizer has a scent like soil.

3.1.3 pH Parameter

The similarity of the pH values of the four combinations is as follows, according to the results of the investigation on the pH parameters shown in table 1:

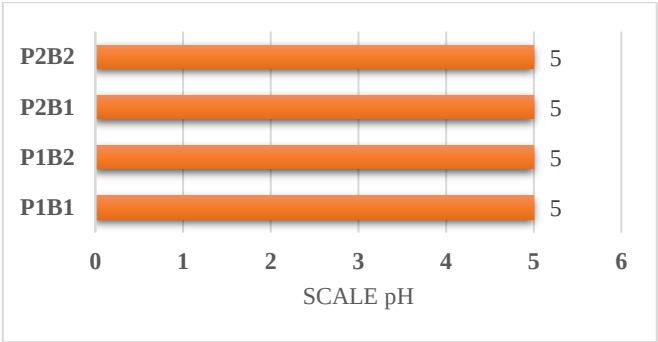


Figure 4. pH of Liquid Organic Fertilizer

The pH parameter in liquid organic fertilizer is one of the quality indicators for liquid organic fertilizer. The pH value during composting has a significant impact on microbial development. If the pH level of the compost is too high, the nitrogen component will convert into ammonia (NH3) (Ekawandani, 2018). The pH of liquid organic fertilizer can be high or low, depending on the fermentation microorganisms (Al-Hadi, 2021).

In Table 1 and Figure 4, the pH of the fermentation process for each of the four liquid organic fertilizer applications of 5. The pH of liquid organic fertilizer can decrease or increase because microorganisms or decomposers in organic matter produce unstable organic acids. Each observation reveals that the pH of mature liquid organic fertilizer is constant and stable. In

accordance with Norhikmah et al.,(2022), during the fermentation of liquid organic fertilizer, decomposition-involved microorganisms convert organic matter into organic acids, resulting in pH fluctuations. The longer the fermentation period, the closer the pH of the fertiliser will approach neutrality.

During the 14-day fermentation period of this investigation, the pH of the fertilizer was 5. It met the standards according to the 2011 Republic of Indonesia Agricultural Regulations concerning Organic Fertilizer, Biological Fertilizer, and Soil Improvement, which states that the minimum pH value of Liquid Organic Fertilizer is between 4-9.

3.2 N, P, K content

On the basis of laboratory results and two-way analysis of variance (Two way ANOVA), the following average yields were determined for the liquid organic fertilizer combination of gamal leaves and tofu dregs with the addition of banana stem bioactivator:

Table 2. the results of the analysis of the average content of Nitrogen (N), Phosphorus (P), and Potassium (K) in the liquid organic fertilizer combination of gamal leaves and tofu dregs with the banana stem bioactivator (%).

Sample Combination	Average Analysis Results		
	N (%)	P (%)	K (%)
P_1B_1	0.71	0.06**	0.09**
P_1B_2	0.72**	0.05*	0.07
P_2B_1	0.47*	0.05*	0.06*
P_2B_2	0.59	0.05*	0.08

Notes: (*) lowest result
(**) highest result

The nutrients contained in the liquid organic fertilizer combination of gamal leaves and tofu dregs with banana stem bioactivator include:

3.2.1 Nitrogen (N) Content

Nitrogen in fertilizer contributes to the synthesis of chlorophyll and the development of plant vegetative organs, such as the production of verdant leaves (Asroh, 2019). Based on of laboratory experiments for nitrogen content in liquid organic fertilizer, the following bar chart can be constructed:

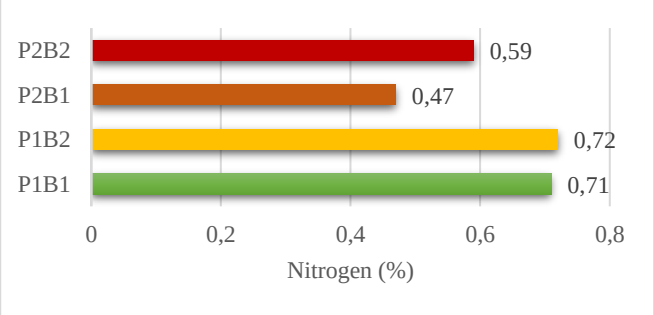


Figure 5. Nitrogen content of liquid organic fertilizer (%)

In Table 2 and Figure 5, the P_1B_2 treatment has the highest Nitrogen content of 0.72%. The lowest Nitrogen concentration was 0.47 % in the P_2B_1 treatment. In terms of the composition of

the used ingredients, the combination of 100 ml : 200 ml contained the highest nitrogen content. According to research Hardikawati et al., (2017), the highest nitrogen content in liquid organic fertilizer can be obtained from a ratio of 100 ml to 200 ml. The highest Nitrogen content is also affected by the addition of bioactivators with the highest combination, namely 150 ml. Because bioactivators in fertilizers can affect Nitrogen content as a result of the decomposition or overhaul of organic materials broken down by microorganisms (Andriany et al., 2018).

Based on the result of Two way ANOVA, it can be concluded that there is an interaction effect between the combination of constituents and the addition of bioactivators on the Nitrogen (N) content, such that each treatment has a different mean, as indicated by a Sig. 0.019 < 0.05 and can be seen from Figure 5. This is consistent with the research Meriatna et al., (2018), which indicates the difference between higher and lesser Nitrogen content is influenced by the growth of microorganisms that divide their cells. Additionally, the fermentation period effects the nitrogen content of the fertilizer. In the production of liquid organic fertilizer, the considerable variation in nitrogen content can be influenced by organic matter containing protein (Jeksen, 2017).

Nitrogen (N) content in liquid organic fertilizer combination of gamal leaves and tofu dregs with the banana stem bioactivator from the four treatment combinations match the requirements of SNI 19-7030-2004 with a minimum standard of Nitrogen (N) content in liquid organic fertilizer, namely 0.40 %.

3.2.2 Phosphorus (P) Content

Phosphorus contributes to the development of seeds, roots, flowers, and fruits in vegetation. Phosphorus content of liquid organic fertilizer is superior to that of solid (Irawan et al., 2021). According to the test results for the Phosphorus content of liquid organic fertilizer, the following bar chart can be constructed:

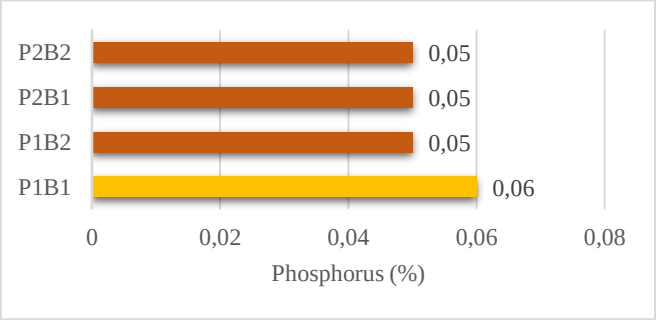


Figure 6. Phosphorus content of liquid organic fertilizer (%)

In Table 2 and Figure 6, the P_1B_1 treatment has the highest Phosphorus concentration in liquid organic fertilizer combined with gamal leaves and tofu dregs with the banana stem bioactivator. The liquid organic fertilizer combination of gamal leaves and tofu remnants with the addition of banana stem bioactivator had the lowest Phosphorus content, at 0.05% on average for the P_1B_2, P_2B_1, and P_2B_2 treatments. Phosphorus content in liquid organic fertilizer is influenced by the nutrient content of the liquid organic fertilizer organic base constituents. Tofu dregs contain more phosphorus than gamal leaves. According to research conducted by Rahmina et al. (2017), the Phosphorus (P) content of tofu dregs is 1.219 %. In the meantime, according to research by Novriani et al. (2019), the Phosphorus content of gamal leaves is 0.22 %.

The duration of fermentation also affects the amount of Phosphorus (P) in liquid organic fertilizer. The average content of the four liquid organic fertilizer treatments decreased, and each treatment had a low average content. In accordance with previous research Rasmito et al., (2019), which states the Phosphorus concentration in fermented liquid organic fertilizer for 10 days is greater than for 15 days. Because the longer the fermentation time, the more air penetrates during fermentation, resulting in the death of decomposing microorganisms due to a lack of nutrients.

Based on the result of Two way ANOVA, it can be concluded that the combination of ingredients, the addition of bioactivator, and the interaction of the combination of ingredients and the addition of bioactivator have no effect on the phosphorus content, as each treatment has a mean close to the Sig. 0.0750 > 0.05 and can be seen fom Figure 6. This is because phosphorus-containing materials in each treatment are not completely broken down by decomposing microorganisms, resulting in a low phosphorus content. According to research Gunawan et al., (2015), phosphate solvent decomposing microorganisms aid in dissolving phosphate to produce available phosphorus content in fertilizers.

The percentage of Phosphorus (P) in the four treatment configurations of liquid organic fertilizer combined with gamal leaves and tofu dregs was categorized as low on average and did not meet SNI 19-7030-2024 standards with a minimum limit of 0.10 %.

3.2.3 Potassium (K) content

The primary function of potassium is to fortify the plant body so that its flowers and fruits do not fall off readily (Lepongbulan et al., 2017). According to the test results for the Potassium content of liquid organic fertilizer, the following bar chart can be constructed:

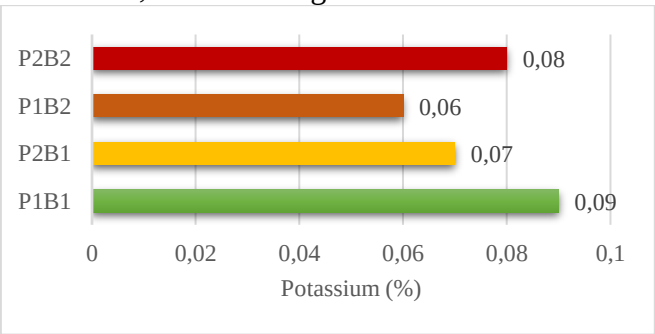


Figure 7. Potassium content of liquid organic fertilizer (%)

The results of Potassium Content test for the four combinations of Liquid Organic Fertilizer treatments in Figure 7 and Table 2 have different average percentages. The highest Potassium content was 0.09% in the P_1B_1 treatment. Meanwhile, the lowest potassium content was 0.06% in the P_1B_2 treatment. The level of Potassium content in liquid organic fertilizer is also influenced by the length of time of fermentation. This is in accordance with research Kusumadewi et al., (2019), Potassium levels are higher in liquid organic fertilizer fermented for one week than for two weeks, because the longer the fermentation, the lower the activity of microorganisms in decomposing organic compounds and the lower the potassium levels obtained. There is no correlation between fermentation time and potassium content.

Based on the result of Two way ANOVA, it is possible to conclude that there is an interaction effect of the combination of materials and the addition of bioactivators on the Potassium (K) content, such that each treatment has a distinct mean with a different Sig. 0.009 < 0.05 and can be seen from Figure 7. Potassium content in each treatment differs due to the number of combined concentrations of the ingredients and the addition of bioactivators to liquid organic fertilizers to speed up the fermentation process carried out by microbes or microbes (Rahmawati et al., 2020). The presence of microorganism activity in the substrate material as a bioactivator in the fermentation process can influence potassium concentration differences (Ratrinia et al., 2014).

The Potassium (K) content of liquid organic fertilizer combined with gamal leaves and tofu dregs with the banana stem bioactivator is low on average and does not meet the SNI 19-7030-2004 minimum limit of 0.20 %.

4. CONCLUSIONS

Based on the research results of liquid organic fertilizer combination of gamal leaves and tofu dregs with banana stem bioactivator, the highest nitrogen content was 0.72% in the P_1B_2 treatment

with sensory properties of dark brown color, soil-like scent , and pH 5. The highest phosphorus content was 0.06% in the P_1B_1 treatment with sensory properties of dark brown color, soil-like scent, and pH 5. The highest potassium content is treatment P_1B_1 was 0.09% with sensory properties of dark brown color, scent like soil, and pH of 5. Thus, according to SNI 19-7030-2004 and Regulation of the Minister of Agriculture of 2011, the quality of fertilizer is not yet SNI 19-7030-2004 standard liquid organic fertilizers because the color parameters, P and K levels obtained are below standard quality standards. However, liquid organic fertilizers can still be used in plants because it comes from organic matter and contains nutrients, although it cannot be traded.

Based on this research, the author suggests that further research is needed with more diverse concentrations of liquid organic fertilizer. It is expected to conduct further tests to determine the quality of liquid organic fertilizer based on micronutrient content.

5. ACKNOWLEDGMENTS

The author would like to thank to Biology Education Study Program, which has provided subsidies for INCOBEST 2023. Further thanks to all parties involved and have encouraged the author.

6. REFERENCES

Al-Hadi, A. M., & Masjud, Y. I. (2021). The Study of Tong Composter in Produced Liquid Organic Fertilizer. *Journal of Environmental Engineering and Waste Management*, *6*(2), 71–89. https://doi.org/10.33021/jenv.v6i2.1451

Andriany, Fahruddin, & Abdullah, A. (2018). Pengaruh Jenis Bioaktivator Terhadap Laju Dekomposisi Seresah Daun Jati *Tectona grandis* L.f., Di Wilayah Kampus UNHAS Tamalanrea (Effect of Bioactivator Type on Teak Leaf Litter Decomposition Rate *Tectona grandis* L.f., in the UNHAS Tamalanrea Campus Area). *BIOMA : JURNAL BIOLOGI MAKASSAR*, *3*(2), 31–42. https://doi.org/https://doi.org/10.20956/bioma.v3i2.5820

Arifan, F., Ari Setyati, W., Wisnu Broto, R., & Larasati Dewi, A. (2020). Pemanfaatan Nasi Basi Sebagai Mikro Organisme Lokal (MOL) Untuk Pembuatan Pupuk Cair Organik di Desa Mendongan Kecamatan Sumowono Kabupaten Semarang (Utilization of Stale Rice as Local Micro Organisms (MOL) for Making Organic Liquid Fertilizer in Mendongan Village, Sumowono District, Semarang Regency). *Jurnal Pengabdian Vokasi*, *1*(4), 252–255.

Asroh, A., & Novriani. (2019). Pemanfaatan Keong Mas Sebagai Pupuk Organik Cair Yang Dikombinasikan Dengan Pupuk Nitrogen Dalam Mendukung Pertumbuhan Dan Produksi Tanaman Selada (*Lactuca sativa* L.) (Utilization of Golden Snail as Liquid Organic Fertilizer Combined with Nitrogen Fertilizer to Support The Growth and Production of Lettuce Plants (*Lettuce sativa* L.). *Klorofil XIV*, *14*(2), 83–89.

Badan Standarisasi Nasional. 2004. Spesifikasi Kompos dari Sampah Organik Domestik. SNI 19-7030-2004. Jakarta:Badan Standarisasi Nasional.

Ekawandani, N., & Anzi Kusuma, A. (2018). Pengomposan Sampah Organik (Kubis Dan Kulit Pisang) Dengan Menggunakan EM4 (Composting Organic Waste (Cabbage And Banana Peel) Using EM4). *TEDC*, *12*(1), 38–43. https://doi.org/https://doi.org/10.31227/osf.io/3gt26

Fangohoy, L., & Wandansari, N. R. (2017). Pemanfaatan Limbah Blotong Pengolahan Tebu Menjadi Pupuk Organik Berkualitas (Utilization of Sugar Cane Processing Blotong Waste into Quality Organic Fertilizer). *Jurnal Triton*, *8*(2), 2085–3823.

Gunawan, R., Kusmiadi, R., & Prasetiyono, E. (2015). Studi Pemanfaatan Sampah Organik Sayuran Sawi (*Brassica juncea* L.) Dan Limbah Rajungan (*Portunus pelagicus*) Untuk Pembuatan Kompos Organik Cair (Study on the Utilization of Mustard Greens Organic Waste (*Brassica juncea* L.) And Swimming Pool Waste (*Portunus pelagicus*) For Making Liquid Organic Compost). *Jurnal Pertanian Dan Lingkungan*, *8*(1), 37–47.

Hardikawati, Isnaini, M., & Asngad, A. (2017). *Uji Kandungan Nitrogen dan Phospor Pupuk Organik Cair Kombinasi Ampas Sagu dan Daun Lamtoro dengan Penambahan Kotoran Itik Sebagai Bioaktivator (Test of Nitrogen and Phosphorous Content of Liquid Organic Fertilizer Combination of Sago Dregs and Lamtoro Leaves with the Addition of Duck Manure as a Bioactivator*). Skripsi. Universitas Muhammadiyah Surakarta.

Heryan, T., Baharta, R., Purwasih, R., & Ramadhan, M. G. (2022). Pengaruh Pemberian Pupuk Organik Cair Air Cucian Beras dan Air Kelapa pada Budidaya Bayam Sistem Wick (The Effect of Applying Liquid Organic Fertilizer to Rice Washing Water and Coconut Water on Wick System Spinach Cultivation). *Jurnal Teknologi Pertanian Gorontalo (JTPG)*, *7*(2), 57–63. https://doi.org/https://doi.org/10.30869/jtpg.v7i2.947

Indrayani, L., Triwiswara, M., & Lestari, D. W. (2019). Pemanfaatan Limbah Zat Warna Alam Batik Pasta Indigo (*Stobilanthes cusia*) Untuk Pembuatan Pupuk Organik Cair Dengan Bioaktivator EM-4 (Effective Microorganism-4) (Utilization of Natural Dyes Waste Indigo Paste Batik (*Stobilanthes cusia*) For Making Liquid Organic Fertilizer With EM-4 Bioactivator (Effective Microorganism-4). *Jurnal Pertanian Agros*, *21*(2), 198–207.

Irawan, S., Tampubolon, K., Elazhari, & Julian. (2021). Pelatihan Pembuatan Pupuk Cair Organik dari Air Kelapa dan Molase, Nasi Basi, Kotoran Kambing Serta Activator Jenis Produk EM4. *Journal Liaison Academia and Sociaty (J-LAS) (*Training on Making Organic Liquid Fertilizer from Coconut Water and Molasses, Stale Rice, Goat Manure and EM4 Product Type Activator), *1*(3), 1–18. http://j-las.lemkomindo.org/index.php/J-LAS/issue/view/J-LAS/showToc

Jeksen, J., & Mutiara, C. (2017). Analisis Kualitas Pupuk Organik Cair Dari Beberapa Jenis Tanaman Leguminose (Quality Analysis of Liquid Organic Fertilizer From Several Leguminose Plants). *Jurnal Pendidikan MIPA*, *7*(2), 124–130.

Jupry, R., & Kurnia, T. D. (2020). Pertumbuhan dan Hasil Tanaman Sawi pada Hidroponik Sistem Rakit Apung Terhadap Konsentrasi Pupuk Organik Cair dari Limbah Ampas Tahu (Growth and Yield of Mustard Plants in Hydroponic Floating Raft System on the Concentration of Liquid Organic Fertilizer from Tofu Dregs Waste). *Jurnal Pertanian Agros*, *22*(1), 61–70.

Kementerian Pertanian. 2011. Peraturan Menteri Pertanian Nomor 70 Tahun 2011 Tentang Pupuk Organik, Pupuk Hayati, dan Pembenahan Tanah. Jakarta.

Kusumadewi, M. A., Suyanto, A., & Suwerda, B. (2019). Kandungan Nitrogen, Phospor, Kalium, dan pH Pupuk Organik Cair dari Sampah Buah Pasar Berdasarkan Variasi Waktu (Content of Nitrogen, Phosphorus, Potassium, and pH of Liquid Organic Fertilizer from Market Fruit Waste Based on Time Variation). *Jurnal Kesehatan Lingkungan*, *11*(2), 92–99. https://doi.org/https://doi.org/10.29238/sanitasi.v11i2.945

Lepongbulan, W., Tiwow, W. M. ., & Diah, A. W. M. (2017). Analisis Unsur Hara Pupuk Organik Cair Dari Limbah Ikan Mujair (*Oreochromis mosambicus*) Danau Lindu Dengan Variasi Volume Mikroorganisme Lokal (MOL) Bonggol Pisang (Nutrient Analysis of Liquid Organic Fertilizer from Mujair Fish Waste (*Oreochromis mozambicus*) Lindu Lake with Local Microorganism Volume Variation (MOL) of Banana Weevil). *J.Akad.Kim*, *6*(2), 92–97. https://doi.org/https://doi.org/10.22487/j24775185.2017.v6.i2.9239

Meriatna, Suryati, & Fahri, A. (2018). Pengaruh Waktu Fermentasi dan Volume Bio Aktivator EM4 (Effective Microorganisme) pada Pembuatan Pupuk Organik Cair (POC) dari Limbah Buah-Buahan (Effect of Fermentation Time and Volume of EM4 (Effective Microorganism) Bio Activator on the Production of Liquid Organic Fertilizer (POC) from Fruit Waste). *Jurnal Teknologi Kimia Unimal*, *7*(1), 13–29. https://doi.org/https://doi.org/10.29103/jtku.v7i1.1172

Norhikmah, Khamidah, N., & Sari, N. (2022). Pengaruh Dekomposer *Trichoderma harzianum*, *Trichoderma koningii*, dan *Trichoderma viridae* terhadap Kualitas Pupuk Organik Cair (POC) dari Purun Tikus (*Eleocharis dulcis*) (Effect of *Trichoderma harzianum*, *Trichoderma koningii*, and *Trichoderma viridae* decomposers on the Quality of Liquid Organic Fertilizer (POC) from Purun Tikus (Eleocharis dulcis). *Agroekotek View*, *5*(1), 70–82.

Novriani, Nurshanti, D. F., Asroh, A., & Al' asri. (2019). Pemanfaatan Daun Gamal Sebagai Pupuk Organik Cair Untuk Meningkatkan Pertumbuhan dan Produksi Tanaman Pakcoy (*Brassica rapa* L.) (Utilization of Gamal Leaves as Liquid Organic Fertilizer to Increase the Growth and Production of Pakcoy (*Brassica rapa* L.) Plants). *Klorofil;*, *14*(1), 7–11. https://doi.org/https://doi.org/10.35138/paspalum.v7i2.118

Rahma, A., Izzati, M., & Parman, S. (2014). The effect of liquid organic fertilizer based on waste based on passage (Brassica chinensis L.) on the growth of sweet corn (Zea mays L. var. Saccharata). *Buletin Anatomi Dan Fisiologi*, *XXII*(1), 65–71.

Rahmawati, T. I., Asriany, A., & Hasan, S. (2020). Kandungan Kalium Dan Rasio C/N Pupuk Organik Cair (POC) Berbahan Daun-Daunan Dan Urine Kambing Dengan Penambahan Bioaktivator Ragi Tape (*Saccharomyces cerevisiae*) (Potassium Content and C/N Ratio Liquid Organic Fertilizer (POC) Made from Leaves and Goat Urine with the Addition of Tape Yeast Bioactivator (*Saccharomyces cerevisiae*). *Buletin Nutrisi Dan Makanan Ternak*, *14*(2), 51–60. https://doi.org/https://doi.org/10.20956/bnmt.v14i2.12553

Rahmina, W., Nurlaelah, I., & Handayani, H. (2017). Pengaruh Perbedaan Komposisi Limbah Ampas Tahu Terhadap Pertumbuhan Tanaman Pak Choi (*Brassica rapa* L. ssp. chinensis) (The Effect of Different Compositions of Tofu Dregs on the Growth of Pak Choi (*Brassica rapa* L. ssp. chinensis) Plants. *Quagga : Jurnal Pendidikan Dan Biologi*, *9*(2), 32–38. https://doi.org/10.25134/quagga.v9i02.746

Rasmito, A., Hutomo, A., & Hartono, A. P. (2019). Pembuatan Pupuk Organik Cair dengan Cara Fermentasi Limbah Cair Tahu, Starter Filtrat Kulit Pisang dan Kubis, dan Bioaktivator EM4 (Making Organic Liquid Fertilizer by Fermenting Tofu Liquid Waste, Starter Filtrate of Banana Peel and Cabbage, and EM4 Bioactivator). *Jurnal IPTEK*, *23*(1), 55–62. https://doi.org/10.31284/j.iptek.2019.v23i1

Ratrinia, P. W., Maruf, W. F., & Dewi, E. N. (2014). Pengaruh Penggunaan Bioaktivator EM4 Dan Penambahan Daun Lamtoro (*Leucaena leucephala*) Terhadap Spesifikasi Pupuk Organik Cair Rumput Laut *Eucheuma spinosum (*Effect of Using EM4 Bioactivator and Addition of Lamtoro Leaves (*Leucaena leucephala*) Against Seaweed

Liquid Organic Fertilizer Specifications *Eucheuma spinosum)*. *Jurnal Pengolahan Dan Bioteknologi Hasil Perikanan*, *3*(3), 82–87.

Sari, D. A. P., Taniwiryono, D., Andreina, R., Nursetyowati, P., & Irawan, D. S. (2022). Pembuatan Pupuk Organik Cair dari Hasil Pengolahan Sampah Organik Rumah Tangga dengan Bantuan Larva Black Soldier Fly (BSF) (Making Liquid Organic Fertilizer from Household Organic Waste Processing with the Help of Black Soldier Fly (BSF) Larvae*)*. *Agro Bali : Agricultural Journal*, *5*(1), 102–112. https://doi.org/10.37637/ab.v5i1.848

Triyanto, Y., & Maharani, S. (2021). Program Pengabdian Masyarakat Melalui Program Pembuatan Pupuk Organik Cair (POC) Dari Bonggol Pisang (Community Service Program Through the Production of Liquid Organic Fertilizer (POC) from Banana Weevils*)*. *Ika Bina En Pabolo : Pengabdian Kepada Masyarakat*, *1*(1), 9–15.

Tuhuteru, S., Rumbiak, R. E. Y., Patras Pumoko, Tinus Kossay, & Yuna Yikwa. (2021). Perbandingan Efektifitas Mikroorganisme Lokal Nanas dan Batang Pisang terhadap Pertumbuhan Tanaman Jagung Manis di Wamena (Comparison of the Effectiveness of Local Microorganisms of Pineapple and Banana Stem on the Growth of Sweet Corn Plants in Wamen*)*. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy*, *49*(3), 288–294. https://doi.org/10.24831/jai.v49i3.36591

Yuliatin, E., Puspita Sari, Y., & Hendra, M. (2018). Efektivitas Pupuk Organik Cair dari Eceng Gondok (*Eichornia crassipes* (Mart), Solm) untuk Pertumbuhan dan Kecerahan Warna Merah Daun Aglaonema "Lipstik" (The Effectiveness of Liquid Organic Fertilizer from Water Hyacinth (*Eichornia crassipes* (Mart), Solm) for the Growth and Brightness of the Red Color of Aglaonema Leaves "Lipstick") *Jurnal Biotropika*, *6*(1), 28–34. https://doi.org/https://doi.org/10.21776/ub.biotropika.2018.006.01.6

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Effects of Socio-Scientific Approach on Junior High School Students' Learning Outcomes

Salsabila Nur Rahmadhani, Putri Agustina*, Sri Mulyani
Biology Education Department. Faculty of Teacher Training and Education. Universitas Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I. Pabelan. Kartasura. Surakarta 57162. Jawa Tengah. Indonesia
SMP Negeri 2 Nguter. Jl. Songgorunggi - Mento. RT 01/RW 06. Celep. Nguter. Dusun II. Celep. Kec. Sukoharjo. Kabupaten Sukoharjo 57571. Jawa Tengah. Indonesia
*Coresponding author : E-mail address: pa182@ums.ac.id

KEYWORDS:
Learning approach
Sosio-scientific issue approach
Scientific learning

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

In learning. students are expected to get success in learning. One of the factors that can influence the success of student learning is the selection of appropriate learning approaches. The Socio-scientific Issue learning approach is a learning approach that examines facts on an event based on social issues related to science in society. The purpose of this research is to find out and examine the effect of the socio-scientific issue learning approach on junior high school student learning outcomes. This type of research is quasi-experimental with quantitative data and processed using non-parametric statistical data analysis techniques to determine the effect of treatment on the dependent variable by controlling the independent variables. In this study. the results showed that the initial ability of the two groups was 31.8 for the control class and 21.8 for the experimental class. After the experimental class received learning using the Socio-scientific Issue approach. it obtained a better average score than the control class. namely 80.9 for the experimental class and 58.8 for the control class. Based on data analysis and discussion. it can be concluded that the Socio-scientific Issue approach has a significant effect on student learning outcomes.

1. INTRODUCTION

Learning is a process carried out to get changes in behavior for the better (Chusni. 2019). The learning process is expected to get success in learning. Learning outcomes are changes in behavior in the form of an improvement in a better direction in a person that can be observed and measured in terms of knowledge. attitudes. and skills (Hamalik. 2016). Learning success can be influenced by various factors. both internal factors (student interest and motivation) and external factors (family. school environment. and community environment). One of the factors that can be controlled by teachers in schools is teaching materials or learning approaches. if teaching materials are less attractive it can cause students' motivation or interest in learning to decrease. so that it will affect student learning outcomes.

The learning approach is a perspective on the learning process (Bastian & Reswita. 2022). The learning approach is a method or strategy used by the teacher to achieve learning goals (Rahim. 2021). The learning approach is used to obtain an educator's frame of mind in implementing learning activities so that they are efficient and have high effectiveness (Rachmawati. 2020). The student center learning approach is a learning approach that focuses on student's needs. abilities. interests. and student learning styles with the teacher as a facilitator in the learning process

Students play an active role in the learning process not only as recipients of knowledge (Baslini & Syafryadin. 2022). Natural Science (IPA) subjects can apply student-centered learning activities. In this science subject. students are expected to be able to use knowledge in the fields of science and technology to think critically by identifying questions. drawing conclusions based on existing evidence. and making changes to nature through human activity (Pertiwi dkk.. 2018).

Therefore. the learning approach is very important to achieve the learning objectives. The learning approach emphasizes the strategy and planning of activities that will be carried out during learning. One of the approaches that can be used in natural sciences is the socio-scientific issue learning approach. The socio-scientific issue learning approach is a learning approach that examines the facts of an event based on social issues within the community. This approach can train students in critical thinking or higher order thinking (Utami Dea Sismawarni dkk.. 2020).

Using the socio-scientific issue learning approach. it is hoped that students can develop the potential for scientific thinking and can improve students' communication skills (Lestari. 2020). According to Nava & Prasetyo (2018) the Socio-Scientific Issue learning approach is an approach related to the environment and issues around it. This approach demands students to think critically and think systematically. This approach uses observations or observations needed to formulate hypotheses or collect data (Suparsawan. 2020). The application of the Socio-Scientific Issue approach requires students to be active. Methods that can help the learning process using a scientific approach include: problem based learning. project based learning. inquiry. and group investigation (Budiyanto. 2016). According to research by Gulacar et al (2020) student learning motivation increases. students are able to make connections between information included in subject matter after using the Socio-Scientific Issue learning approach in the curriculum.

The advantages of the socie-scientific issue approach include: students are taught to solve problems. so students are easier to understand and realize in the surrounding environment. students can think critically and can improve students' ability to accept the material being taught (Putriana dkk.. 2018). Students are taught to solve problems. so that students more easily understand and realize the environment around them. Students can think critically. this approach has shown good results in improving students' ability to accept the material being taught (Putriana dkk.. 2018). According to Sadler in Nava & Prasetyo (2018) the Socio-Scientific Issue approach can train students' argumentation and reasoning skills from various perspectives.

Based on observations and interviews conducted by researchers. it was found that the teacher carried out learning activities using the lecture method. This learning method is believed to be the fastest method for completing the material. However. this method can cause students to easily get bored in learning activities. resulting in decreased student interest in learning which can lead to decreased student learning outcomes. Teachers need to pay attention to the right approaches and methods in carrying out learning activities so that students can acquire new knowledge that is fun and satisfying learning outcomes. Therefore. the purpose of this research is to identify and examine the effect of the socio-scientific issue learning approach on junior high school student learning outcomes.

2. MATERIALS AND METHODS

2.1. Type and Research Design

This research is included in the quasi-experimental research with non-equivalent group pretest-posttest research design. The research design is presented in (**Table 1**).

Table 1. Research Design

Group	Pretest	Independent variable	Posttest
A	Y1	X	Y2
B	Y2	-	Y2

Description:
Y1: control class
Y2: experimental class
X: experiment implementation

Quasi-experimental research is research conducted by measuring the effect of independent variables on the dependent variable with research subjects. namely humans (Sohilait. 2020). In this study the researcher will use two groups of subjects who will be randomly selected. then the researcher will give pretest questions to the two groups of subjects. Giving a pretest is done to determine the initial abilities possessed by students. Then the researcher will give treatment to one of the randomly selected groups. After the learning activities have been carried out. the researcher will give posttest questions to the two groups of subjects. Researchers will compare the changes in pretest and posttest scores and then compare the posttest scores between the two groups of subjects.

2.2. Research Place and Time

2.2.1. Research Place

This research was carried out in State Junior High Schools.

2.2.2. Samples and Sampling

2.2.2.1. Sample : this study used 2 classes with a total of 56 students. 1 class as experimental class and 1 class as control class.

2.2.2.2. Sampling : Class sampling was carried out by cluster random sampling technique.

2.3. Data and Data Sources

Data and data sources are presented in (**Table 2**).

Table 2 Data and Data Sources

Data	Sources	Method	Instrument
Student learning outcomes:			
1. Cognitive	Student	Test	Pretest and posttest question sheets
2. Affective	Student	Observation	Observation sheet
3. Psychomotor	Student	Observation	Observation sheet

2.4. Data Collection Techniques and Instruments

Data collection techniques in this study are:

2.4.1. Test

The test was conducted to measure the knowledge possessed by students. Before questions with biotechnology material are tested on students. the questions must be validated by two experts. the questions must be validated by two experts. If the questions are declared feasible. the questions are tested on students and then tested for the validity of the items. discriminating power. level of difficulty. and reliability of the questions.

2.4.1.1. Validation Test.

This test was conducted to find out whether the questionnaire was valid or not to be used as a research data collection tool. The validity test in this study was carried out with the help of the IBM SPSS Statistics 20 program. The validity test results are presented in (**Table 3**).

Table 3. Validity Test Results

Question Number	r Table	r Count	Description
1	0.388	0.460	Valid
2	0.388	0.658	Valid
3	0.388	0.439	Valid
4	0.388	0.502	Valid
5	0.388	0.477	Valid
6	0.388	0.350	Invalid
7	0.388	0.420	Valid
8	0.388	0.527	Valid
9	0.388	0.458	Valid
10	0.388	0.475	Valid

2.4.1.2. Discriminating Power Test

The reliability test was carried out to determine the extent to which the questionnaire can be trusted or relied upon. The criteria for a research instrument are said to be reliable if the reliability coefficient (r11)> 0.6. or compared to the r table (Product Moment) if the Alpha Conbach reliability coefficient value is greater than r table. then it is declared reliable. and vice versa. Reliability test results are presented in (**Table 4**).

Table 4. Reliability Test Results

Reliability Statistics

Cronbach's Alpha	N of Items
.619	10

Known N = 26. α = 5% 0.05; N in 10 items. then the obtained r table is 0.388. From the output results. the value of r11 = 0.619 > t table = 0.388. it can be concluded that the questions are reliable.

2.4.1.3. Difficulty Level Test

Difficulty level test is used to find out if a question is included in the easy. medium or difficult category. According to Arikunto in Nurcahyanto (2018) Interpretation of the level of difficulty as contained in (**Table 5**).

Table 5. Interpretation of Difficulty Level

Difficulty level (TK)	Interpretation or Explanation TK
TK < 0.30	Hard
0.30 ≤ TK ≤ 0.70	Medium
TK > 0.70	Easy

The results of the Difficulty Level Test are presented in (**Table 6**).

Table 6. The results of the Difficulty Level Test

Question Number	Interpretation of difficulty level	Description
1	0.269	Hard
2	0.269	Hard
3	0.808	Easy
4	0.538	Medium
5	0.654	Medium
6	0.615	Medium
7	0.269	Hard
8	0.5	Medium
9	0.615	Medium
10	0.231	Hard

2.4.1.4. Differentiating Power Test

The differentiating power test is to find out the magnitude of the differential power of the items. According to Nurcahyanto (2018) Interpretation of the level of differentiating power as contained in (**Table 7**).

Table 7. Interpretation of Differentiating Power Levels

Differentiating Power (DP)	Interpretation or Explanation (DP)
DP ≥ 0.70	Very well
0.40 ≤ DP ≤ 0.70	Good
0.20 ≤ DP ≤ 0.40	Enough
DP < 0.20	Bad (Revise)

The results of the differentiating power level test are presented in (**Table 8**).

Table 8. The Results Of The Differentiating Power Level Test

Question Number	Interpretation of differentiating power level	Description
1	0.231	Cukup
2	0.231	Cukup
3	0.385	Cukup
4	0.461	Baik
5	0.384	Cukup
6	0.307	Cukup
7	0.231	Cukup
8	0.23	Cukup
9	0.307	Cukup
10	0.462	Baik

2.4.2. Observation

Make observations during the teaching and learning process to observe student activities during the learning process using a scientific approach by filling out the observation sheet provided. This research uses Participant Observation which allows researchers to be involved in activities carried out by the sample (Rahmawati & Amar. 2017).

2.4.3. Phases of Research Activity

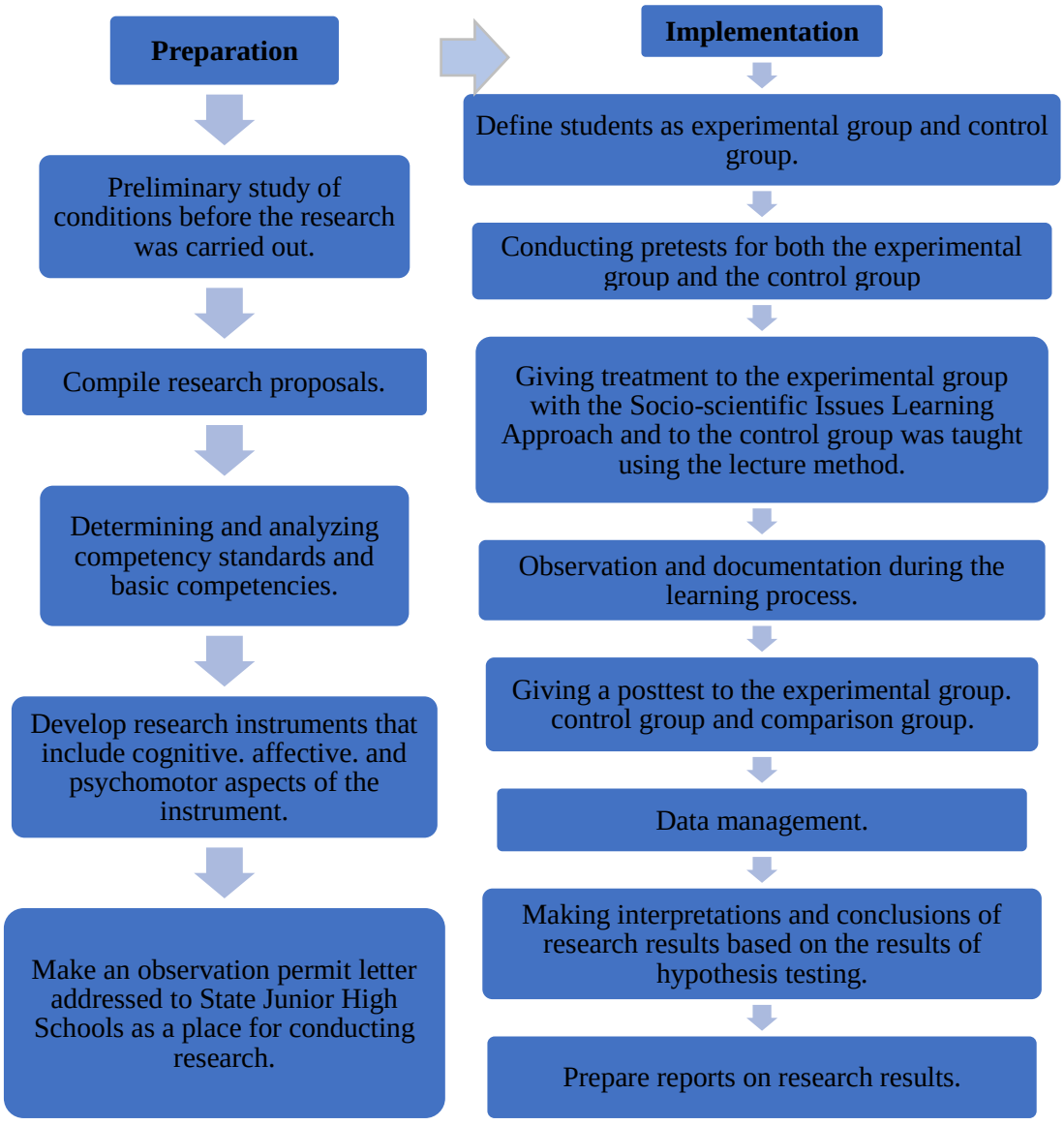


Figure 1. Implementation Activities Stages

2.5. Research Data Analysis

The data in this research is quantitative data. so the research data is processed using descriptive statistics to summarize the data so that it is easier to understand. This data analysis was carried out with the help of the IBM SPSS Statistics 20 computer program to process the research. Before the hypothesis test is carried out. it is necessary to carry out the prerequisite analysis test. namely the normality test and homogeneity test. The normality test was carried out to determine whether the data obtained from the population was normally distributed or not. The homogeneity

test was carried out to test whether the variation of the population was homogeneous or not for the two treatment groups (Nurcahyanto. 2018).

Prerequisite analysis test is carried out to find out the hypothesis test that will be carried out on research data. If the results of the normality test and homogeneity test are normally distributed and homogeneous data. the data can be tested by means of a parametric statistical test. However. if the results of the normality test and hygienity test are data that are not normally distributed and homogeneous. then the data can be tested by means of a non-parametric statistical test Kruskal Wallis (Misbahudin & Iqbal Hasan. 2022).

3. RESULTS AND DISCUSSION

This research is based on the results of observations and interviews that have been conducted in state junior high schools. where problems were found. namely the low learning outcomes of science subjects on certain materials. The lack of use of the learning approach resulting in a lack of student interest in learning is one of the causes of low student learning outcomes. Referring to these initial conditions. the researcher aims to determine the effect of the socio-scientific issue approach to learning on student learning outcomes. After being applied to learning activities. it is hoped that students will have an interest in learning so that students get better learning outcomes.

In this discussion. researchers will explain the differences in student learning outcomes with learning using the socio-scientific issue learning approach and learning without using the socio-scientific issue learning approach. The following is a description of the research results.

3.1. The Influence of the Socio-Scientific Issue Approach to Cognitive Learning Outcomes.

Cognitive learning outcomes data were obtained from pretest and posttest scores in both sample groups. The pretest was carried out to determine students' initial abilities while. it was carried out to determine the progress of students' abilities in Biotechnology and food production material after learning was carried out according to the treatment of each class. The following presents the results of students' cognitive learning in (**Table 9**).

Table 9. Cognitive Learning Outcomes After Studying The Material Of Biotechnology And Food Production

Description	Control Class		Eksperiment Class	
	Pretest	**Postest**	**Pretest**	**Postest**
N	28	28	28	28
Max	50	80	60	100
Min	25	35	10	65
Rata-rata	31.8	58.8	21.8	80.9
Standard deviations	7.9	8.3	11.4	13.6

After the posttest was carried out for the two sample groups. the pretest scores and posttest scores will be analyzed hypotheses using the help of the IBM SPSS 20 application to determine the effect of the socio-scientific issue approach on student learning outcomes. Before the hypothesis analysis is carried out. the data that has been obtained is carried out to test the prerequisite analysis first. Data analysis prerequisite test for normality analysis is presented in (**Table 10**). and the prerequisite test data for hypothesis analysis are presented in (**Table 11**) and (**Table 12**).

Table 10. Normality Test Data Analysis.

Tests of Normality

	Kelas	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Hasil Belajar kognitif	Pretest eksperimen	.328	28	.000	.707	28	.000
	Postest eksperimen	.260	28	.000	.826	28	.000
	pretest kontrol	.302	28	.000	.791	28	.000
	postest kontrol	.416	28	.000	.712	28	.000

a. Lilliefors Significance Correction

Table 11. Homogeneity Test Data Analysis

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Hasil Belajar kognitif	Based on Mean	1.850	3	108	.142
	Based on Median	1.607	3	108	.192
	Based on Median and with adjusted df	1.607	3	90.218	.193
	Based on trimmed mean	1.883	3	108	.137

Table 12. Homogeneity Test Data Analysis

Test of Homogeneity of Variances

Hasil Belajar kognitif

Levene Statistic	df1	df2	Sig.
1.850	3	108	.142

Based on (**Table 10**) Normality Test Data Analysis obtained a significance value of 0.000. Due to the significance value <0.05. it can be concluded that the data obtained is not normal. Based on (**Table 11**) and (**Table 12**) Analysis of Homogeneity Test Data obtained a significance value of 0.142. Due to the significance value > 0.05. it can be concluded that the variance of the data from these groups is the same (homogeneous). Both of these tests were carried out to determine the hypothesis test that would be carried out by the researcher. Therefore. the data obtained by the researcher was carried out by testing the non-parametric hypothesis.

The non-parametric hypothesis test uses the Kruskal Wallis test. which is an alternative test to the ANOVA test. The Kruskal Wallis test aims to test the difference between the dependent variable and the independent variable if the data scale of the dependent variable is ordinal but not normally distributed. The basis for decision making on the Kruskal Wallis test is based on a comparison of probability values (Asymp.sig.) If probability (Asymp.sig.) > 0.05. H0 is accepted and if probability (Asymp.sig.) < 0.05. H0 is rejected. Analysis of the Kruskal wallis hypothesis test is presented in (Table 13).

Table 13. Analysis Of The Kruskal Wallis Hypothesis Test

Test Statistics[a,b]

	hasil Belajar Kognitif
Chi-Square	34.343
df	1
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Kelas

Based on (**Table 13**) (Kruskal Wallis) above. the value of Sig. is 0.000. Because the Asymp.Sig. is smaller than the significance level (0.05). then H0 is rejected and Ha is accepted. It can be concluded that there is a statistically significant difference regarding the average cognitive scores of science subjects in Biotechnology material between the control class and the experimental class. So this means that the socio-scientific issue learning approach has a significant influence on students' cognitive values.

The application of the Socio-scientific issue learning approach is expected to improve students' cognitive learning outcomes. In this study. the results showed a significant increase in student learning outcomes in the experimental class. This can be seen in (**Table 9**) which shows that the average initial ability of the two groups was 31.8 for the control class and 21.8 for the experimental class. After the experimental class received learning using the Socio-scientific issue approach. it obtained a better average score than the control class. namely 80.9 for the experimental class and 58.8 for the control class. The results of the analysis of research data processed with non-parametric statistical Krusskal Wallis test obtained statistically very significant results.

This is in line with research conducted by Rosana & Hestiana (2020) on class VII students of SMP Negeri 6 Yogyakarta. it was found that science learning outcomes using the Socio-scientific issue approach had higher learning outcomes. The pretest and posttest scores of these students were then analyzed using statistical ANOVA hypothesis testing to obtain significant results. These results can be interpreted that the Socio-scientific issue approach affects the cognitive learning outcomes of class VII students of SMP Negeri 6 Yogyakarta. (Kartina dkk.. 2022) conducted research to find out the increase in the Minimum Competency Assessment Ability (AKM) through scientific learning in class VIII students of Payaraman 2 Public Middle School. the results showed increased student activity and AKM literacy abilities as seen from the learning outcomes. This can be interpreted that the socio-scientific issue approach has an effect on students' cognitive learning outcomes. Research conducted by Nava & Prasetyo (2018) which was conducted on class VII students of junior high school showed that science learning with the Socio-scientific issue approach significantly affected the scientific literacy of junior high school students.

3.2. The Influence of the Socio-Scientific Issue Approach to Affective Learning Outcomes..

This research was conducted by observing students during learning activities. Observations were made directly by observing and assessing student behavior during the student learning process and then the researcher recorded it on the observation sheet. Affective learning outcome data are presented in (**Table 14**).

Table 14. Affective Learning Outcome Data After Studying The Material Of Biotechnology And Food Production

Description	Control Class	Experiment Class
N	28	28
Max	100	100
Min	25	25
Average	36.2	42.4
Standard deviation	24.6	25.1

Based on the table above. it was found that the students' affective learning outcomes between the experimental class and the control class had not too much difference. These results indicate that the average of the two groups is 42.4 for the experimental class and 36.2 for the control class. This is in line with research that has been conducted by Siska et al (2020) which says that the Socio-Scientific Issue approach is an approach that is taken in the learning process requiring students to be able to play an active role. Thus the use of the Socio-Scientific Issue approach is expected that students will not only be able to improve cognitive learning outcomes but also be able to shape student character.

3.3. The Influence of the Socio-Scientific Issue Approach to Psychomotor Learning Outcomes

This research was conducted by observing students during the learning process. Observations were carried out by researchers directly by observing learning activities and then recorded in the observation sheet. The psychomorphic learning outcomes in this study included two things. namely students' enthusiasm in asking questions and students' enthusiasm in answering questions posed by teachers and other students. Psychomotor learning outcomes data are presented in (**Table 15**).

Table 15. Psychomotor Learning Outcomes Data After Studying The Material Of Biotechnology And Food Production

Description	Control Class	Experiment Class
N	28	28
Max	75	95
Min	65	75
Average	68.6	81.1
Standard deviation	4.0	7.8

Based on the table above. there are differences in psychomotor learning outcomes between the control class and the experimental class. These results can be seen in (**Table 15**) which shows that the average ability of the two groups. namely 81.1 for the experimental class. while the control class got a score of 68.6. This is in line with the research of Siska et al (2020) which states that the socio-scientific issue approach uses aspects of everyday life in the community. so that it can generate curiosity in students. Tsai (2018) said argumentation can encourage students to use logic and reasoning when faced with problems. The argumentation process can train students' deductive and inductive reasoning skills as well as coordination skills by providing evidence. According to Dewantari et al research (2022) that through the socio-scientific issue approach. students can gather information from various sources. such as observing. asking. trying. or gathering information from various sources. According to Wicaksono research (2020) the Socio-Scientific Issue approach has an effect on students' critical thinking abilities in various educational units from

elementary to high school. This approach provides an opportunity for students to understand the lesson from solving the presented problems.

4. CONCLUSIONS

Based on the results of data analysis and the discussion on cognitive. affective. and psychomotor learning outcomes in biotechnology and food production. it can be concluded that the socio-scientific issue learning approach has a significant effect on student learning outcomes. This is because there are statistically significant differences between the average cognitive scores of the control class and the experimental class. Affective and psychomotor learning outcomes obtained higher results in the experimental class where students actively asked questions and expressed their opinions about the problems presented.

5. REFERENCES

Baslini. & Syafryadin. (2022). Modul Pembelajaran Bahasa Ingris Berbasis Flipped Classroom Untuk Meningkatkan Hasil Belajar Siswa. Lakeisha.

Bastian. A.. & Reswita. (2022). Model dan Pendekatan pembelajaran. penerbit adab.

Budiyanto. Moch. A. K. (2016). SINTAKS 45: Model Pembelajaran dalam Student Centered Learning (SCL). UMM Pess.

Chusni. M. M. dkk. (2019). Strategi Belajar Inovatif. CV. pradina Pustaka Grub.

Dewantari. T.. Hasnunidah. N.. & Maulina. D. (2022). Kajian Kemampuan Argumentasi Siswa pada Materi Pokok Animalia Melalui Pendekatan Saintifik di SMA dengan Peringkat Akreditasi yang Berbeda. BIOEDUSAINS:Jurnal Pendidikan Biologi dan Sains. 5(1). 267–278. https://doi.org/10.31539/bioedusains.v5i1.3285

Gulacar. O.. Zowada. C.. Burke. S.. Nabavizadeh. A.. Bernardo. A.. & Eilks. I. (2020). Integration of a sustainability-oriented socio-scientific issue into the general chemistry curriculum: Examining the effects on student motivation and self-efficacy. Sustainable Chemistry and Pharmacy. 15. https://doi.org/10.1016/j.scp.2020.100232

Hamalik. O. (2016). Proses Belajar Mengajar. Bumi Aksara.

Kartina. Missriani. & Fitriani. Y. (2022). Peningkatan Kemampuan Asesmen Kompetensi Minimum (AKM) Literasi Siswa Melalui Pendekatan Saintifik SMP Negeri 2 Payaraman. Januari. 20(1). 128–139.

Lestari. E. T. (2020). Pendekatan Saintifik di Sekolah Dasar. Penerbit Deepublish.

Misbahudin. & Iqbal Hasan. (2022). Analisis Data Penelitian dengan Statistik. Bumi Aksara.

Nava. T. H. N. S.. & Prasetyo. Z. K. (2018). Pengaruh Pendekatan Socio-Scientific Issue Berbasis STEM Terhadap Literasi Sains Siswa. E-Journal Pendidikan IPA. 7(5). 162–167.

Nurcahyanto. G. (2018). Analisis Data Statistik Penelitian Pendidikan dengan SPSS. Laboratorium Komputer Fakultas Keguruan dan Ilmu Pendidikan Universitas Muhammadiyah Surakarta.

Pertiwi. U. D.. Atanti. Rina Dwik. & Ismawati. Riva. (2018). Pentingnya Literasi Sains Pada Pembelajaran IPA SMP Abad 21. Indonesia Journal of Natural Science Educarion (IJNSE). 1(1). 24–29.

Putriana. Sunyono. & Diawati. C. (2018). Pengaruh Penggunaan Isu Sosiosaintifik untuk Meningkatkan Kemampuan Metakognisi Siswa pada Materi Larutan Elektrolit dan Non-Elektrolit. Jurnal Pendidikan dan Pembelajaran Kimia. 7(2). 1–10.

Rachmawati. R. (2020). Strategi Pembelajaran. Jakad Media Publishing.

Rahim. R. dkk. (2021). Pendekatan Pembalajaran Guru. Yayasan Kita Menulis.

Rahmawati. B. F.. & Amar. S. (2017). Evaluasi Pembelajaran Sejarah. Universitas Hamzanwadi Press.

Rosana. D.. & Hestiana. (2020). The Effect of Problem Based Learning Based Sosio-Scientific Issues on Scientific Literacy and Problem-Solving Skills of Junior High School Students. Journal of Science Education Research Journal. 2020(1). 15–21. www.journal.uny.ac.id/jser

Siska. Triani. W.. Maryuningsih. Y.. Yunita. & Mujib Ubaidillah. (2020). Penerapan Pembelajaran Berbasis Socio Scientific Issue untuk meningkatkan Kemampuan Argumentasi Ilmiah. Jurnal Pendidikan Sains & Matematika. 8(1).

Suparsawan. I. K. (2020). Kolaborasi Pendekatan Saintifik dengan Model Pembelajaran STAD geliatkan Peserta Didik. Tata Akbar.

Tsai. C. Y. (2018). The effect of online argumentation of socio-scientific issues on students' scientific competencies and sustainability attitudes. Computers and Education. 116. 14–27. https://doi.org/10.1016/j.compedu.2017.08.009

Utami Dea Sismawarni. W.. Hamid. N.. & Kusumaningtyas. P. (2020). Pengaruh Penggunaan Isu Sosiosaintifik dalam Model Pembelajaran Berbasis Masalah Terhadap Keterampilan Berpikir Tingkat Tinggi Siswa. Jambura Journal of Educational Chemistry. 2(1). 10–17. http://ejurnal.ung.ac.id/index.php/jjec

Wicaksono. A. G. (2020). Systematic Review Pengaruh Pendekatan Saintifik Terhadap Peningkatan Keterampilan Berpikir Kritis Siswa. Profesi Pendidikan Dasar. 1(1). 65–76. https://doi.org/10.23917/ppd.v1i1.10822

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Study of Science Practicum in Junior High School, Sukoharjo, Indonesia

Farikha Muya Sarah, Putri Agustina*, Harini Hastowati
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: pa182@ums.ac.id

KEYWORDS:
Science Laboratory, Permendiknas Number 24 of 2007, Quality of facilities and infrastructure, Implementation of science practicum

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Practicum or experiments in the laboratory are needed to support science learning activities. According to Permendiknas Number 24 of 2007 the educational process requires supporting facilities and equipment so that the learning process can run optimally. In the implementation of science practicum, there are benefits, including arousing motivation to learn science and giving students the opportunity to satisfy their curiosity, as a source of learning a scientific approach. The purpose of this study was to determine the quality of facilities and infrastructure, as well as the implementation of science practicum in research junior high schools. The type of research used is descriptive qualitative with data collection techniques using observation, documentation, interviews, and questionnaires. The results showed that the quality of science laboratory facilities and infrastructure in junior high schools was included in the good category as stated in Permendiknas Number 24 of 2007 is evidenced by an average percentage of 77.42%. The implementation of science practicum is in a very good category where the average percentage obtained is 89.25%. The results of the questionnaire showed that the average percentage of science practicum implementation was 65.8% in the good category, in the sense that the implementation of science practicum class IX in the even semester went well.

1. INTRODUCTION

Natural Science (IPA) is defined as a subject that studies natural phenomena and the surrounding environment by emphasizing direct experience to students through scientific processes, products, and attitudes (Rizkika, 2022). That way, the learning a process related to science must be real, can be through field observations or practicum in the laboratory (Sugiarti et al., 2021). IPA has very distinctive characteristics because it originates from natural phenomena and phenomena that we often encounter in our daily lives. The characteristics of science include 1) science has scientific value, which means that in the learning process science is expected to be able to train and provide understanding to students about the importance of thinking scientifically, the material contained in science subjects, 2) knowledge that is systematically arranged, 3) science is theoretical knowledge obtained or compiled in a uniquely, 4) Natural Science is a series of interrelated concepts, 5) Natural Science includes four elements, namely product, process, application, and attitude (Nugraha, 2020).

Learning is a process of interaction between students and educators and learning resources in a certain environment (Saputro, 2021). The objectives of learning science are basically the same as other learning, namely aiming to build good interactions between the two components, namely teachers and students (Wisma, 2021). Learning science or science can be achieved by connecting the concepts of everyday life with what students learn. Because when academic success is

achieved, students can understand the material is being studied and can know how to apply it to solve problems in everyday life (Pertiwi, 2018).

In carrying out learning activities in schools Science Laboratory Infrastructure Facilities are one of the factors to facilitate students in applying the theory that has been taught by the teacher in class. School laboratories are used to carry out practices, experiments, research, prove theories obtained in books and so on (Zulkarnain, 2018). The implementation of the practicum learning process cannot be separated from good planning. The important role of the teacher in paying attention to practicum learning planning is expected to be able to provide opportunities for students to understand the learning process in the laboratory and outside the laboratory (Ramadhan, 2020).

According to the Regulation of the Minister of National Education Number 24 of 2007 concerning Standardization of Science Laboratories including laboratory layout, laboratory administration, laboratory management, and storage of practicum tools and materials (Susanti, 2021). The science laboratory room can accommodate a minimum of one study group. The minimum ratio of the science laboratory space is 2.4 m/student. For study groups of less than 20 students, the minimum area of the laboratory room is 48 m. The science laboratory room is equipped with facilities to provide adequate lighting to observe experimental objects (Rusydi, 2018). The educational process requires facilities and equipment that support teaching and learning activities so that the learning process can run optimally. Management activities include: planning, procurement, inventory, utilization, and arrangement of good facilities and infrastructure an order to create a pleasant atmosphere for both teachers and students and improve the quality of learning, because the facilities are adequate for all learning processes (Wasiya, 2021).

Practicum or experiments in the laboratory are needed to support science learning activities. The absence of practicum tools and materials is often an obstacle in not doing practicum (Salirawati, 2018). This relates to research conducted by (Candra, 2020). in which the application of practicum in improving process skills and work skills in the science laboratory at SMP Muhammadiyah 3 Depok, Yogyakarta is experiencing problems caused by insufficient practicum tools and materials, insufficient time, and an inadequate atmosphere. laboratories that are not conducive and the use of laboratories that are not used according to their function as science laboratories, and there are no laboratory assistants.

Based on Permendiknas RI Number 24 of 2007 the existence of a science laboratory is very important to support learning. The minimum science laboratory space can accommodate one study group. Has practice, storage, and prep space. The facilities available at least have adequate light, clean water. Facilities include, furniture, educational equipment, and other equipment (Rahman, 2017). This is related to (Nahdiyaturrahmah, 2020) research regarding the implementation of natural science practicum where laboratories are used as learning resources. It would be better if they were managed before being used in order to achieve an optimal target. In terms of the implementation of laboratory management at SMPN 2 Singaraja, it has not been able to run properly, this is due to limited tools and materials, as well as administration that is not well prepared, so that students rarely carry out practicum activities in the laboratory.

According to (Suryaningsih, 2017) practicum is defined as a learning activity that is intended to provide opportunities for students to test and apply theory by using facilities in the laboratory and outside the laboratory. (Yamin, 2022) states that there are five important reasons for practicum in science learning, namely practicum can create motivation to learn, develop general scientific skills, make learning a vehicle for a scientific approach, increase understanding of concepts, and develop critical thinking skills.

In using the science laboratory more effectively there are several administrations that must be prepared including: 1) student attendance list; 2) diary of science laboratory activities; 3) schedule and list of users of science laboratory equipment/materials; 4) inventory list of science laboratory tools and materials; 6) list of planned maintenance and working mechanism; 7) request form for science laboratory tools/materials; 8) form for borrowing tools; 9) materials (equipment loan receipt); 10) list of submission of practicum results and list of values (Rasyid, 2019). In using the science laboratory more effectively there are several administrations that must be prepared including: 1) student attendance list; 2) diary of science laboratory activities; 3) schedule and list of users of science laboratory equipment/materials; 4) inventory list of science laboratory tools and materials; 6) list of planned maintenance and working mechanism; 7) request form for science laboratory tools/materials; 8) form for borrowing tools; 9) materials (equipment loan receipt); 10) list of submission of practicum results and list of values (Rasyid, 2020).

The school used for the research is a junior high school with an accreditation standard located in Kec. Nguter, Sukoharjo Regency. Middle School has a laboratory as one of the infrastructure facilities in the school. Science laboratories are usually used to support science learning in grades VII, VIII, and IX. Therefore, it is hoped that the quality and completeness of laboratory facilities and infrastructure can support science learning activities. Based on the interviews conducted, the implementation of practicum at school in one semester is carried out only 1-2 times. Based on this background, the purpose of this study was to determine the quality of science laboratory facilities and infrastructure in research junior high schools and to find out how science practicums were carried out.

2. MATERIAL AND METHODS

2.1. Type and research design

This research is a qualitative descriptive study. The data obtained from this study will objectively describe the Study of Science Practicum in Junior High School, Sukoharjo, Indonesia 2022/2023 which can be viewed from the quality of facilities and infrastructure, as well as the implementation of the practicum. In this study the researcher described and made observations of all available data from various sources, namely interviews, observations that had been written down in field notes, and photographic images. In addition, this research is reviewed based on the current conditions.

2.2. Place and time of research

This research was conducted in February - March in the Middle School Science Laboratory Room Of Nguter 2 Junior High School which is located at Jl. Songgorunggi – Mento, RT 01/RW 06, Celep, Nguter, Dusun II, Celep, Kec. Nguter, Sukoharjo Regency, Central Java 57571.

2.3. Research Procedure

Figure 1. Research Procedure

2.4. Data collection techniques

The data in this study were reviewed based on (1) the quality of science laboratory facilities and infrastructure, (2) the implementation of science practicum. Sources of data were obtained from science laboratories, science subject teachers, and class IX students. Data collection techniques in this study were observation, documentation, interviews, and questionnaires. Data analysis in this study was carried out descriptively with the percentage technique, this technique is used to determine the quality of facilities and infrastructure, as well as the practicum implementation. The data that has been obtained from observations, interviews, and questionnaires based on the instrument sheets that have been prepared, is then compared with the standard Permendiknas Number 24 of 2007 to then calculates the percentage using the following formula:

$$P = \frac{n}{N\ Maks} \times 100\%$$

Where P is the percentage of achievement (%), n is the acquisition score and N Max is the Maximum Score.

The results of the percentage of achievement (P) are then interpreted based on the following criteria:

81 % - 100 % : Very Good (SB)

61 % - 80 % : Good (B)

41 % - 60 % : Enough (C)

21 % - 40 % : Not Good (KB)

0 % - 20 % : Not Good (TB)

Augustina (2019).

3. RESULT AND DISCUSSION

3.1. Research result

Based on the results of the research that has been carried out, data is obtained in the form of observing the quality of facilities and infrastructure in the Science laboratory for the 2022/2023 Academic Year which include laboratory rooms, laboratory furniture facilities, educational equipment, educational media, and other equipment, then adjusted to the Standard Regulations of the Minister of National Education Number 24 of 2007. For other data sources such as practicum implementation, practicum implementation, questionnaires, interviews, and documentation are used to find out an overview of school laboratories and how the implementation of natural science practicums supports science learning at the school.

3.1.1. Quality of laboratory facilities and infrastructure

Based on observations regarding the quality of laboratory facilities and infrastructure in research schools, the results of data analysis regarding laboratory room conditions, laboratory facilities and infrastructure, educational equipment, educational media, and other equipment were obtained which are presented in Table 1.

Table 1. Quality of science laboratory facilities and infrastructure

Number	Aspect	Percentage (%)	Category
1	Laboratory	100	Very Good
2	Laboratory furniture	57,1	Enough
3	Educational equipment	70	Good
4	Educational media	100	Very Good
5	Other equipment	60	Enough
	Average	**77,42**	**Good**

Based on Table 1. it can be seen that the condition of science laboratories in research schools is generally included in the good category which is evidenced by an average percentage of 77.42 %. This shows that the completeness of the science laboratory facilities and infrastructure is sufficient to meet the minimum criteria for an ideal laboratory as stated in the Regulation of the Minister of Education and Culture Number 24 of 2007. In general, the condition of this science laboratory is included in the good category, it is proven that each aspect has a different score and percentage, which ranges from 57,1 – 100 %.

The results of observations of the science laboratory room show that the minimum area of the laboratory room is 12.8 x 8.5 m = 108.8 with a ratio of 108.8 : 32 students = 3.4, the storage and preparation room area is 10.5 x 2.8 = 29.4 , adequate lighting equipped with windows and air circulation, and the availability of clean water. This is already in the very good category as evidenced by the percentage of 100 %. Laboratory furniture facilities are included in the sufficient category with a percentage of 57,1 % where suitable furniture includes student and teacher chair tables, tool and material cabinets, and sinks, while those that are not suitable include demonstration tables, preparation tables, and 1 material cupboard with open place.

In the aspect of educational equipment, it is included in the good category with a percentage of 70% where out of 40 types of educational equipment 27 of them are suitable for use and 9 of the equipment are not available including stopwatches, roller meters, inclined planes, fixed and moving pulleys, genetic posters, pictures/models of the circulatory system humans, pictures/models of the human respiratory system, and pictures/models of the throat in humans. The 4 educational equipment that do not match the ratio are beakers, droppers and magnifying glasses. In the aspect of educational media, it is included in the very good category with a percentage of 100% and has complied with Permendiknas Number 24 of 2007. For other aspects of equipment, it is included in the sufficient category with a percentage of 60 %, including electric sockets, trash cans, and wall clocks that are already in place. laboratory room while fire extinguishers, first aid kits are not yet equipped in the science laboratory.

3.1.2. Implementation of science practicum

The results of observations of the implementation of science practicum class IX for the 2022/2023 Academic Year are included in the sufficient category with a percentage of 60 %. Based on the KD reference (Basic Competency) class IX Semester 2, it can be seen that practicum in one even semester of the 5 KD is carried out only on KD 3.6 and 4.6, namely magnetism and biotechnology. In other materials, practicum was not carried out due to limited time for class IX with an exam schedule. As for the results of observations of the practicum implementation, they are presented in Table 2.

Table 2. Implementation of science practicum

Number	Aspect	Percentage (%)	Kategori
1.	Prepare	85	Very Good
2.	Implementation	93,75	Very Good
3.	Closing	89	Very Good
	Average	89,25	Very Good

Practical implementation in the science learning process is carried out based on 3 stages, namely preparation, implementation and closing. The implementation of the IX class science practicum this semester was carried out 2 times, namely KD 3.6 and 4.6 Magnetism where students were asked to test the properties of magnets and observe the strong or weak attraction caused by magnets. In KD 3.7 and 4.7 in Biotechnology, students conducted an experiment to make yogurt and then presented whether yogurt was successful or not. In carrying out practicum the teacher usually makes preparations starting from the place of practicum implementation, tools and materials, explains the use of tools and materials, gives instructions on the use of practicum materials, asks questions and answers, explains the objectives of the practicum, gives motivation, and provides practicum instructions to students. After that, carry out the practicum carried out by students and end with data collection, presentations, discussions, and making conclusions. Observations made at this stage showed that the practicum implementation was included in the very good category where the average percentage obtained was 89.25 %.

3.1.3. Practicum Implementation Questionnaire

The implementation of science practicums can be seen from the questionnaires that have been distributed to students as a way to collect data and find out how science practices are carried out in research schools in 2022/2023. The results of the questionnaire data recapitulation can be seen in Table 3. And the graph can be seen in Figure 1.

Table 3. Recapitulation of Questionnaire Data for the Implementation of Science Practicum

Aspect	Average (%)	Category
Frequency/Intensity of Practicum Implementation	61	Good
Student Interest in Practicum	65.7	Good
Practicum Implementation Time	67	Good
Practicum Implementation Time	69.9	Good
Overall average	65.8	Good

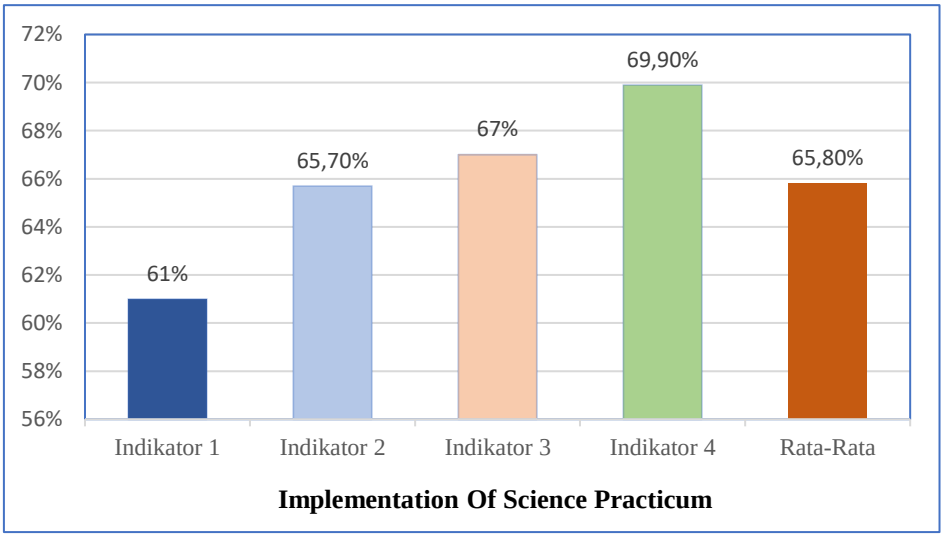


Figure 2. Questionnaire Average Graph

3.2. Discussion

The existence of facilities and infrastructure in science subjects is very important to support the smoothness and ease of the learning process in class and practicum activities. According to (Zakiyah, 2022) in optimizing the role of the laboratory, facilities and infrastructure are needed to meet the qualifications and standards according to the type of laboratory. In the Regulation of the Minister of National Education Number 24 of 2007, which contains that the components of science laboratory facilities in junior high schools include laboratory buildings or rooms, furniture, educational equipment, experimental tools and materials, educational media, consumable materials, and other equipment. Practicum activities can be carried out optimally if they meet laboratory quality standards based on Permendiknas Number 24 of 2007.

3.2.1. Quality of laboratory facilities and infrastucture

Based on the research conducted, it was found that the quality of the science laboratory facilities and infrastructure in the research schools had different percentage comparisons in each aspect. The condition of the science laboratory room has an average percentage of 77,42 %. This indicates that the completeness of science laboratory facilities and infrastructure is sufficient to meet the minimum criteria for an ideal laboratory as stated in Permendiknas regulations Number 24 of 2007. (Hayati, 2020) states that from the results of research and data analysis it is concluded that the fulfillment of infrastructure facilities in the biology laboratory has been said to meet the standards of Permendiknas Number 24 of 2007 with an average percentage value of 81,2%.

The science laboratory in a research school is one of the special rooms used to carry out science practicum learning activities. The condition of this laboratory room has an achievement percentage of 100%, which is included in the very good category. Based on interviews conducted with Science Subject Teachers, it was stated that the Science laboratory already has its own room and is very strategically located which is close to classrooms, counseling rooms, bathrooms, mosques, and libraries. This is in line with (Agustina, 2017) research which said that the biology laboratory at SMA Muhammadiyah 1 Surakarta is strategically located adjacent to the teacher's room, counseling room, opposite the principal's room and administration. The laboratory faces the outer courtyard and is adjacent to the classroom so that it is easy for teachers and students to reach.

The area of the science laboratory is 12.8 m x 8.5 m = 108.8 , with a ratio of 108.8 : 32 students = 3.4 , this room can be used to accommodate a study group of 32 students. The science laboratory room is divided into 3 rooms, namely the practicum room, storage room, and preparation room. The storage and preparation room has an area of 10.5 x 2.8 = 29.4 . In line with (Ismiyanti, 2021) research that laboratory rooms generally consist of practice rooms, storage rooms, and preparation rooms. Laboratory room designed with a minimum of 2.4 m2/student and accommodates a minimum of 20 people in it with an area of 48m2.

Figure 3. Science Laboratory Room

The laboratory room has facilities such as adequate lighting to carry out practicum activities and is equipped with air circulation. In the laboratory room lighting is very important because it functions to help with lighting and air circulation. (Nahdiyaturrahmah, 2020) said that a good laboratory room location must have good lighting. The laboratory should be located away from the sun's rays. Sunlight is needed to illuminate the room, because practical activities sometimes require observations that require more lighting. This room is also equipped with a faucet and clean water.

Science laboratory furniture facilities have an achievement percentage of 57.1 % which is included in the sufficient category. Furniture facilities in this laboratory include student tables and chairs, teacher tables and chairs, demonstration tables, preparation tables, tools and material cupboards, clean water sinks. The results of observations made obtained results include: 16 tables and 32 chairs for participants, in 1 table can accommodate 2 students / 4 students if in groups, there is 1 table and 1 chair for the teacher. There is no demonstration table and preparation table, when the practicum takes place the tools and materials are placed on the front table first. (Decarpio, 2013) stated that cabinets as laboratory furniture must always be present in the laboratory and used to store various kinds of tools and materials. There are 10 tool cabinets in this laboratory room, including 5 glass cabinets for torsos, 3 glass cabinets for tools, 1 open cupboard that cannot be locked, and 1 wooden cupboard that cannot be locked. There is 1 ingredient cupboard that is open and cannot be locked. There are 5 sinks in the laboratory room with clean water located on the right and left of the students' desks, while there are no sinks in the preparation room.

Picture 4. Science Laboratory Furniture Facilities

Science laboratory educational equipment has an achievement percentage of 70 % included in the good category. Of the 40 types of educational equipment in the laboratory, 27 of them are suitable for use which include: 15 rulers, 6 vernier calipers, 54 100c thermometers, 26 measuring cups, 5 metal masses with a mass of 1kg and 3 metal masses with a mass of 500gr, 9 AC/DC multimeters, 8 magnetic rods, 1 globe , there is a solar system model in good condition, 6 tuning forks, 10 dynanometers, 7 wooden blocks, 1 length expansion experiment, 2 folding plane mirrors, 12 sets of electrical circuit experiments, 6 sets of simple molecules, 10 pieces of spirit burners , 15 evaporating cups, 27 tripods, 19 drip plates, 31 monocular microscopes (partly not functioning) 2 human skeleton models (1 bone detached and 1 intact), 2 human body models, 4 human eye models (2 fit for use, 2 not feasible), 2 models of the human digestive system, 4 models of the human heart, 4 models of the human ear, and 12 experimental manuals in good condition.

According to research (Noorjanah, 2022) which states that some educational equipment is inadequate because it is damaged. In accordance with the results of the interview with the Science Teacher, he said that there were several materials that were damaged and unfit for use because they had not been used and maintained for a long time due to the pandemic. Estimates of tools and materials that can be used are 75 % and 25 % are not feasible. In the research junior high school

laboratory there were 9 types of equipment that did not exist in the laboratory such as a stopwatch, roller meter, inclined plane, fixed pulley, moving pulley, genetic poster, picture/model of the human circulatory system, picture/model of the human respiratory system, picture/model of the throat man.

As for there were 3 other equipment that were damaged or not in accordance with the ratio, including chemical glasses in the laboratory room, out of a ratio of 30 pieces/lab, there were only 26 pieces, 90 dropper pipettes (10 pieces were functional, 80 pieces were damaged), and a magnifying glass in a ratio of 6 pieces /lab there is only 1 fruit. The absence of equipment and damage to laboratory equipment is due to the length of time the equipment has not been used, causing the maintenance of tools and materials to be less than optimal so that laboratory equipment is damaged and some are lost. This is in line with (Kurniawan, 2021) research which states that around 75% of the facilities in the science laboratory at MTs Negeri 8 Jember have met the standards of existing laboratory facilities. However, the existing facilities are still lacking. This is because many laboratory equipment is damaged and rarely used, especially during a pandemic where all learning activities are limited so that science practicum activities cannot be carried out in the laboratory, which results in many facilities being damaged because they have not been used for too long. (Marcella, 2018) states that the educational equipment in the Bhayangkari Private Middle School Science laboratory is in a good category with good conditions and can be used, but does not match the ideal number of equipment that must be present in the laboratory.

Educational media in school laboratories, obtained an achievement percentage of 100% included in the very good category. (Agustina, 2022) said that facilities and infrastructure related to learning tools really support the success or failure of schools and teachers in teaching. Facilities and infrastructure can be in the form of tables, chairs, blackboards. In this aspect, the laboratory room provides 1 blackboard with a size of 120 cm x 240 cm equipped with erasers and markers which meet the standards of Permendiknas Number 24 of 2007. In addition, there are additional media such as LCD and projectors that can function properly and be utilized to display the presentation of learning materials and practicum.

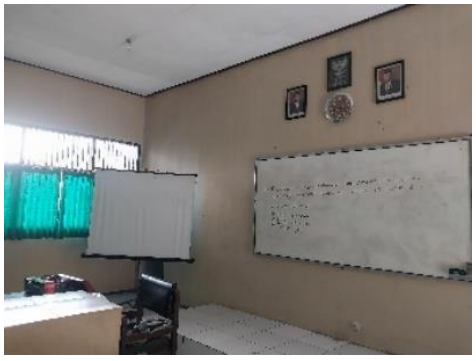


Figure 5. Science Laboratory Educational Media

As for other equipment or supporting equipment in the school science laboratory, an achievement percentage of 60 % is included in the sufficient category. Other equipment in this aspect includes 8 power sockets located in the center of the table and 3 in the laboratory room, there is 1 trash can in the room, and 1 wall clock. (Aseng, 2021) research states that fire extinguishers and first aid kits are special facilities that should be in every laboratory. However, in this laboratory facilities such as fire extinguishers and first aid kits are not yet available in the laboratory room. This is due to the lack of maintenance of first aid kits, so many are missing.

Figure 6. Other Equipment of Science Laboratory

3.2.2. Implementation of science practicum

The implementation of practicum in schools is an indicator of the success of schools and teachers in carrying out science learning activities because science learning does not only study theory but hones science process skills. Based on the results of observations of the implementation of science practicum based on Basic Competency (KD), it is known that the implementation of science practicum class IX for the 2022/2023 academic year is included in the sufficient category with a percentage of 60%. (Rahmah, 2021) said that the implementation of biology practicum in class XI SMA Kota Banda Aceh was categorized as sufficient with a percentage value of 62,81%. Based on the results of interviews with school educators, the practicum was not implemented due to several obstacles encountered. These obstacles include the unavailability of props for practicum, insufficient time allocation. (Lestari, 2020) also said that the problem in learning science at the moment is not only low learning outcomes but also the low quality of ongoing learning. Science laboratory supporting components are still inadequate because there is no specific time.

Practicum in class IX is carried out only on Magnetism and Biotechnology material, for other materials practicum is not carried out due to insufficient time constraints. In KD 3.6 and 4.6 on Magnetism, practicum in one group of students is asked to test the properties of magnets and observe the strong or weak attraction generated by magnets using steel nails. In KD 3.7 and 4.7 in Biotechnology, students conducted an experiment to make yogurt and then presented whether yogurt was successful or not. The results of the Yoghurt material practicum were almost all successful, but there was one group that failed because the cloth covering was too thin during fermentation so that the Yoghurt product failed.

Picture 7. Implementation Of Science Practicum

Based on Table 2. It is known that the quality of the implementation of science practices is included in the very good category with an average percentage of 89,25%. The implementation of the science practicum is carried out based on 3 stages, namely preparation, implementation and closing. In the preparatory stage, the teacher makes preparations starting from the place of practicum, tools and materials and their use, explaining the purpose and how to carry out the practicum as well as possible so that the practicum can run smoothly. After preparing the students to carry out the practicum in accordance with the material being practiced with the tools and materials that are already available, we collect data on the implementation of the Science practicum. Furthermore, in the final stage, namely closing, students make presentations, discussions, and clarifications with the science teacher.

When the implementation of the science practicum took place, it cannot be denied that there were obstacles that occurred. In accordance with the interviews that have been conducted, in the implementation of practicum there are usually several obstacles that are often experienced, one of which is due to limited tools and materials so they are used interchangeably. (Haris, 2019) said the obstacle in carrying out practicums in developing countries is the lack of equipment to support practicum activities. In addition, the lack of cooperation in groups also resulted in practical activities not running optimally.

3.2.3. Science Practicum Implementation Questionnaire

(Hakim, 2020) says that implementing science practicum at the junior high school level has its own challenges. In addition to the level of teacher ability and motivation to carry out natural science practicum activities, the availability of facilities and infrastructure to support natural science practicum activities also determines the sustainability of practicum activities. Based on the results of a questionnaire regarding the implementation of the science practicum given to students and containing statement items arranged based on indicators, the results of the data recapitulation were calculated as a percentage for each indicator listed in Table 3.

Based on the frequency/intensity indicator of practicum implementation, the average percentage of the 5 samples, namely 61 %, was included in the good category. This is because practice in one even semester has been carried out 2 times, although not all material is held for practicum. An indicator of student interest in practicum obtained an average percentage of 65,7% in the good category. This is because the students are enthusiastic about doing the practicum, but there are also some students who are less enthusiastic and are still playing around when the practicum is carried out. The indicator for practicum implementation time obtained an average percentage of 67% in the good category. This is because the practicum schedule starts according to the agreed time, but does not finish on time because the equipment is used alternately. Not all material can be done in practicum due to limited time for class IX in pursuing the material. The indicators of preparation and implementation of practicum obtained an average percentage of 69,9% in the good category. This is because before the practicum is carried out the teacher prepares tools and materials first. And the average results for the implementation of science practicums in research schools obtained an average percentage of 65.8 % in the good category, in the sense that the implementation of science practicums went well. Of the 5 KD in one practicum semester it is carried out 2 times, the time allocation for carrying out the practicum is still lacking because it has to compensate by pursuing material in other chapters.

4. CONCLUSION

Based on the research that has been done, it is concluded that the quality of science laboratory facilities and infrastructure in terms of the completeness of facilities and infrastructure (laboratory rooms, laboratory facilities and infrastructure, educational equipment, educational media and other equipment) is included in the good category and fulfills as stated in the regulations Permendiknas Number 24 of 2007 is evidenced by an average percentage of 77.42 %. Inadequate equipment and damage to laboratory equipment due to long unused equipment causing maintenance of tools and materials to be less than optimal so that laboratory equipment is damaged and some are lost. The implementation of the science practicum in Junior High School researchers in terms of preparation, implementation, and closing is very good category where the average percentage obtained is 89.25 %. The results of the questionnaire showed that the average percentage of the implementation of the science practicum in terms of the intensity of the practicum implementation, student interest, implementation time, as well as the preparation and implementation of the practicum was 65.8 % in the good category, in the sense that the implementation of science practicum class IX in the even semester went well Good.

5. REFERENCES

Agustina, D., Nurjannah, A., Harahap, A., Lestari, V., & Hafizhah, Z. (2022). Konstruksi Pemahaman Pentingnya Sarana Prasarana di Sekolah. *Edumaspul: Jurnal Pendidikan*, *6*(1), 1352–1359. https://doi.org/10.33487/edumaspul.v6i1.4202

Agustina, P., Saputra, A., Qonitat, L. M., Utami, R. D., & Yohana. (2017). Kesesuaian Laboratorium Biologi sebagai Penunjang Pembelajaran Biologi di SMA Muhammadiyah se-Surakarta dengan Standar Laboratorium Biologi. *Proceeding Biology Education Conference*, *14*(1), 559–564.

Aseng, M. D., & Hau, R. R. H. (2021). Peralatan P3K Dalam Labolatorium Sebagai Penunjang Aktivitas Praktikum Yang Aman. *Pendidikan Fisika Dan Sains*, *2*(1).

Candra, R., & Hidayati, D. (2020). Penerapan Praktikum dalam Meningkatkan Keterampilan Proses dan Kerja Peserta Didik di Laboratorium IPA. *Edugama: Jurnal Kependidikan Dan Sosial Keagamaan*, *6*(1), 26–37. https://doi.org/10.32923/edugama.v6i1.1289

Decarpio, R. (2013). *Tips Mengelola Laboratorium Sekolah.* Semarang: Diva Press

Hakim, A., Jufri, A. W., Kosim, K., Bachtiar, I., & Bahri, S. (2020). Kajian Pelaksanaan Praktikum Ilmu Pengetahuan Alam Sekolah Menengah Pertama Di Kota Mataram. *Jurnal Pijar Mipa*, *15*(2), 93–98. https://doi.org/10.29303/jpm.v15i2.1458

Haris, H., B, N., & Rachmawaty. (2019). *Keterlaksanaan Praktikum IPA Biologi Kelas VIII SMP 8 Kota Makassar*.

Hayati, A., & Sumarsih, S. (2020). Evaluasi Standar Sarana Dan Prasarana Laboratorium IPA Di Sekolah Model SMA Negeri 7 Bengkulu Selatan. *Manajer Pendidikan: Jurnal Ilmiah Manajemen Pendidikan Program Pascasarjana*, *14*(2), 60–67. https://doi.org/10.33369/mapen.v14i2.12827

Ismiyanti, N., Windasari, R., M. S, A., H.M, V., & Aziz, A. (2021). Identifikasi Standarisasi Laboratorium IPA di Salah Satu MTs Jember. *VEKTOR: Jurnal Pendidikan IPA*, *2*(1), 41–48. https://doi.org/10.35719/vektor.v2i1.24

Kurniawan, Alfarizi, Rivo. (2021). Analisis Standarisasi Sarana, Prasarana dan Tenaga Laboratorium IPA MTs Negeri 8 Jember. *Edulab : Majalah Ilmiah Laboratorium Pendidikan*, *6*(1), 29–42. https://doi.org/10.14421/edulab.2021.61.03

Lestari, D. P., & Supahar. (2020). Students and teachers' necessity toward virtual laboratory as an instructional media of 21st century science learning. *Journal of Physics: Conference Series*, *1440*(1), 0–7. https://doi.org/10.1088/1742-6596/1440/1/012091

Marcella, Z., Susanti, N., & Dani, R. (2018). Jurnal Edufisika. *Jurnal Edufisika*, *3*(2), 41–48.

Nahdiyaturrahmah, Pujani, N. M., & Selamet, K. (2020). Pengelolaan Laboratorium Ilmu Pengetahuan Alam (IPA) SMP Negeri 2 Singaraja. *Jurnal Pendidikan Dan Pembelajaran Sains Indonesia (JPPSI)*, *3*(2), 118–129.

Noorjanah, Aprilia, D., Astuti, R., & Sa'diyah, H. (2022). PROFIL LABORATORIUM IPA DI SMP NEGERI 2 KARANGDOWO TAHUN AJARAN 2021/2022 Aprilia. *Journal of Education Learning and Innovation*, *3*(1), 1–15.

Nugraha. (2020). *Pengantar Pendidikan dan Pembelajaran di Sekolah Dasar.* Tasikmalaya: Edu Publisher.

Pertiwi, U. D., Atanti, R. D., & Ismawati, R. (2018). Pentingnya Literasi Sains Pada Pembelajaran Ipa Smp Abad 21. *Indonesian Journal of Natural Science Education (IJNSE)*, *1*(1), 24–29. https://doi.org/10.31002/nse.v1i1.173

Rahmah, N., Iswadi, I., Asiah, A., Hasanuddin, H., & Syafrianti, D. (2021). Analisis Kendala Praktikum Biologi di Sekolah Menengah Atas. *Biodik*, *7*(2), 169–178. https://doi.org/10.22437/bio.v7i2.12777

Rahman, M. S. (2017). Kajian Standarisasi Sarana Prasarana Laboratorium Ipa Berdasarkan Permendiknas No. 24 Tahun 2007 Di Smpn 4 Sumenep. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, *7*(1), 1–12. https://doi.org/10.24929/lensa.v7i1.18

Ramadhan, T., & Suyanto, S. (2020). Biology science practicum learning: An evaluation study in junior high school of Ngemplak-Indonesia. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(3), 361–366. https://doi.org/10.22219/jpbi.v6i3.13657

Rasyid. (2020). *Mengelola Laboratorium IPA Sekolah.* Klaten: Penerbit Lakeisha.

Rizkika, M., Dwi, P., & Ahmad, N. (2022). Development of E-LKPD Based on STEM on Substance Pressure Materials to Improve Critical Thinking Skills for Junior High School Student. *Pancasakti Science Education Journal PSEJ*, *7*(1), 41–48. https://doi.org/10.4905/psej.v7i1.142

Rusydi, A. (2018). *Pembelajaran terpadu: karakteristik, landasan, fungsi, Prinsip dan model.* Medan: Lembaga Peduli Pengembangan Pendidikan Indonesia (LPPPI).

Salirawati, D. (2018). *Smart Teaching Solusi Menjadi Guru Profesional.* Jakarta: Bumi Aksara.

Saputro, B. (2021). *Best Practices Penelitian Pengembangan (Research & Development) Bidang Manajemen Pendidikan IPA.* Lamongan: Academia Publication.

Sugiarti, S., Koto, I., & Hambali, D. (2021). Pengembangan Panduan Praktikum IPA Untuk Meningkatkan Kemampuan Berpikir Kritis Mahasiswa Program Studi PGMI Fakultas Tarbiyah dan Tadris IAIN Bengkulu. *Jurnal Pembelajaran Dan Pengajaran Pendidikan Dasar*, *4*(2), 158–171. https://doi.org/10.33369/dikdas.v4i2.14642

Suryaningsih, Y. (2017). Pembelajaran Berbasis Praktikum Sebagai Sarana Siswa Untuk Berlatih Menerapkan Keterampilan Proses Sains Dalam Materi Biologi. *Jurnal Bio Educatio*, *2*(2), 49–57.

Susanti. (2021). *Teknik Pengelolaan Laboratorium.* Yogyakarta: ANDI.

Wasiya, Karunia, S., Agustina, R. W., & Nur Lora Sirikit. (2021). *Pengelolaan Sarana Dan Prasarana Dalam Meningkatkan Mutu Pendidikan Di SDN 1 Panembahan*. *3*(1), 295–300.

Wisma. (2021). *Aplikasi PhET, Pilihan Simulasi Pembelajaran IPA.* NTB: Pusat Pengembangan Pendidikan dan Penelitian Indonesia.

Yamin, M., Sarjan, M., Jufri, A. W., & Hakim, A. (2022). Urgensi Praktikum IPA Berbasis Ekowisata Megapodius reinwardt untuk Meningkatkan Kemampuan Berpikir Kreatif Mahasiswa. *JPIn: Jurnal Pendidik Indonesia*, *5*(2), 14–25.

Zakiyah, A., Kurniawati, I., Firdaus, Nurul, A., & Mahardika, Ketut. I. (2022). Pengaruh Sarana Prasarana Laboratorium IPA Terhadap Motivasi Belajar Siswa di SMP Negeri 10 Jember Kelas 7. *Jurnal Ilmiah Wahana Pendidikan*, *8*(24), 417–423. doi: https://doi.org/10.5281/zenodo.7494535

Zulkarnain, W. (2018). *Manajemen Layanan Khusus di Sekolah.* Jakarta: PT Bumi Aksara.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Kefir Combination Between Soy Milk and Skim Milk On Variation of Sugar and Fermentation Duration

Masithoh Uswatiningtyas, Titik Suryani*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: ts169@ums.ac.id

KEYWORDS:
Fermentation duration
Kefir
Organoleptic
Skim Milk
Soy Milk

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Kefir is one of the functional beverages that has an acidic taste due to the activity of lactic acid during the fermentation process. One of the ingredient innovations for kefir was soy milk, skim milk and variations of sugar types. Soy milk protein has an amino acid structure similar to cow's milk, so it is very good for people with lactose intolerance. The aim of this study is to know the quality (total of lactic acid and the organoleptic quality) of the kefir combination between soy milk and skim milk on the variation of sugar and fermentation duration. The study used experimental methods and complete random design (CRD) with two factors. Factor I was the sugar variation (N) palm sugar and white sugar. Factor II was the variation of fermentation duration (K) 24 hours, 36 hours, and 48 hours. The results of the study showed that the lowest lactic acid of kefir combination between soy milk and skim milk was 0.896 % on N2K1 treatment (white sugar + 24-hour fermentation duration). The best organoleptic quality of kefir combination between soy milk and skim milk was N2K1 white sugar + 24-hour fermentation duration) in white color, sour taste, and soft texture.

1. INTRODUCTION

Functional beverages are one of the types of beverages that give a positive influence on the health of the body for those who consume them because they contain elements of nutrients and non nutrients (Al Fath, 2021). Functional beverages are supplemented with tertiary functions such as probiotics, adding to the intake of certain vitamins and minerals, increasing the body's stamina, and reducing the risk of certain diseases (Widyantari, 2020). Functional beverages should fulfill two main food functions, namely to provide nutritional intake and sensory loading such as good taste and texture (Herawati, 2012). One of the functional beverage products is kefir. Kefir is one of the functional beverages with the basic ingredients of animal milk that has an acidic taste due to the activity of lactic acids formed during the fermentation process to preserve products and give a taste or flavor to certain food products that are expected to improve the nutritional quality of the products (Aryanta, 2021). Kefir contains proteins with complete essential amino acids, vitamin A, vitamin B1, vitamin B2, vitamin B5, vitamin B6, vitamin B7, vitamin B9, vitamin B12, vitamin C, vitamin K, potassium, calcium, phosphorus, magnesium, iron, zinc, copper, and manganese (Lararenjana, 2020). Kefir has a total acidity of about 0.5 % to 2.0 %, a pH of 4.6, and a protein content of 3.2 % (SNI, 2009). Kefir can be made from natural materials that are easily obtained in everyday life, such as plant and animal materials (Fortin, 2021).

Soy milk is a beverage made from yellow beans that are yellow-white and similar to milk (Arianty, 2019). The nutritional content of soy milk per 100 g of soybeans is 44 calories, 3.6 g of

protein, 2 g of fat, and 2.9 g of carbohydrates (Sugiarsih, 2022). Soy milk protein has an amino acid structure similar to cow's milk, so it is very good to consume for those who are allergic to dairy, lactose intolerance (Alfiyah, 2017). Soy milk contains carbohydrates including oligosaccharides that can be indirectly digested into kefir because it is difficult to be used by starter cultures as an energy source and a source of carbon. Therefore, it is necessary to add other sources of carbs such as lactose that will be utilized by the Lactate Acid Bacteria (BAL) as a source of energy and nutrients during its growth in the kefir fermentation process (Rossi, 2016).

Skim milk is milk made by reducing the amount of water and existing fat. The low fat content of skim milk can be replaced by its deficiency because it has a high enough protein content, lactose, and minerals. (Afrizal, 2019). According to Mandei (2019) skim milk has a fat content of 0.50 %, protein of 1.10 %, ashes of 0.68 %, acidity of 0.8 %, and is a source of nitrogen to carry out the growth of microorganisms during fermentation. The use of skim milk plays an important role in the manufacture of probiotic beverages in order to obtain the amount of bacteria that meets the standards (Hakiki, 2022). Adding skim milk can increase acidity and lower pH (Septiani, 2013). The Lestari study (2021) also stated that the addition of skim milk is aimed at increasing the protein and carbohydrate substrate, thus supporting the growth of kefir microorganisms.

Factors affecting the quality of kefir are kefir seeds, milk types, sugar types, time, temperature, and fermentation duration (Gamba, 2020). Sugar is one of the simple carbohydrates that is a major source of energy and a commodity. Sugar is used to change the taste into sweet and the condition of food or beverage (Mahfud, 2018). Sugar can be in the form of particles, flour, liquid, and solid. The color can be white or brown with a sweet taste. The types of sugar circulating in society are white sugar, brown sugar, and liquid sugar (Rahmi, 2020). Palm sugar contains approximately 84 % more sucrose compared to cane sugar and beet sugar which are only 20 % and 17 % respectively so palm sugar is able to provide higher energy than beet sugar and cane sugar (Lempang, 2020). In the fermentation of kefir, sugar is used as an energy source and a source of carbon for cell biosynthesis especially for glycolysis cycles (Gunawan et al., 2015). Fermentation time is one of the factors in the process of making kefir. As the fermentation duration increases, there is more and more time available for lactic acid bacteria to refine the nutrients contained in the substrate which can allow the accumulation of organic acids such as lactic acids in more amounts (Pangaribuan, 2022). Lestari study (2018) found that different fermentation duration influenced the levels of acidity, viscosity, and alcohol levels in which the yield rate increased as the fermention duration increased. Therefore, this study aims was to determine the Quality of Kefir Combination Between Soy Milk and Skim Milk On Variation of Sugar and Fermentation Duration.

2. MATERIALS AND METHOD

The study was conducted in February – June 2023 at the Biology Laboratory of the Faculty of Keguruan and Education Sciences of the Muhammadiyah University of Surakarta. Testing of pH levels and organoleptic quality (taste, colour, flavour, texture, and acceptivity) at the Muhammadiyah Surakarta University Biological Laboratory, and total of lactic acid testing was carried out at the Pratama Yogyakarta Chem Mix Laboratory.

2.1. Materials

The ingredients used in the manufacture of kefir combination between soy milk and skim milk is namely soymilk, skim milk (greenfields), palm sugar, white sugar, and kefir grain.

2.2. Research Procedure

The research process includes: 1. The preparatory stage by preparing the tools and materials to be used for research 2. Sterilize equipment using hot water for 10 minutes 3. The stage of aplication first, mixing soy milk and skim milk then pasteurized, then put the white sugar and palm sugar into the mixture of soy milk and skim milk while stired until evenly mixed, then put the mixture of ingredients into the jar in a cold state, then put the grain kefir into the jar according to the measure, then close the jar and store at room temperature, then kefir harvesting is adjusted to the fermentation duration, and then the harvested kefir was put into the refrigerator to further test the organoleptic quality of the 15 panelists.

2.3. Research Design

The study used experimental methods and complete random design (CRD) with two factors. Factor 1 was the type of sugar (N1= palm sugar 16 g, N2= white sugar 30 g) and factor 2 was the fermentation duration (K1 = 24 hours, K2= 36 hours, K3= 48 hours). Testing the total of lactid acid content by titration method and presenting it in the form of a table with the final result in percentage form and performing organoleptic tests (taste, colour, flavour, texture, and acceptivity) with a questionnaire sheet of 15 panelists.

2.4. Data Analysis

Research data were presented in the form of tables. Total of lactid acid testing analysis using quantitative descriptive methods. During organoleptic testing, taste, colour, flavour, texture, and acceptivity. Quantitative test data analysis using a two-way variance analysis test (Two Way ANOVA) and qualitative test data analysis using Excel.

3. RESULTS AND DISCUSSION

3.1. Result

Based on the study of pH and total of lactid acid kefir combination between soy milk and skim milk on variation of sugar and fermentation duration that have been performed from six samples obtained the following results:

Table 1. Results of pH and total of lactid acid kefir combination between soy milk and skim milk on variation of sugar and fermentation duration.

Number	Treatment	pH		Total of lactid acid (%)
		Before the fermentation	After the fermentation	
1	N1K1 palm sugar 24 hours	6.55	3.83	1.079
2	N1K2 palm sugar 36 hours	6.65	3.74	1.192
3	N1K3 palm sugar 48 hours	6.68	3.62	1.337
4	N2K1 white sugar 24 hours	6.88	4.48	0.896
5	N2K2 white sugar 36 hours	6.86	4.25	1.057
6	N2K3 white sugar 48 hours	6.71	3.68	1.151

Based on table 1, the highest total acid content in kefir combination between soy milk and skim milk in the N1K3 treatment showed an average of 1.337 %, while the lowest total acid content

in kefir in the N2K1 treatment showed an average of 0.896 %. Based on the results of the Two Way Annova statistical test, which showed sig 0.001 <0.05 that there was a significant effect on the total sugar variation and fermentation time. The results of Duncan's further test showed that the fermentation time of 48 hours had a significant effect on the total acidity of the kefir combination of soy milk and skim milk.

Based on the research of organoleptic quality kefir combination between soy milk and skim milk on variation of sugar and fermentation duration that has been performed from six samples obtained the following results :

Table 2. Result of organoleptic quality kefir combination between soy milk and skim milk on variation of sugar and fermentation duration.

No	Treatment	Organoleptic Quality				
		Taste	Color	Flavour	Texture	Acceptivity
1	N1K1 palm sugar 24 hours	Sour	Young Chocolate	Less Tasteful	Softly	Less Like
2	N1K2 palm sugar 36 hours	Sour	Young Chocolate	Tasty	Softly	Less Like
3	N1K3 palm sugar 48 hours	Sour	Young Chocolate	Less Tasteful	Softly	Less Like
4	N2K1 white sugar 24 hours	Sour	White	Tasty	Softly	Like
5	N2K2 white sugar 36 hours	Sour	White	Tasty	Softly	Like
6	N2K3 white sugar 48 hours	Sour	White	Less Tasteful	Softly	Less Like

Based on table 2, the organoleptic quality of kefir combination between soy milk and skim milk showed a sour taste in all treatments, the color of kefir in treatment N1 was light brown and in treatment N2 it was white. The aroma of kefir in the N1K1, N1K3, and N2K3 treatments was not pleasant, while the N1K2, N2K1, and N2K2 treatments were pleasant. The texture of kefir on all treatments was soft, while the panelists acceptability on all treatments did not like it except for the N2K1 and N2K2 treatments, they liked it.

3.2. Discussion

3.2.1. Total of Lactid Acid

Table 1 showed best total of lactid acid value on N2K1 treatment (white sugar + 24 hours fermentation duration) was 0.89 %. The total result of the total of lactid acid treatment of N2K1 in accordance with SNI (2009) was 0.5 – 2.0 %. The decrease in total of lactid acid output was affected by bacterial activity. Bacterial activity is influenced by the available energy sources. The more energy sources available, the more bacterial activity will increase, so that the acid produced also greatly affects the decrease in the pH of kefir. In Table 1, the total acidity of palm sugar is higher than that of white sugar. This is because the content of palm sugar is higher than white sugar, so the bacterial activity in the kefir with added palm sugar was higher than white sugar. The highest sucrose content was found in palm sugar of 84.31% compared to cane sugar of 71.89 % (Yudho, 2021). In the study Widya et al (2018) also stated palm sugar contains higher sucrose 84 % compared to cane sugar which is 20 %. Palm sugar contains approximately 84% more sucrose compared to cane sugar and beet sugar, so palm sugar is able to provide more energy than cane sugar and beet sugar (Lempang, 2020). The increase in the amount of BAL occurs because the availability of substrate in the fermentation media increases with the increase in sucrose concentration. The more the amount of LAB, the more the total acid produced (Indriasari, 2022). In the study Nisa et al (2018) also stated that lactic acid bacteria use sugar as a source of growth energy and produce metabolites in the form of lactic acids during fermentation. In the study

Pangaribuan (2022) it was stated that the length of fermentation also affects the resulting pH. As the fermentation time increases, more and more time is available for lactic acid bacteria to refine the nutrients contained in the substrate which can allow more organic acids such as lactic acids to accumulate. This is demonstrated in the long-term treatment of the 48 – hour fermentation which produced the highest total acid compared to the 24 – hour and 36 – hour processings.

3.2.2. Organoleptic Quality

Based on Table 2 (results), it shows that in terms of flavor, the kefir combination between soy milk and skim on treatment N1K1 (palm sugar + 24 hours), N2K2 (palm sugar + 36 hours), N3K3 (palm sugar + 48 hours), N2K1 (white sugar + 24 hours), N2K2 (white sugar + 36 hours) and N2K3 (white sugar + 48 hours) have a sour taste. The results of organoleptic quality treatment N2K1 in accordance with SNI (2009) indicate that the kefir beverage should have a distinctive acidic flavor, a fluid appearance, and a normal flavour. The kefir combination between soy milk and skim milk has a characteristic acidic taste. The feeling of sour in kefir is caused by the activity of lactic acid bacteria which produce primary metabolites and lower the pH (Rahmiati & Mumpuni, 2017). The sensory value of the flavor of the panels is related to the pH produced by kefir, the more acidic it is. The lower the pH of kefir, the more sour the panelis feel. The color of kefir combination between soy milk and skim on the treatment N1K1 (palm sugar + 24 hours), N1K2 (palm sugar + 36 hours) and N1K3 (palm sugar + 48 hours) have the same color which is brown white. Brown-white can appear due to the basic ingredients of palm sugar. At the treatment N2K1 (white sugar + 24 hours), N2K2 (white sugar + 36 hours) and N2K3 (white sugar + 48 hours) have the color white. This is in line with Mandang study (2016) stated that the difference in color kefir soy milk is due to the presence of fat and solid content in milk. Research by Jaya et al (2017) also revealed that the type of sugar will affect the color of kefir. When whey kefir milk is added, a combination of types of sugar with different concentrations will produce a brown color. The brown color appears because of the base ingredients of the palm sugar used, so the color of whey kefir tends to be brown.

Based on Table 2 (result) shows that in terms of flavour, the average kefir combination between soy milk and skim milk has a tasty flavour. According to a Medi study (2023) it is stated that the interaction of the type of sugar affects the aroma of whey because during the fermentation of the kefir it will produce the smell of alcohol. The flavor that resembles tape is due to the presence of high alcohol and esters, so both palm and tea sugar will produce an acidic flavour and cover the characteristic flavour of raw materials before fermentation. The acid flavour produced by kefir is due to the presence of lactic acid present in kefir. This is consistent with the statement of Musdholifah et al (2016) that the flavour in kefir is caused by the formation of volatile compounds during the fermentation process, thus generating a characteristic acid flavour. The volatile compounds found in kefir are lactic acid, acetic acid, and alcohol. This is supported by a statement by Lestari et al (2018) that stated that the volatile compounds in kefir affect the sharpness of the flavour of kefir where the higher the content of the volatile compound in the food, the sharper the flavour of the kefir. The kefir combination between soy milk and skim milk on treatments N1K1 (palm sugar + 24 hours), N2K2 (palm sugar + 36 hours), N3K3 (palm sugar + 48 hours), N2K1 (white sugar + 24 hours), N2K2 (white sugar + 36 hours) and N2K3 (white sugar + 48 hours) the same texture is soft. Kefir composition of soy milk and skim milk has a soft texture due to its low flavor content, which is consistent with the results of the Nurkhoeriyati (2017) study which stated that the sourness flavor of soy kefir is lower compared to commercial kefir. This is because soy milk have a lower fat content than animal milk. Skim milk also affects the texture produced by

kefir. This is in line with Lestari's study (2021) which states that the higher the total kefir solidity of corn milk, the thicker the texture of the kefir milk products produced. The kefir combination between soy milk and skim milk on treatment N1K1 (palm sugar + 24 hours), N2K2 (white sugar + 36 hours) and N2K3 (white sugar + 48 hours) have less like acceptifity. This was caused by a too acidic taste and a too sharp smell. Kefir combination between soy milk and skim on treatment N2K1 (white sugar + 24 hours), N2K2 (white sugar + 36 hours) has a acceptifity like.

4. CONCLUSION

It can be concluded the lowest lactic acid and best organoleptic quality of kefir combination between soy milk and skim milk was 0.896 % in white color, sour taste, and soft texture on N2K1 treatment (white sugar + 24-hour fermentation duration) where according to SNI 2009.

5. ACKNOWLEDGMENTS

Thank you to the Biology Education Department for providing subsidized assistance in INCOBEST.

6. REFERENCES

Afrizal, A. (2019). Pengaruh Pemberian Susu Bubuk Skim Terhadap Kualitas Dadih Susu Kambing. *Jurnal Ilmiah Fillia Cendekia , 4* (2), 88-94.

Al Fath ,Ananda Anisa., Setiyoningsih, Hesti., Haikal., Rahmiati, Ida., Ajeng, Auliyak., Sadewa, Naufal Maulana., Izzaturrizqina., Aulia, Weni., Fariska, Igi Windi ., Musa Zidan Akmal., Fahira, Widda Amalia., Kharisma, Devi., dan Atunnisa, Ima Lukluk. (2021). *Jejak tapak di ranah perantauan* . Semarang : Graf Literasi.

Alfiyah, N., Maududi, A., & Lestari, S. (2017). Identifikasi bakteri Escherichia coli pada susu kedelai yang dijual di toko-toko desa Sumobito Jombang. *Jurnal Insan Cendekia , 4* (2).

Aryanta, I. W. R. (2021). "Kefir dan Manfaatnya Bagi Kesehatan". *Widya Kesehatan*, 3(1), 35-38.

Fortin, GA, Asnia, KKP, Ramadhani, AS, & Maherawati, M. (2021). Minuman fungsional serbuk instan kaya antioksidan dari bahan Nabati". *Agrointek: Jurnal Teknologi Industri Pertanian , 15* (4), 984-991.

Gamba, R. R., Yamamoto, S., Abdel-Hamid, M., Sasaki, T., Michihata, T., Koyanagi, T., Enomoto, T. (2020). "Chemical, Microbiological, and Functional Characterization of Kefir Produced from Cow's Milk and Soy Milk". *International Journal of Microbiology* 2020: 1-11

Gunawan, G., Atmodjo, P., & dan Sidharta, B. (2015). Variasi Kismis dan Sukrosa terhadap Pertumbuhan Asam Laktat dan Alkohol Kristal Alga. Yogyakarta: Fakultas Teknobiologi Universitas Atma Jaya Press.

Hakiki, Fahmy Kafa., Nocianitri, Komang Ayu., Hatiningsih, Sayi. 2022. "Pengaruh Konsentrasi Susu Skim Terhadap Karakteristik Minuman Probiotik Susu Jagung Manis (*Zea mays L. Saccharata*) Terfermentasi dengan Lactobacillus rhamnosus SKG34*". Jurnal Ilmu dan Teknologi Pangan,* 11(3): 420-434

Herawati, N., & Windrati, WS (2012). Pembuatan Minuman Fungsional Berbasis Ekstrak Kulit Buah Naga Merah (*Hylocereus polyrhizus*), Rosela (*Hibiscus sabdariffa* L.) Dan Buah Salam (*Syzygium polyanthum* wigh walp). *Jurnal Agroteknologi*, *6* (01), 40-50.

Indriasari, Y., Berlian, M., & Hujana, N. (2022). "Pengaruh Tempat Tumbuh Dan Konsentrasi Sukrosa Terhadap Jumlah Bakteri Asam Laktat Dan Total Asam Kefir Air Kelapa". *Jurnal Pengolahan Pangan*, 7(1), 38-43.

Jaya, Firman., Parwadi, dan Wahyu Novia Widodo. 2017. Penambahan madu pada minuman whey kefir ditinjau dari mutu organoleptik, warna, dan kekeruhan . Jurnal Ilmu dan Teknologi Hasil Ternak. Vol. 12(1): 16-21.

Lestari, M. W., Bintoro, V. P., & Rizqiati, H. (2018). "Pengaruh Lama Fermentasi Terhadap Tingkat Keasaman, Viskositas, Kadar Alkohol, Dan Mutu Hedonik Kefir Air Kelapa". *Jurnal Teknologi Pangan*, *2*(1), 8-13.

Lestari, YN, Amin, N., Ananda, D., & Rengganis, NA (2021). Identifikasi Karakteristik Kimiawi dan Daya Simpan Kefir Susu Jagung (*Zea mays* L. Saccharata). Jurnal Gizi , 10 (2), 20-32.

Mahfud, Mahfud., dan Sabara, Zakir. 2018. Industri Kimia Indonesia. Sleman : Deepublish.

Mandei, JH, Edam, M., & Assah, YF (2019). Rasio Campuran Air Kelapa Sari Wortel dan Variasi Susu Skim Terhadap Mutu Minuman Probiotik. *Jurnal Riset Industri Indonesia , 11* (2), 192-205.

Medi, I., Anggrayni, YL, & Siska, I. (2023). "Pengaruh Kombinasi Jenis Gula Terhadap Karakteristik Susu Kefir Whey. *Jurnal Pengembangan Ilmu Pertanian* , 12 (1), 138-145.

Musdholifah dan E. Zubaidah. 2016. "Studi aktivitas antioksidan kefir teh daun sirsak dari berbagai merk dipasaran". *Pangan dan Agroindustri*, 4 (1) : 29-39.

Nisa, F. C., Kusnadi, J., & Chrisnasari, R. (2018). "Viabilitas dan Deteksi Subletal Bakteri Probiotik pada Susu Kedelai Fermentasi Instan Metode Pengeringan Beku (Kajian Jenis Isolat dan Konsentrasi Sukrosa sebagai Krioprotektan". *Jurnal Teknologi Pertanian*, 1(9) : 40–51.

Pangaribuan, JF, Nocianitri, KA, & Darmayanti, LPT. 2022. "Pengaruh Lama Fermentasi Terhadap Karakteristik Minuman Probiotik Sari Buah Nanas (*Ananas comosus* L.) dengan Isolat Lactobacillus rhamnosus SKG34 Pengaruh Waktu Fermentasi Terhadap Karakteristik Jus Probiotik Nanas (*Ananas comosus* L.) dengan Lactobacillus rhamnosus SKG34 Isolat". *Itepa*, 11(4), 699-711.

Rahmi, Y., & Kusuma, TS (2020). *Ilmu Bahan Makanan* . Malang: Universitas Brawijaya Press.

Rahmiati, R., & Mumpuni, M. (2017). Eksplorasi Bakteri Asam Laktat Kandidat Probiotik Dan Potensinya Dalam Menghambat Bakteri Patogen. Elkawnie, 3(2), 141–150.

Rossi, E., Hamzah, F., & Febriyani, F. (2016). Perbandingan susu kambing dan susu kedelai dalam pembuatan kefir. *Jurnal Peternakan Indonesia (Jurnal Peternakan Indonesia) , 18* (1), 13-20.

Septiani, AH, Kusrahayu, K., & Legowo, AM (2013). Pengaruh penambahan susu skim pada proses pembuatan frozen yogurt yang berbahan dasar whey terhadap total asam, pH dan jumlah bakteri asam laktat. Jurnal Peternakan , 2 (1), 225-231.

Standarisasi Nasional Indonesia (SNI). 2009. Minuman Susu Fermentasi Berperisa (SNI 7522:2009). Standarisasi Nasional Indonesia (SNI). Jakarta.

Sugiarsih, U., & Solihah, E. (2022). *Meningkatkan Kadar Hemoglobin melalui Es Krim Susu Kedelai* . Penerbit NEM. Pekalongan

Widia, R., & Kasuma, N. (2018). "Comparison of Salivary pH Before and After Consuming A Solution of Sugar and Palm Sugar In Dentistry Faculty's Student Of Andalas University". *Andalas Dental Journal*, 6(2), 69-78.

Yudho, F. H. P. (2021). "Peningkatan Mutu Dan Pemasaran Gula Aren". *JE (Journal of Empowerment)*, 2(1), 150-161.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Coconut Husks and Eggshells Liquid Organic Fertilizer's Effect on The Growth and Calcium Levels of Kale

Nabila Junisky Susetyawati, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Calcium Levels
Coconut husks
Egg shells
Kale
Liquid Organic Fertilizer

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Kale (*Brassica oleracea var. achepala*) is an essential vegetable for human development due to its calcium levels. Lack of hares in the soil is the cause of the decline in kale production. The purpose of this study was to test eggshell and coconut husk liquid organic fertilizers for kale plant growth and calcium levels. The research was conducted at the green house of Biology Education, FKIP UMS. Liquid organic fertilizer dosage (P1 = 100 ml and P2 = 150 ml) and time intervals (W1 = 3 days once and W2 = 5 days once) were tracked using the completely randomized design (RAL) with control treatment as comparison and 3 times replication. Data was analyzed using two-way ANOVA. The plant height, number of leaves, fresh weight, and calcium levels are the variables that were observed. The study revealed that P2W2 treatment had the highest development rate, with average number of leaves of 14 strands, growth height of 13.3 cm, fresh weight of 51.5 g, and calcium levels of 0.141%. Based on the results of the research, it was shown that coconut husks and eggshell liquid organic fertilizer are effective on the growth and increase calcium levels of kale.

1. INTRODUCTION

The completion of balanced nutritional suitability numbers will guarantee the well-being and health of Indonesians. Good sources of nutrition come from vegetables, meat, and fruits. Vegetables become one of the most important components of meeting nutritional needs because many contain the proteins and minerals that the body needs. One of the most important nutrients in vegetables is calcium. Calcium is very necessary for the period of human growth; the older a person is, the more calcium the body needs. When the need for this calcium is insufficient, it will cause inhibition of the human growth process or calcium deficiency, which will imply a high body growth disorder or stunting (Wibowo and Dasuki 2020). It is a serious problem that affects the health of the population and the fulfillment of intellectual and economic potential, such as malnutrition status, which can affect the health, growth, and development of children (Vaivada et al. 2020).

In order to prevent calcium deficiency, it is necessary to consume foods that contain calcium, such as milk, fruits, and vegetables. One of the vegetables high in calcium content (Ca) is kale plants. Based on the decision of the Minister of Agriculture No. 511/Kpts/PD.310/9/2006, kale plants are of the type of cabbage, which includes construction commodities. However, from the data obtained by the (Irjayanti et al. 2021) on the production of cabbage plants in Central Java from 2019 to 2021, there was a decline from 277,478 tons in 2019 to 245.502 tons in 2020 and a decrease in yield in 2021, which is 226.695 tons.

Some factors affecting the decrease in such output can be caused by a lack of plant nutrition from fertilization processes and inappropriate planting techniques. So efforts can be made to increase the output of this Kale variety cabbage plant by paying attention to soil nutrition and good planting techniques. Soil nutrition can be met with the use of fertilizers derived from organic materials. One is from the organic waste of coconut husks and egg shell; both are non-used parts, so they become waste only when they are not recycled or reused properly. Coconut husks and egg shell can be used as materials for the manufacture of liquid organic fertilizer, as they both have the macro- and micro-nutrients that plants need.

Coconut husks have quite good benefits because it contain the necessary compound elements for plants. In addition to having a natural source of potassium (K), coconut husk has the content of other benefits for plants such as phosphorus (P), calcium (Ca), magnesium (Mg), sodium, and some others (Harahap 2021). The concentration of liquid organic fertilizer in coconut husks has a real influence on the fresh weight of the potato kleci plant. The fresh weight is a representation of the collection of photosynthesis and water content in plants (Suripto et al. 2018). And on the egg shell, as much as 97% of calcium is contained in chicken egg shells. This high calcium levels is known as an excellent calcium carbonate compound as a raw material for making POCs and can raise the pH of soil and water media (Suhastyo and Raditya 2021).

Giving fertilizer to plants in a dose that corresponds to their needs is important because each plant has a different need for a different element. Too much or too little fertilizer will cause a decrease in the output of the plant itself. According to (Khotimah et al. 2020) Treatment P4 (300 ml of liquid organic fertilizer) may have administered an unbalanced or excessive dose of fertilizer to the plant, resulting in a significant decrease in the growth of collard saws. So the dose of fertilizer given must be appropriate so that the production of plants can be maximized. According to (Eka et al. 2018) from the treatment of liquid organic fertilizer by dividing the dose and time intervals showed results on average that the grain plant with the highest levels of calcium was found in the treatment P3W1 (liquid organic fertilizer with a dose of 13 ml and a time interval of 5 days) with a calcium level of 2.54 mg/g. The dose of 13 ml of liquid fertilizer gave tangible results on the collard plant, as seen from the test results of the increased calcium levels. The organic elements in liquid organic fertilizer will help soil absorb water and sunlight, making it more fertile. The aim of this study was to find out the effectiveness of the administration of liquid organic fertilizer from coconut husk and egg shells on the growth and increased calcium levels of kale plants (*Brassica oleracea var. achepala*).

2. MATERIALS AND METHODS

2.1. Place and Time

The research was conducted at the Green house of Biology Education, Faculty of Teacher Training and Education, University Of Muhammadiyah Surakarta, on the Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Central Java, Indonesia. And at the BPSMB Surakarta. The research starts from January – April 2023

2.2. Material and Tools

The required materials are divided into two categories, Materials for liquid organic fertilizer production with various formulations (organic waste of Coconut husk, egg shells, water, granulated sugar, and EM4 as starter liquid organic fertilizer) and materials during planting in the field (two-week-old Kale seedlings, polybags, and liquid organic fertilizer according to treatment,

ruler, soil media, etc.) and in the greenhouse (shovel, bucket, sprayer, camera, etc.) are required. In addition, material for calcium testing (Spectrophotometers).

2.3. Experimental Design

This study used a completely randomized design (RAL) with 2 factors, namely the dose of liquid organic fertilizer and the time interval for applying fertilizer, with 3 replications. The factors are as follows:

Factor 1: Dosage of Liquid organic fertilizer coconut husk and egg shell
P1 = 100 ml of liquid organic fertilizer
P2 = 150 ml of liquid organic fertilizer
Factor 2: Time interval for the application of liquid organic fertilizer
W1 = 3 days once
W2 = 5 days once

2.3.1. Treatment plan

P / W	W_1	W_2
P_1	P_1W_1	P_1W_2
P_2	P_2W_1	P_2W_2

Treatment control P0W0 as compare for treatment plant

Description:
P0W0 (Control) = Only Water every days
P1W1 = 100 ml of liquid organic fertilizer + Once every 3 days
P2W1 = 150 ml of liquid organic fertilizer + Once every 3 days
P1W2 = 100 ml of liquid organic fertilizer + Once every 5 days
P2W2 = 150 ml of liquid organic fertilizer + Once every 5 days
From the treatment repeated 3 times repeatation, so it takes 15 (5 x 3) experimental plots.

2.4. Research implementation

2.4.1. Production of Coconut Husk and Egg Shell Liquid Organic Fertilizer

After getting all of the components and implements ready, the next step was to clean and cut up some of the organic waste products, such as coconut husk and egg shell., combined with 50 liters of well water, brown sugar, and EM4 solution, placed in a sealed container, stirred until smooth, and fermented for two weeks. The liquid organic fertilizer is filtered and placed in ready-to-use jerry cans before being applied to the land in accordance with the prescribed treatment.

2.4.2. Planting and Maintenance of Kale Plants

a) Planting and fertilization: Following the completion of the soil's preparation, the planting of the kale seedlings in the polybags can begin. Following the planting, the procedure is continued by the application of a liquid organic fertilizer made from

coconut husk and eggshell in accordance with the treatment. This application occurs once every three days and once every five days.

b) Kale plant maintenance: From planting to harvest, plants are watered once per day in the morning or evening during the arid season. The subsequent step is the mechanical removal of weeds. At the time of weeding, the insect is eliminated if an infestation is present. Virus-free seeds, proper sanitation, crop rotation, uprooting, tossing, or burning damaged plants in a distant site, removing and destroying eggs or caterpillars that attack plants, and other natural methods are used to control pests and illnesses. Other natural approaches include: crop rotation.

2.4.3. Calcium Test

Based on (Badan Standardisasi Nasional 1992) Calcium testing procedure by method CPC (O-Cresolphthalein-Complexone). Weigh 1 g of kale plants and put them in a porcelain or 100-ml Pyrex glass cup. Use a pipette to add 10 ml of a magnesium nitrate in ethanol solution blended with a mixer bar. Evaporate ethanol over the water taper, mix it once, heat it over the electric taper, and close the glass cup with the watch glass. Move the glass cup into a barrel at 2000 °C, gradually elevate it to 5000 °C for 2 hours, and blur all night at 450 – 5000 °C. Leave the glass on the asbestos. After cooling, add 1 ml of water and 2 ml of HNO3 p.a. and dry over the water bath if carbon residues remain. Reheat for 1 hour at 5000 °C. Repeat until white ashes appear. Add 5 ml of the HCl/HNO_3 solution to the ashes through the glass cup wall and heat over the water bath until the ashes dissolve. Impregnate a 100-ml volumetric flask with boiling water after quantitatively transferring the solution. Filter-paper: Whatman-540. Cooperating with Blanco. A spectrophotometer measures standard solutions, blank solution, and kale absorption. Create an absorption-concentration calibration curve. The calcium found in kale plants is calculated using the formula:

$$Calcium\ levels = \frac{C \times P \times V}{W}$$

Where: *Calcium levels* is calcium content (%), *C* is initial of ug metal/ml from the calibration curve, *P* is initial of dilution, *V* is initial volume of solvent (ml), and *W* is weight of kale sample (g).

2.5. Data Calculation and Analysis

The data obtained in the study will be analyzed using two-way ANOVA on a complete random design. (RAL). SPSS 20.0 is a computer program used for statistical analysis. It is used to analyze whether there is an interaction between fertilization factors using liquid organic fertilizer from coconut seals and egg shells with different fertilizer levels and nutrition delivery times.

3. RESULT AND DISCUSSION

Based on the research that has been carried out, the data obtained from the observation results of the sensory growth test of kale plants on the soil medium of polybag for 1 month with different fertilizer concentrations and time intervals have different results. The measurement parameters

used are plant height, number of leaves, wet weight, and calcium content. Observation data was obtained as follows:

Table 1. Average Data of Plant Growth

Treatment	Number of Leaves (Strands)	Plant Height (cm)	Plant Weight (g)	Calsium (Ca) Levels (%)
P0W0 (Control)	5,33**	4,67**	31,40**	0,076**
P1W1	8,67	8,67	37,70	0.123
P1W2	10,33	6,50	38,43	0.136
P2W1	12,33	11,33	44,50	0,139
P2W2	14,33*	13,33*	51,53*	0,141*

Description :
* Plant growth with the highest average value
** Plant growth with the lowest average value

3.1. Number of Leaves

Based on Table 2 that shows the results of the hypothesis test of the number of leaves using the ANOVA Two-Way technique. The value of significance of the influence of fertilizer concentration and the time interval of fertilizer administration on the amount of leaves is 0.701 compared with the level of significance of 0.05, so that the value sig 0.702>0.05.

Table 2. The hypothesis test of the number of leaves Tests of Between-Subjects Effects Dependent Variable: Response Y Number of Leaves

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Model	1703.667[a]	5	340.733	638.875	.000
Doses_P	44.083	1	44.083	82.656	.000
Time_W	10.083	1	10.083	18.906	.001
Doses_P * Time_W	.083	1	.083	.156	.701
Error	5.333	10	.533		
Total	1709.000	15			

a. R Squared = .997 (Adjusted R Squared = .995)

It can be understood that the concentration of fertilizer and the time interval of fertilizer donation do not interact, so it does not affect the growth of the number of leaves on kale plants. This is consistent with the results of the study (Khasanah et al. 2018) which show that the slow-release urea fertilizer of the composite matrix does not affect the growth and yield of caisim plants at ages 14, 21, and 28 hst, This suggests that the number of leaves is unaffected by the application of urea fertilizer or delayed release because the plant's roots have not yet absorbed the available nitrogen. One of the factors most likely to cause low leaf production output is uncontrollable environmental factors, such as long sun exposure and temperature at the research site. According to research results from (Cahyono 2016) N, Fe, and Mg are the most important constituents in the increase in leaf count. When cell division occurs at the end of the stem and the plant obtains

carbohydrates through photosynthesis, the number of leaf filaments can increase. The results of observing the average increase in the height of the kale that were treated with fertilizers and different watering intervals can be seen in the graph below:

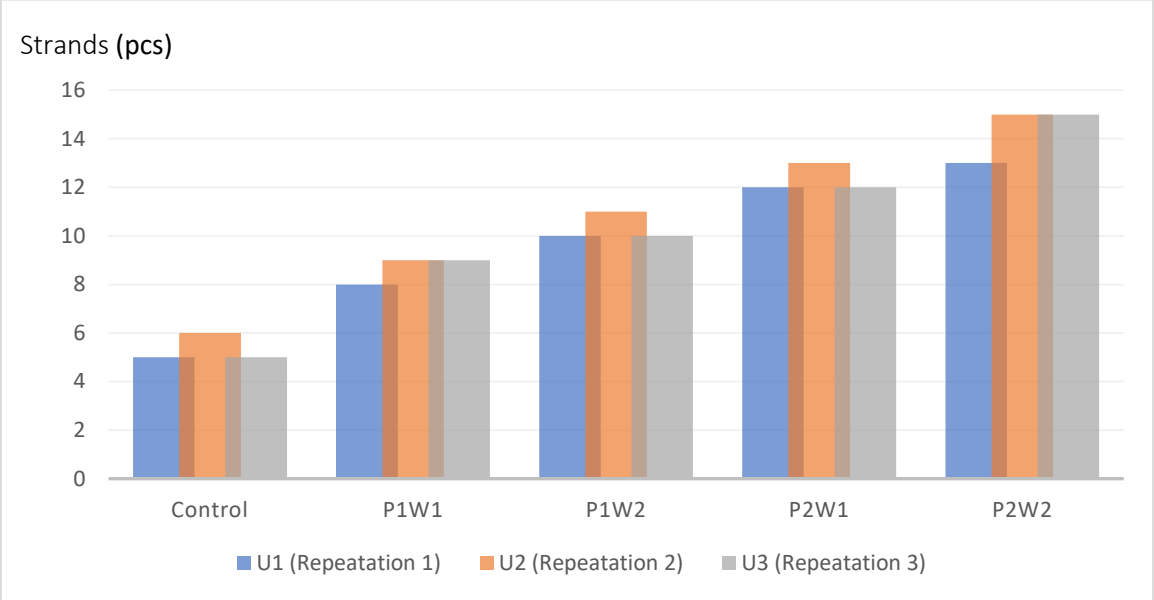


Fig. 1. The Number of Leaves

It can be understood that the higher the dose of fertilizer and the ideal time for fertilization can makes greater the number of kale leaves, On the measurement parameter of the number of leaves, the highest ratio value on the P2W2 behavior (Liquid organic fertilizer concentration of 150 ml with administration time of every 5 days) is 14 strands. While the ratio of the lowest number of leaves is on the control treatment, or P0W0 (without fertilizer concentration), which is only 4 strands. This is because the supply of liquid organic fertilizers from the combination of coconut husk and egg shell has not good enough to influence on the number of leaves of kale plants because the fertilizer contains low nitrogen which is one of the essential element of hares. According to the results of the study (Pramitasari et al. 2016) which stated that the dose of nitrogen fertilizer affected the leaf area and the number of leaves produced, it was shown that a treatment of 126.5 kilograms of nitrogen per ha-1 (N5) produced a larger leaf surface area than a treatment of 92 kilograms of nitrogen per ha-1 (N2). Thus, if the plant receives a sufficiently high amount of nitrogen fertilizer, the number of leaves produced will increase, resulting in a larger leaf area.

3.2. Plant Height

Plant height growth is one of the parameters that can be measured to determine the growth of mustard greens. Based on the results of Figure 2 shows the process of sensory testing the growth of kale plants on the high parameters of the kale using ruler, A high ratio of kale plant trunks treated with fertilizer doses and different time intervals shows the average high increase of the different kale plant stems.

Fig. 2. Measurement of Plant Height

Based on the results of In Table.2, the results of the test of the number of leaves using the ANOVA Two-Way technique indicate that the significance of the interaction of the influence of fertilizer concentration and the time interval of fertilizer administration on the height of the stem is 0.002 compared to the significance level of 0.05, so the sig value is 0.002<0.05.

Table 3. The hypothesis test of Plant Height Tests of Between-Subjects Effects Dependent Variable: Response Y Plant Height of Kale

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Model	1336.083[a]	5	267.217	372.860	.000
Doses_P	67.688	1	67.688	94.448	.000
Time_W	.021	1	.021	.029	.868
Doses_P * Time_W	13.021	1	13.021	18.169	.002
Error	7.167	10	.717		
Total	1343.250	15			

a. R Squared = .995 (Adjusted R Squared = .992)

The interaction between the factor providing fertilizer concentration and the time interval provides fertilizer has a significant effect on the stem height of kale plants. This is consistent with the research findings (Harjo 2021) that the use of various concentrations of liquid organic fertilizer on carrot plants has a noticeable effect on plant growth, with the highest dose of 0.75 liters of liquid organic fertilizer per 15 liters of water. The P2W2 treatment (liquid organic fertilizer dose of 150 ml and POC administration time of 5 days once) showed the best results, with an average high increase of 13.33 cm. Whereas the highest increase of plants is the lowest at the Control P0W0 treatment (only irrigated with water), the average value of the high increase is only 4.66 cm. This is due to the fact that P0W0 does not use fertilizer, so the growth of plants becomes slow. This can occur due to a lack of the necessary potassium-based element, so that photosynthesis produces fewer nutrients than plants with higher plant-based elements. (Anzila dan Asngad 2022) stated in the results of their research that the element potassium is very important for the growth of salmon crops. Potassium triggers high levels in Pak Choy plants and acts as an enzyme activator in metabolism. If potassium is lacking, the plant can become dwarfed. According to (Advinda 2018) the provision of hares in the vegetative phase with sufficient concentration can provide

optimal results for plant growth. In Figure 3, it can be seen that the graph of improvement on each treatment in its repeat has a different high increase of the rod.

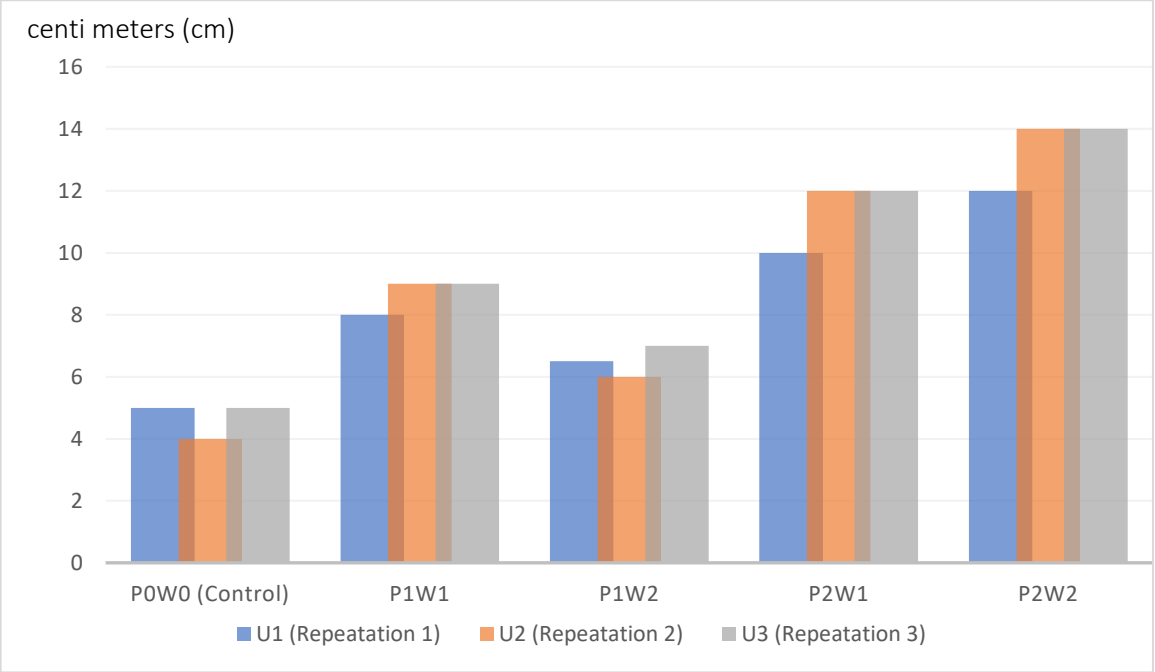


Fig. 3. Plant Height

It means that the best repeat results are on U3 in the treatment P2W2 and the lowest on U2 control. The high stems of kale plants with treatment P3W2 have the highest growth of the stem due to the nutrition obtained from the liquid fertilizer combination of coconut husk and egg shell as well as the ideal fertilization time. This indicates that the nutrient elements available in the soil meet the needs of plants to increase the height of the stems. Fertilizers containing the elements N, P, and K can maximize the growth of plants. Coconut sable contains other elements that are beneficial to plants, such as phosphorus (P), calcium (Ca), magnesium (Mg), Sodium (Na), and some others nutrient (Harahap 2021).

3.3. Plant Weight

Plant fresh weight is one of the parameters that can be measured to determine the growth of plants. The measurement of the wet weight of the plant is done at the end of the observation in the fourth week, that is, at the time of harvest. The results of the test of the number of leaves hypothesis using the ANOVA two-way technique are presented in Table. 4 These results are as follows: it is possible to determine that the value of significance of the influence of the concentration of fertilizer and the interval of time of fertilization on the height of the stem is 0.000 in comparison to the level of significance of 0.05, which means that the value sig is 0.000<0.05.

Table 4. The hypothesis test of Wet Weight Tests of Between-Subjects Effects Dependent Variable: Response Y Fresh Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	25560.917[a]	5	5112.183	15065.373	.000
Doses_P	297.007	1	297.007	875.268	.000
Time_W	45.241	1	45.241	133.323	.000
Doses_P * Time_W	29.767	1	29.767	87.723	.000
Error	3.393	10	.339		
Total	25564.310	15			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

It can be understood that there is an interaction between the administration of fertilizer doses and the time interval between fertilizer doses that has a real effect on the fresh weight of kale plants. The high K content in coconut husk liquid organic fertilizer can increase the plant's fresh weight by increasing the number of cells and decreasing transpiration. The difference in the resulting wet weight of kale plants can be seen in Figure 4, where the fresh weight of kale plants weighed using a digital balance shows a tangible difference in results.

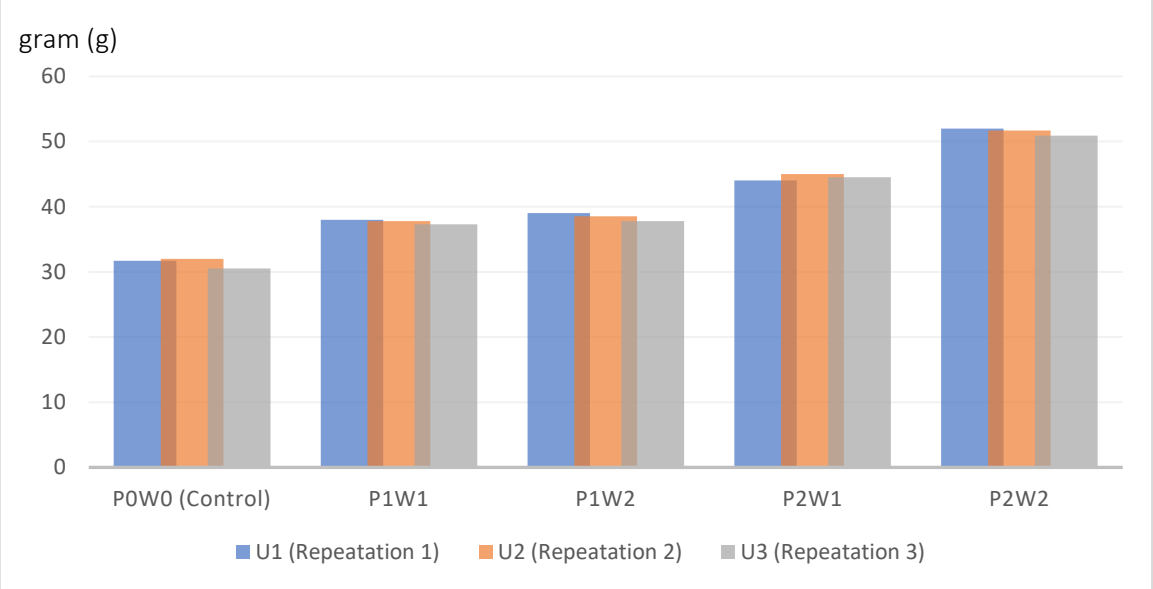


Fig. 5. Plant Weight

Based on Figure 5, it can be concluded that the U1, U2, and U3 graphs for each treatment in 3x repetitions almost form a parallel line, indicating that the average moist weight of plants treated with liquid organic fertilizer from coconut husk and eggshell has a stable defect value. This is due to the interaction between the fertilizer dose factor and the time interval of irrigation, which has a real effect on the fresh weight of kale. In this study, the data obtained the average value of the highest plant wet weight on the treatment of P2W2, with the average wet weight of the plant being 50.9 grams. Whereas the fresh weight value is the lowest on the P0W0 control treatment with an average fresh plant weight of 30.5 grams. Based on the average net weight column of kale plants in Table 1, treatment P2W2 produced the highest weight of kale plants after storage of 51.53 g,

while the lowest wet weight was produced from the control treatment of 31.4 g. This is due to the essential factor of fertilizer that increases the weight of plants, one of which is the calcium content in coconut husk and egg shell fertilizer, which has several functions to maintain the stability of cell walls and can increase the fresh weight of the plants. According to (Thor 2019) Calcium is an important factor for cell walls and membrane stability. When Ca supply is low or Ca transport is disrupted, local calcium deficiency occurs, which can lead to membrane damage or cell wall strengthening failure (Hocking et al. 2016).

3.4. Percentage of Calcium Levels

Calcium is especially needed for the human growth period from the time of infants and children to adults. The older a person is, the more calcium the body needs. Each person's calcium needs range between 400 and 1000 mg/day (Qurniani 2017). Calcium plays an important role in the formation of plant cell walls in humans, as well as the formation of bones, teeth, and other body structures (Noviyanti et al. 2017). Calcium levels testing in kale plants is carried out at the end of the observation after harvest, which is at week 4. In this study, the calcium content of kale plants was tested at BPSMB. The calcium testing was performed with a spectrophotometer with a wavelength of 422,7 n/m based on (Badan Standardisasi Nasional 1992).

In **Table.5** the results of the calcium level hypothesis test using the ANOVA Two-Way technique show that the significance value of the influence of fertilizer concentration and the time interval of fertilizer administration on calcium levels is 0.001, compared with the level of significance of 0.05, so that the value of sig 0.001<0.05.

Tabel.5 The hypothesis test of Calcium Levels Dependent Variable: Response Y Calcium Levels

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	.243[a]	5	.049	19200.684	.000
Doses_P	.000	1	.000	126.447	.000
Time_W	.000	1	.000	52.632	.000
Doses_P * Time_W	5.633E-005	1	5.633E-005	22.237	.001
Error	2.533E-005	10	2.533E-006		
Total	.243	15			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

It can be understood that there is an interaction between the doses of fertilizer doses and the time interval of fertilizer administration that has a real impact on the growth of kale plants. This is in line with research of (Eka et al. 2018) The calcium content of selada plants given liquid fertilizers from gerampadi waste and chicken egg shells has a calcium content on treatment P3W1 (fertilizer of 13 ml with a 5-day fertilizer time interval) of 2,54 mg/100 g. Giving kale plants organic fertilizer liquid made of coconut husk and eggshell can thereby increase the amount of calcium that the plants contain. In addition, the calcium content (Ca) in liquid organic fertilizers made from coconut husk and eggshell can help to reinforce the plant stems, stimulate the growth of new roots, and assist the overall development of plants. Result of each treatment shown in Figure 6 that calcium levels in kale plants at each repeatation U1, U2, and U3 increased, which

can be interpreted to mean that the higher the dose of fertilizer given and the ideal fertilization time, the higher the levels of calcium in kale.

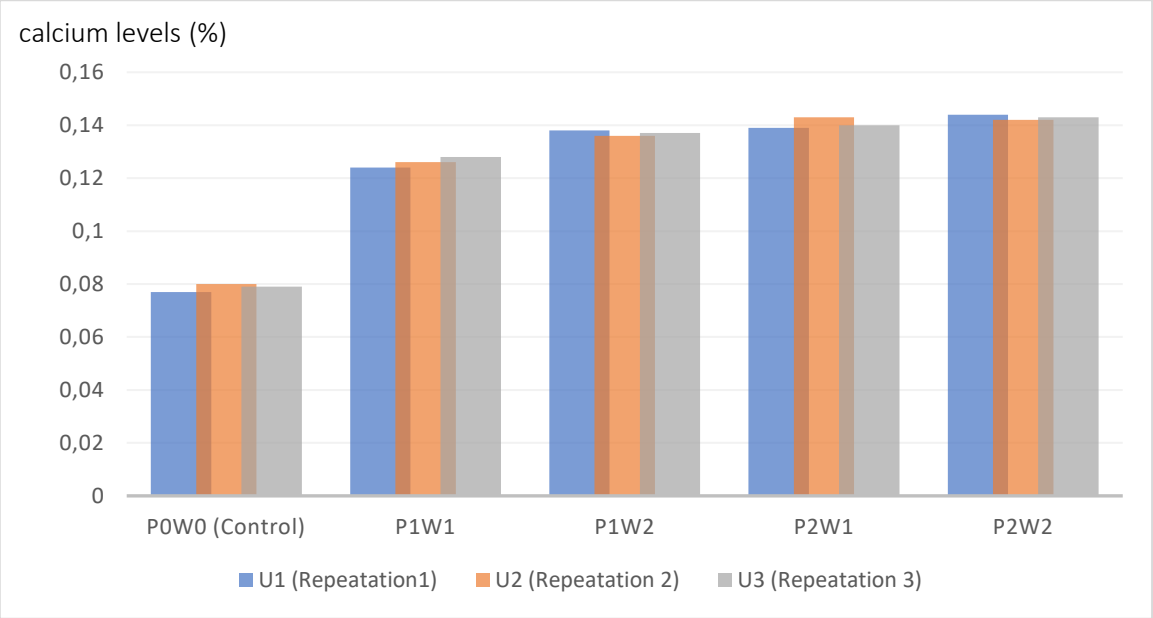


Fig. 6. Calcium (Ca) Levels

The ratio of calcium levels with the best results on treatment P2W2, which has a calcium level on 1 gram of kale of 0.141 % and the lowest calcium content on treatment P0W0 (control), which is on 1 gram of kale, is only 0.076 %. From the data, it can be understood that organic fertilizer, liquid coconut husk, and egg shells influence the increase in calcium levels. This is due to the presence of calcium content in coconut husk and egg shells. The dissolving Ca in the soil makes it easier for plants to absorb the elements, so it can affect the calcium contents found in kale plants. Coconut husk contains 53.83% macro and micro water, 0.28% sodium, 0.1% phosphorus, 6.726 ppm potassium, 140 ppm calcium, and 170 ppm magnesium, so coconut husk can be used as a material to make liquid organic fertilizer (Ramadhan et al. 2018). Chicken egg shells contain 97% calcium, which makes them an excellent calcium carbonate compound for making POCs and increasing the pH of soil and water media (Suhastyo dan Raditya 2021).

4. CONCLUSION

On the variables of plant height, leaf number, fresh weight per plant, and calcium content, there is a very substantial effect. On kale crop land, The most optimal combination of liquid organic fertilizer made from coconut husk and eggshell that produces the greatest growth and yields is a treatment of P2W2 with an average number of leaves of 14 strands, a growth height of 13.3 cm, a fresh weight of 51.5 g, and calcium levels of 0.141 %.The suggestion of the researchers is to carry out advanced research with the use of higher concentrations of fertilizer, conduct advanced studies with different irrigation time intervals, and conduct an advanced study of testing the contents of calcium levels on plant in liquid organic fertilizers combined with coconut husk and eggshells. Based on the aforementioned findings, it is prudent to conduct additional research on the how, when, and dosage of liquid organic fertilizer in various climatic conditions, locations, and commodities. Utilizing liquid organic fertilizer made from coconut husk and eggshell is recommended when preparing kale plant cultivation land and its environs.

5. ACKNOWLEDGMENTS

The author expressed gratitude to several parties, among them: 1) University of Muhammadiyah Surakarta, which has facilitated the research site; and 2) Balai Pengujian dan Sertifikasi Mutu Bahan (BPSMB) as a place to be able to perform calcium levels testing.

6. REFERENCES

Advinda, L. 2018. *Dasar-dasar fisiologi tumbuhan*. Deepublish, Yogyakarta.

Anzila, S. M., dan Asngad, A. 2022. Produktivitas Tanaman Sawi Pakcoy (Brassica rapa L .) Dengan Metode Hidroponik. *BIO-Lectura: Jurnal Pendidikan Biologi* 9(2): 168–178.

Badan Standardisasi Nasional. 1992. SNI 01-2891-1992 Uji Kalsium (Ca). Badan Standardisasi Nasional (BSN).

Cahyono, R. N. 2016. Pemanfaatan Daun Kelor Dan Bonggol Pisang Sebagai Pupuk Organik Cair Untuk Pertumbuhan Tanaman Bayam (Amaranthus sp.). *Karya Ilmiah* 5–6.

Eka, S., Wahyuni, T., dan Asngad, A. 2018. Pemberian Pupuk Organik Cair Limbah Jerami Padi Dan Limbah Cangkang Telur Ayam Untuk Meningkatkan Kandungan Kalsium Tanaman Sawi. *Seminar Nasional Pendidikan Biologi dan Saintek II* 2: 198–203.

Harahap, Q. H. 2021. Pengaruh Pemberian Pupuk Organik Cair dari Batang Pisang, Sabut Kelapa, Rebung Bambu Terhadap Produksi Tanaman Kacang Tanah (Arachis hypogaea L.). *Jurnal Agrohita* 6(2): 340–345.

Harjo, M. S. 2021. Pengaruh Pemberian Pupuk Organik Cair (Poc) Terhadap Pertumbuhan Dan Produksi Tanaman Wortel (Daucus carota L .) The Effect Of Liquid Organic Fertilizer (POC) On The Growth and Production Of Carrot (Daucus carota L . *Jurnal ArgotekMas* 64–69.

Hocking, B., Tyerman, S. D., Burton, R. A., dan Gilliham, M. 2016. Fruit Calcium : Transport and Physiology. *Frontiers in Plant Science* 7(April): 1–17. DOI: 10.3389/fpls.2016.00569

Irjayanti, A. D., Wibowo, A. S., Sumartini, N. P., Nurfalah, Z., Adani, A. D., Sijabat, M. S., Situmorang, R. N., Iman, Q., Damayanti, S. R., dan Putra, Y. R. 2021. *Statistik Holtikultura*. (R. Setiawati dan T. H. Marpaung, ed.) BPS-Statistics Indonesia.

Khasanah, A., Hajoeningtijas, O. D., Budi, G. P., dan Pamungkas, R. B. 2018. Uji Pupuk Urea Slow Release Matriks Komposit Pada Pertumbuhan Dan Hasil Tanaman Caisin (Brassica chinensis L.). *Pembangunan Pertanian Berkelanjutan dalam Perspektif Teknologi, Sosial, dan Ekonomi* 173–180.

Khotimah, K., Dahlianah, I., dan Novianti, D. 2020. Respons Pertumbuhan Tanaman Sawi Caisim (Brassica juncea L.) Terhadap Pupuk Organik Cair Buah Pepaya (Carica papaya L.). *Indobiosains* 2(2): 64. DOI: 10.31851/indobiosains.v2i4.4492

Noviyanti, A. R., Pandu, R., Eddy, D. R., Kimia, L., Kimia, D., Matematika, F., Padjadjaran, U., Raya, J., dan Jatinangor, B. K. 2017. Chimica et Natura Acta. *Chimica et Natura Acta* 5(3): 107–111. DOI: https://doi.org/10.24198/cna.v5.n3.16057

Pramitasari, H. E., Wardiyati, T., dan Nawawi, M. 2016. Pengaruh Dosis Pupuk Nitrogen dan Tingkat Kepadatan Tanaman Terhadap Pertumbuhan Dan Hasil Tanaman Kailan (Brassica oleraceae L.). *Jurnal Produksi Tanaman* 4(1): 49–56.

Qurniani, A. 2017. Pengaruh Variasi Dosis Pupuk Limbah Cair Nanas (LCN) terhadap Pertumbuhan dan Kadar Kalsium Bayam Merah (Althernanthera amoena Voss.) untuk Penyusunan Bahan Ajar Monograf Berbasis Saintifik Materi Pertumbuhan dan Perkembangan. *Jurnal Lentera Pendidikan Pusat Penelitian LPPM UM Metro* 2(1): 99–110.

Ramadhan, D., Rinia, M., dan Santoso, T. 2018. The Utilization of Cocopeat as Growing Media for Paraserianthes falcataria and Intsia palembanica. *Jurnal Sylva Lestari* 6(2). DOI: https://doi.org/10.23960/jsl2622-31

Suhastyo, A. A., dan Raditya, F. T. 2021. Pengaruh Pemberian Pupuk Cair Daun Kelor Dan Cangkang Telur Terhadap Pertumbuhan Sawi Samhong (Brassica juncea L.). *Jurnal Agrosains Dan TeknologI* 6(1): 1. DOI: 10.24853/jat.6.1.1-6

Suripto, W., Purwani, T., dan Nugroho, B. 2018. Pengaruh Konsentrasi Pupuk Organik Cair Sabut Kelapa terhadap Pertumbuhan dan Hasil Kentang Kleci. *Prosiding Seminar Nasional Fakultas Pertanian UNS* 2 (1)(1): 220–229.

Thor, K. 2019. Calcium — Nutrient and Messenger. *Frontiers in Plant Science* 10(April). DOI: 10.3389/fpls.2019.00440

Vaivada, T., Akseer, N., Akseer, S., Somaskandan, A., Stefopulos, M., dan Bhutta, Z. A. 2020. Stunting in childhood: An overview of global burden, trends, determinants, and drivers of decline. *American Journal of Clinical Nutrition* American Society for Nutrition. 112: 777S-791S. DOI: 10.1093/ajcn/nqaa159

Wibowo, H. K. A., dan Dasuki, M. S. 2020. Hubungan Asupan Kalsium dan Pendidikan Ibu dengan Kejadian Stunting. *Fakultas Kedokteran Universitas Muhammadiyah Surakarta* 146–154.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Phosphate Solubilisation Index and Antagonism Potential of Frangipani Tree Rhizosphere Bacterial Isolates from Cemetery

Vika Febriyanti, Erma Musbita Tyastuti, Yasir Sidiq, Triastuti Rahayu*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: tr124@ums.ac.id

KEYWORDS:
Cemeteries
Frangipani Tree
PGPR
Plant Growth Promoting Rhizobacteria
Rhizosfer Bacteria

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Frangipani trees (*Plumeria acuminata*) are commonly found in cemeteries. Cemeteries are used as a location for interment so that the corpse actively decomposes to provide soil minerals that encourage the formation of microbes, including bacteria. Bacteria around the roots of frangipani trees are thought to have potential as plant growth-promoting rhizobacteria (PGPR). Based on reference searches, there has been no research on frangipani tree rhizosphere bacteria from burial grounds. The aim of this study was to investigate the phosphate-dissolving and blast disease-causing *Pyricularia oryzae* fungus-inhibiting properties of frangipani tree rhizosphere bacteria from Pracimaloyo cemetery, Surakarta. A total of 39 isolates of frangipani tree rhizosphere bacteria were tested for their ability to dissolve phosphates using PKA media (Pikovskaya), while the antagonism test against the fungal pathogen *Pyricularia oryzae* used the dual assay method. The results of the study showed that 15% of the rhizosphere bacteria of the frangipani tree were able to dissolve phosphate, and 33% of the isolates were able to inhibit the growth of the fungus *Pyricularia oryzae* with an inhibitory power of more than 40%. Based on the results, the rhizosphere bacterial isolates from Pracimaloyo TPU show the characteristics of a possible PGPR.

1. INTRODUCTION

The frangipani tree, which has the Latin name *Plumeria acuminata*, is included in the gummy plant and grows at an altitude of 1–1000 meters above sea level. This plant comes from South America and is spread throughout Indonesia (Yuliani et al. 2021) where it is commonly found in public burial places (TPU) (Bihani et al. 2021). The presence of trees in the cemetery area is beneficial to the environment. The presence of frangipani trees in the cemetery area that have sweet-smelling flowers can make the atmosphere more sacred (Zain et al. 2020). Its habitus, in the form of a large tree, can also be used as a protector and shade so as to create a beautiful atmosphere. Plant roots secrete root exudate that can affect the activity of surrounding microorganisms (Prayudyaningsih et al. 2015). In addition, root exudates such as sugars, amino acids, organic acids, phenolic compounds, enzymes, phytohormones, and vitamins can attract some rhizosphere bacteria, and others microorganisms (Olanrewaju et al. 2019).

Rhizosphere bacteria are bacteria found around plant roots. Its existence around the roots is one form of specific interaction between plants and microorganisms (Yang et al. 2017) so the type of rhizosphere bacteria will be different for other types of plants. Rhizosphere bacteria are referred to as PGPR (Plant Growth Promoting Rhizobacteria) because they can trigger plant growth by producing growth hormones, dissolving phosphates, producing siderophores to chelate Fe, and being biocontrol agents against plant pathogens (Nuraini et al. 2020; Pathania et al. 2020). Soil moisture and the state of plant roots affect the bacterial population of the rhizosphere. High

bacterial populations indicate that energy requirements, temperature suitability, and water availability are sufficient for bacteria to grow (Kadeawi et al. 2020).

In previous studies, a population of frangipani tree rhizosphere bacteria from TPU Pracimaloyo was calculated, and it was detected that the population was abundant, ranging from 1.9–10.4 x 106 CFU/g. These rhizosphere bacteria isolates are known to act as biostimulants because they are able to produce IAA growth hormone up to 113.58 ppm (Putra et al, 2023), whereas rhizosphere bacteria isolates from other plants, such as rice plants, only range from 64.03–84.12 ppm (Prihatiningsih et al. 2019). Therefore, it is necessary to characterize its capabilities as another PGPR. In this study, the character to be tested is its ability to dissolve phosphate, determined through the phosphate solubilization index, and its potential antagonism to pathogenic fungi.

Isolates that are able to dissolve phosphate can be applied as biofertilizer because most of the phosphate present in the soil is present in the form of bound metal elements. The presence of rhizosphere bacteria can help break the bond between phosphate and metal elements so that they can be used by plants (Pratika et al. 2020). Physiological status and bacterial growth as well as soil nutrient diversity are influences for rhizosphere bacteria in dissolving phosphates (Alori et al. 2017). Phosphate itself has an important role for plants, especially in the metabolic process, namely at the time of photosynthesis (Sharma et al. 2013).

The ability of rhizosphere bacteria to inhibit the growth of plant pathogenic fungi is actually a supporting character of plant growth indirectly by forming biocontrol agents (Ahemad and Kibret 2014). This ability can be used as a biopesticide (Walida et al. 2019) because some strains of rhizosphere bacteria are effective in inhibiting the growth of pathogenic fungi (Kadeawi et al. 2020). One of the pathogenic fungi is *Pyricularia oryzae*, which causes blast disease in rice plants. This disease causes rhomboid-shaped spots with tapered tips on the leaves, and in the middle of the spots are gray spots with brown surroundings (Kadeawi et al. 2020). Based on data obtained from the Central Statistics Agency (BPS 2020) in 2018–2019, there was a decrease of 7.76 % in national rice production. Then in 2020, the area of harvested land decreased by 6.15 % compared to 2018. As a result of this disease, farmers lose their crops by around 50 – 90 % (Kadeawi et al. 2020).

This study aims to test the ability of frangipani tree rhizosphere bacteria from Pracimaloyo Cemeteries, Surakarta, to dissolve phosphate and inhibit the growth of the Pyricularia oryzae fungus that causes blast disease in rice plants. Data from this study will complement the character of Cambodian tree rhizosphere bacteria isolated as PGPR, so that its application to plants will be more appropriate.

2. MATERIALS AND METHODS

2.1. Materials

The tools used in this study were Erlenmeyer 125 ml and 500 ml (Iwaki), test tubes (Iwaki), test tube racks, 100 ml measuring cups (Iwaki), beakers, petri dishes, analytical balances (Durascale DAB-E223), spatulas, micropipettes (Socorex 10-100), yellow tips, deck glass, object glass, scissors, plastic, cotton buds, aluminum foil, magnetic hot plate (Ciramex +), oven (Maspion), incubator (Memmert), autoclave (GEA LS-35LJ), laminar air flow (LAF), microscope (Olympix CX2 Binocular), spirtus burner, lighter, spray bottle (sprayer), refrigerator (Sharp), jar glass, ose, latex gloves, stationery, and documentation tools.

The materials needed in this study are 39 isolates of frangipani tree rhizosphere bacteria from TPU Pracimaloyo, which is a collection of the Biological Laboratory of FKIP Universitas Muhammadiyah Surakarta, nutrient agar (Merck), nutrient broth (NB) media, Pikovskaya media (PKA), bacterialogical agar (Himedia), potato dextrose agar (PDA) media, 70% alcohol, aquades, tissue, cotton, and paper.

2.2. Methods

2.2.1. Rejuvenation of Bacterial Isolate

Rejuvenation is carried out by isolating rhizosphere bacteria subcultured using ose to oblique nutrient agar media (NA) in test tubes to be grown by incubating at 37 °C for 48 hours.

2.2.2. Phospate Dissolving Ability Test

This study was conducted in the Biological Laboratory of FKIP Universitas Muhammadiyah Surakarta. To determine the solubility of phosphate tested using solid Pikovskaya media (PKA) with a composition of ingredients per 1 liter of media used, namely glucose 10 g; $(NH_4)_2SO_4$ 0.5 g ; NaCl 0.2 g ; $MgSO_4.7H_2O$ 0.1 g ; KCl 0.2 g ; $MnSO_4.H_2O$ 0.002 g ; $FeSO_4.7H_2O$ 0.002 g ; yeast extract 0.5 g ; and bacteriological agar 20 g, follows the procedure (Rahayu 2022). PKA (Pikovskaya) media is made into a hole with a diameter of 6 mm using a cork borer, and then 10µL suspension of rizosphere bacteria that has been shaken for 24 hours on NB media is inserted into the hole. Then incubated for 72 hours at room temperature. Measure the clear zone (halo) as well as the diameter of the bacterial colony and calculate the phosphate solubility index (PSI) using the following formula (Sharon et al. 2016):

$$\text{PSI} = \frac{CD + HZ}{CD}$$

where *PSI* is the phosphate solubility index, *CD* is the colony diameter, and *HZ* is the halo zone.

2.2.3. Antagonism Test

This study was conducted in the Biological Laboratory of FKIP Universitas Muhammadiyah Surakarta. To see the ability of rhizosphere bacteria to inhibit pathogenic fungi, *Pyricularia oryzae* was tested using solid potato dextrose agar (PDA) media to make pure cultures. Then the fungi culture is inoculated into NA media by the agar block method using cork punches and incubated for 3 days at room temperature. Cultures of frangipani tree rhizosphere bacteria were etched on NA media containing *Pyricularia oryzae* colonies at a distance of 2-3 cm and reincubated for 4 days at room temperature. Measuring the inhibitory power of frangipani tree rhizosphere bacteria against *Pyricularia oryzae* fungi using the formula (Ningsih et al. 2016):

$$\text{IP} = \frac{(r1 - r2)}{r1} \times 100$$

where *IP* is the inhibitory power (%), *r1* is the radius of the fungal colony away from the bacteria, and *r2* is the maximum radius of the fungus.

3. RESULTS AND DISCUSSION

The test results of the ability of frangipani tree rhizosphere bacteria isolates to dissolve phosphate and their antagonism against *Pyricularia oryzae* are fully presented in (**Table 1**).

Table 1. Results of phosphate dissolving test and antagonism test

Isolate Code	Antagonism towards *P.oryzae* (%)		Phosphate Dissolving	
	Day 2	Day 4	Ability	PSI for 72 hours
P1	24,1	40.5	+	4.4
P2	37.9	51.4	+	5.3
P3	31.0	48.6	+	3.8
P4	27.5	45.9	+	5.6
P5	27.5	40.5	-	-
P6	31.0	40.5	-	-
P7	34.4	37.8	-	-
P8	37.9	35.1	-	-
P9	37.9	37.8	-	-
P10	31.0	39.2	-	-
P11	27.5	41.9	-	-
P12	20.6	32.4	-	-
P14	27.5	37.8	-	-
P15	24.1	35.1	-	-
P16	24.1	37.8	-	-
P17	27.5	39.2	-	-
P18	25.8	35.1	-	-
P19	31.0	37.8	-	-
P20	27.5	43.2	-	-
P21	31.0	40.5	-	-
P24	34.4	39.2	-	-
P25	27.5	37.8	-	-
P26	24.1	37.8	-	-
P27	31.0	41.9	-	-
P28	29.3	40.5	-	-
P29	17.2	32.4	-	-
P31	24.1	37.8	-	-
P32	27.5	40.5	-	-
P33	24.1	37.8	-	-
P34	22.4	32.4	-	-
P35	25.8	29.7	-	-
P36	20.6	32.4	-	-
P37	24.1	28.3	-	-
P38	25.8	40.5	+	4.5
P39	20.6	35.1	-	-
P40	24.1	39.2	-	-
P41	25.8	37.8	+	3.5
P42	24.1	35.1	-	-
P43	20.6	32.4	-	-

Note :
(-) does not have the ability to dissolve phosphates and (+) has the ability to dissolve phosphates.

3.1. Phosphate dissolving ability

Based on the results shown in Table 1, it can be known that 6 out of 39 isolates of rhizosphere bacteria from frangipani trees (15 %) have the ability to dissolve phosphate. This can be seen from the formation of a halo zone (clear zone) on a petri dish containing Pikovskaya media that has

been suspended from rhizosphere bacterial isolates. The clear zone formed is only used as an early indication that bacteria can dissolve phosphate or not, not showing how much phosphate is dissolved by bacteria (Silaen 2015). Of the 6 isolates, the phosphate solubility index (PSI) was highest at P4 with a value of 5.6, while the phosphate solubility index (PSI) was lowest at P41 with a value of 3.5. The difference in the solubility index value of phosphate in each isolate occurs due to the ability of genetically varying bacteria. Bacteria produce organic acids and phosphatase enzymes needed for phosphate dissolution (Sembiring et al. 2020). Phosphatase enzymes themselves are a group of enzymes that catalyze hydrolytic mineral reactions by releasing insoluble phosphates into enzymatic solutes (Ranjan et al. 2013).

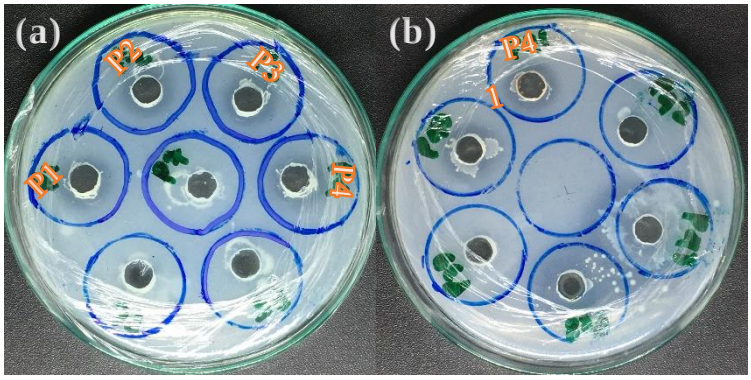


Figure 1. Test results for phosphate dissolving ability (a) The highest phosphate solubility index at P4 is 5.6; (b) The lowest phosphate solubility index at P41 is 3.5.

The Solubility Index (IKF) value of rhizosphere bacteria of frangipani trees at Pracimaloyo Cemeteries is higher than rhizosphere bacteria from rubber plantations (Wulandari et al. 2020), bamboo plants (Lengkong et al. 2022) and acacia plants (Rini et al. 2020) each ranging from 1.0 to 1.62, 1,0 to 1,29, and 0.1 to 1.1 cm. These results prove that in the rhizosphere area of TPU, which is known as the place where the decomposition of bodies rich in nutrients occurs, it can help bacteria dissolve phosphate. Burial soils that are thousands of years old have high calcium and phosphorus content due to bone decomposition processes in the soil, which are a source of metal elements for plants (Asare et al. 2020). This is in accordance with research (Żychowski 2021) which suggests that the soil used as a burial place during World War II was dominated by phosphorus, which is a transitional stage of bone decomposition. Soil composition, such as soil pH, can affect bacteria's ability to dissolve phosphates. Phosphate-solvent bacteria tend to be more effective at neutral soil pH. The activity of phosphate solvent bacteria in the mineralization of organic matter and nitrification will be disrupted in soils that are too acidic (Marista et al. 2013). Phosphate solvent bacteria have thermophilic properties that can withstand hot temperatures in a certain range, so enzymes and organic acids produced by bacteria to dissolve phosphate are not easily damaged (Respati et al. 2017).

3.2. Antagonism towards Pyricularia oryzae

Table 1 shows that all isolates of rhizosphere bacteria can inhibit the growth of the pathogenic fungus *Pyricularia oryzae* with different inhibitory powers. On day 2, the observations that had the highest resistance were P2, P8, and P9 with 37.9 %, and the lowest resistance was P29 with 17.2 %. Then on the 4th day, the observation that had the highest

inhibitory power was P2 with 51.6 %, and the lowest inhibitory power was P35 with 29.7%. The percentage of inhibitory power produced by rhizosphere bacteria from frangipani trees at Pracimaloyo Cemeteries is higher than that produced by rhizosphere bacteria from rice plants in Bali (Quintao et al. 2015) and rhizosphere bacteria from oil palm plants (Widiantini et al. 2018) which each have a percentage of inhibition ranging from 39.47 – 46.67 % and 7.67 – 22.89 %, respectively. According to (Pitasari and Ali 2018) this difference in inhibition occurs because each isolate releases different types and amounts of secondary metabolites to inhibit the growth of pathogenic fungi. Physiological differences in bacteria in the use of nutrients from the media are also the cause of differences in inhibitory power (Saputra et al. 2015) because some bacteria use nutrients to support growth and some use them to produce secondary metabolite compounds (Flori et al. 2020).

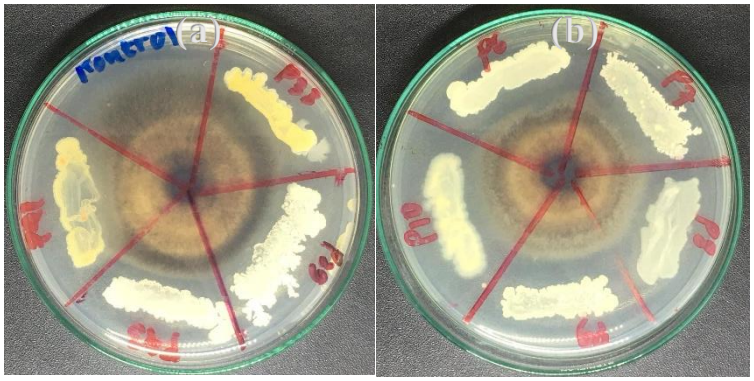


Figure 2. Antagonism Test Results (a) Control treatment; (b) P6 rhizosphere bacterial isolate with 40.5% inhibitory power

In fact, PGPR bacteria have the ability to secrete secondary metabolite compounds when facing pathogens. This is in accordance with the statement (‘Aini et al. 2013) that the antifungal effect of metabolite compounds can be produced by bacteria that have a role as biological agents. According to (Widiantini et al. 2018) compounds released by antagonistic bacteria are able to inhibit the growth of pathogenic fungi by causing swelling and shortening of hyphae. The mechanism of antibiosis that causes changes in hyphal structure can also occur due to antagonistic activity (Ainy et al. 2015).

Inhibition of bacterial isolates in antagonism tests against pathogenic fungi can also occur because bacterial isolates are able to secrete chitinase enzymes. It is known that the chitinase enzyme can degrade cell walls in several types of fungi (Banna and Hartati 2017). This statement is in accordance with what was stated by (Gómez-Godínez et al. 2023) that some enzymes produced by rhizosphere bacteria, such as the chitinase enzyme, can destroy pathogenic cell walls. In addition, rhizosphere bacteria can also produce antimicrobial peptides that control infection through induced systemic resistance (ISR). Other mechanisms used by rhizosphere bacteria to protect themselves from pathogenic fungi are competing for nutrients, producing antibiotics (Wang et al. 2021) and colonizing root surfaces to prevent pathogenic fungi (Ali et al. 2022).

4. CONCLUSION

As many as 15% of frangipani tree rhizosphere bacteria isolates from Pracimaloyo Cemeteries have the character of potential PGPR, which is able to dissolve phosphate, and as many

as 33 % of rhizosphere isolates are able to inhibit the growth of *Pyricularia oryzae* fungi, which cause blast disease in rice plants, with inhibitory power above 40 %. From this study, it can be concluded that the isolates of frangipani tree rhizosphere bacteria from Pracimaloyo Cemeteries have the characteristics of potential PGPR. The study obtained a potential bacterial isolate as PGPR, but the identity of the species is not known, so further testing is needed to identify species of rhizospheric bacteria from the frangipani trees present in the cemetery and need to conduct direct experiments on plants to prove that the bacteria isolate can help the growth of plants.

5. ACKNOWLEDGMENTS

The author would like to thank several parties, including: 1) the Universitas Muhammadiyah Surakarta, which has provided research funds for the Study Program Excellence Research Scheme (PUPS) number: 110.30/A.3-III/LRI/VI/2022; and 2) the Head of the Surakarta City Housing Office, who has given permission to take soil samples at Pracimaloyo Cemeteries.

6. REFERENCES

Aini, F. N., Sri-Sukamto, Wahyuni, D., Suhesti, R. G., and Ayunin, dan Q. 2013. Penghambatan Pertumbuhan *Colletotrichum gloeosporioides* oleh *Trichoderma harzianum*, *Trichoderma koningii*, *Bacillus subtilis* dan *Pseudomonas fluorescens* (Growth Inhibition of *Colletotrichum gloeosporioides* by *Trichoderma harzianum*, *Trichoderma koningii*, *Bacillus subtilis* and *Pseudomonas fluorescens*). *Pelita Perkebunan* 29(1): 44–52.

Ahemad, M., and Kibret, M. 2014. Mechanisms and applications of plant growth promoting rhizobacteria : Current perspective. *Journal of King Saud University - Science* King Saud University 26(1): 1–20. DOI: 10.1016/j.jksus.2013.05.001

Ainy, E. Q., Ratnayani, R., and Susilawati, L. 2015. Uji Aktivitas Antagonis *Trichoderma Harzianum* 11035 Terhadap *Colletotrichum capsici* TCKR2 dan *Colletotrichum acutatum* TCK1 Penyebab Antraknosa pada Tanaman Cabai (Activity Test of *Trichoderma Harzianum* 11035 Antagonist Against *Colletotrichum capsici* TCKR2 and *Colletotrichum acutatum* TCK1 Causes of Anthracnose in Chili Plants). *Prosiding seminar nasional XII pendidikan biologi FKIP UNS. Surakarta, 8 Agustus 2017*. 892–897.

Ali, A., Iftikhar, Y., Mubeen, M., Ali, H., Zeshan, M. A., Asad, Z., Zafar-ul-Hye, M., Abdul, M., Rehman, Abbas, M., Rafique, M., and Ghani, M. U. 2022. Antagonistic Potential of Bacterial Species against Fungal Plant Pathogens (FPP) and Their Role in Plant Growth Promotion (PGP): A Review. *Phyton-International Journal of Experimental Botany* 91(9): 1859–1877.

Alori, E., Glick, B., and Olubukola, O. 2017. Microbial phosphorus solubilization and its potential for use in sustainable agriculture. *Frontier Microbiology* 2 (8): 971.

Asare, M. O., Šmejda, L., Horák, J., Holodňák, P., Černý, M., Pavlů, V., and Hejcman, M. 2020. Human burials can affect soil elemental composition for millennia—analysis of necrosols from the Corded Ware Culture graveyard in the Czech Republic. *Archaeological and Anthropological Sciences* 12(11). DOI: 10.1007/s12520-020-01211-1

Banna, M. Z. Al, and Hartati. 2017. Isolasi dan Uji Antagonistik Bakteri Endofit dan Rizosfer Bambu Asal Tana Toraja Terhadap Jamur Patogen Tanaman (Isolation and Antagonistic Tests of Bamboo Endophytic and Rhizospheric Bacteria from Tana Toraja Against Plant Pathogenic Fungi). *Jurnal Dinamika* 8(2): 20–30.

Bihani, T., Tandel, P., and Wadekar, J. 2021. Plumeria obtusa L.: A systematic review of its traditional uses, morphology, phytochemistry and pharmacology. *Phytomedicine Plus* Elsevier B.V. 1(2): 100052. DOI: 10.1016/j.phyplu.2021.100052

BPS. 2020. *Luas Panen dan Produksi Padi di Indonesia 2019 (Harvested Area and Rice Production in Indonesia 2019)*. Badan Pusat Statistik, Jakarta.

Flori, F., Mukarlina, and Rahmawati. 2020. Potensi Antagonis Isolat Bakteri *Bacillus* spp. Asal Rizosfer Tanaman Lada (*Piper nigrum* L.) Sebagai Agen Pengendali Jamur *Fusarium* sp.JDF (Potential Antagonist of Bacterial Isolate Bacillus spp. Origin of the Rhizospheric Plant of Pepper (*Piper nigrum* L.) As a Controlling Agent for the Fungus *Fusarium* sp.JDF). *Bioma : Jurnal Biologi Makassar* 5(1): 111–120.

Gómez-Godínez, L. J., Aguirre-Noyola, J. L., Martínez-Romero, E., Arteaga-Garibay, R. I., Ireta-Moreno, J., and Ruvalcaba-Gómez, J. M. 2023. A Look at Plant-Growth-Promoting Bacteria. *Plants* 12(8). DOI: 10.3390/plants12081668

Kadeawi, S., Non, S., Nasution, A., Hairmansis, A., Obara, M., N.Hayashi, and Fukuta, Y. 2020. Pathogenicity of isolates of the rice blast pathogen (*Pyricularia oryzae*) from Indonesia. *Plant Disease* 105(3): 1–38.

Lengkong, S. C., Siahaan, P., and Tangapo, A. M. 2022. Analisis Karakteristik dan Uji Bioaktivitas Bakteri Rizosfer PGPR (Plant Growth Promoting Rhizobacteria) Isolat Kalasey (Characteristics Analysis and Bioactivity Test of PGPR (Plant Growth Promoting Rhizobacteria) Bacteria of Kalasey Isolate). *Jurnal Bios Logos* 12(2): 104–113.

Marista, E., Khotimah, S., and Linda, R. 2013. Bakteri Pelarut Fosfat Hasil Isolasi dari Tiga Jenis Tanah Rizosfer Tanaman Pisang Nipah (*Musa paradisiaca* var . nipah) di Kota Singkawang (Phosphate Solubilizing Bacteria Result of Isolation from Three Types of Rhizospheric Soil Nipah Banana Plant (*Musa paradisiaca* var. nipah) in Singkawang City). *Protobiont* 2(2): 93–101.

Ningsih, H., Hastuti, U. ., and Listyorini, D. 2016. Kajian Antagonis Trichoderma spp. terhadap Fusarium solani Penyebab Penyakit Layu Pada Daun Cabai Rawit (*Capsicum frutescens*) Secara in Vitro (*Trichoderma spp.* Antagonist Study against *Fusarium solani* Cause of Wilting Disease in Cayenne Pepper *(Capsicum frutescens)* Leaves in Vitro. in: *Proceeding Biology Education Conference* 814–817.

Nuraini, C., Saida, Suryanti, and Nontji, M. 2020. Isolasi dan Identifikasi Bakteri Rhizosfer Tanaman Jagung pada Fase Vegetatif dan Generatif (Isolation and Identification of Corn Rhizosphere Bacteria in the Vegetative and Generative Phases). *Jurnal Agrotekmas* 1(1): 24–30.

Olanrewaju, O. S., Ayangbenro, A. S., Glick, B. R., and Babalola, O. O. 2019. Plant health: feedback effect of root exudates-rhizobiome interactions. *Applied Microbiology and Biotechnology* Applied Microbiology and Biotechnology 103(3): 1155–1166. DOI: 10.1007/s00253-018-9556-6

Pathania, P., Rajta, A., Singh, P. C., and Bhatia, R. 2020. Role of plant growth-promoting bacteria in sustainable agriculture. *Biocatalysis and Agricultural Biotechnology* Elsevier Ltd 101842. DOI: 10.1016/j.bcab.2020.101842

Pitasari, A., and Ali, M. 2018. Isolasi dan Uji Antagonis Bakteri Endofit dari Tanaman Bawang Merah (*Alllium ascalonicum* L.) terhadap Jamur *Alternaria porri* Ellis Cif (Isolation and Antagonistic Test of Endophytic Bacteria from Shallot Plants (*Alllium ascalonicum* L.) against *Alternaria porri* Ellis Cif Fungus) . *JOM Faperta* 5(1): 1–12.

Pratika, E. D., Alfariza, A., Abib, F., and Sriwulan, S. 2020. Pembibitan Kentang Hitam (*Solanum rotundifolius*) dengan Pemberian PGPR Indigen (Black Potato Nursery (*Solanum rotundifolius*) with Indigen PGPR). *Agrovigor: Jurnal Agroekoteknologi* 13(1): 29–32.

Prayudyaningsih, R., Nursyamsi, and Sari, R. 2015. Mikroorganisme tanah bermanfaat pada rhizosfer tanaman umbi di bawah tegakan hutan rakyat Sulawesi Selatan (Beneficial soil microorganisms in root crop rhizosphere under South Sulawesi community forest stands). *Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia* 1(4): 954–959. DOI: 10.13057/psnmbi/m010453

Prihatiningsih, N., Djatmiko, H. A., and Lestari, P. 2019. Bakteri Rizosfer Padi Sebagai Agens Hayati *Xanthomonas oryzae* pv. oryzae dan Pengaruhnya Terhadap Perkecambahan Benih Padi (Rice Rhizospheric Bacteria As Biological Agents *Xanthomonas oryzae* pv. oryzae and Its Effect on Rice Seed Germination). in: *Prosiding Seminar Nasional LPPM Unsoed* 13–21.

Quintao, V., Ngurah Suprapta, D., Gede Rai Maya Temaja, I., and Khalimi, K. 2015. Potensi Rizobakteri Yang Diisolasi Dari Rizosfer Tanaman Padi Sebagai Agen Hayati Untuk Menghambat Pertumbuhan Jamur *Pyricularia oryzae*, Penyebab Penyakit Blas Pada Tanaman Padi (Rhizobakteri Isolated From Rice Rhizospheric Potential As Biological Agents to Inhibit *Pyricularia oryzae* Fungus Growth, Causing Blast Disease In Rice Plants). *J. Agric. Sci. and Biotechnol* 4(1): 23020–113.

Rahayu, T. 2022. Komunitas Bakteri Endofitik Kultivar Pisang Kluthuk dan Ambon Serta Potensi Pemanfaatannya (Endophytic Bacterial Communities of Kluthuk and Ambon Banana Cultivars and Their Potential Utilization). Universitas Gadjah Mada Yogyakarta.

Ranjan, A., Mahalakshmi, M. R., and Sridevi, M. 2013. Isolation and Characterization of Phosphate-Solubilizing Bacterial Species from Different Crop Fields of Salem, Tamil Nadu, India. *International Journal Of Nutrition, Pharmacology, Neurological Disease* 3 (1): 29–33.

Respati, N. Y., Yulianti, E., and Rakhmawati, A. 2017. Optimasi Suhu dan pH Media Pertumbuhan Bakteri Pelarut Fosfat Dari Isolat Bakteri Termofilik (Optimization of Temperature and pH of Phosphate Solubilizing Bacteria Growth Media From Thermophilic Bacteria Isolates). *Jurnal Prodi Biologi* 6(7): 423.

Rini, I. A., Oktaviani, I., Asril, M., Agustin, R., and Frima, F. K. 2020. Isolasi dan Karakteristik Bakteri Penghasil IAA (Indole Acetic Acid) Dari Rhizosfer Tanaman Akasia (*Acacia mangium*) (Isolation and Characteristics of IAA (Indole Acetic Acid) Producing Bacteria from the Rhizosphere of Acacia Plants (*Acacia mangium*)). *Agro Bali: Agricultural Journal* 3(2): 210–219. DOI: 10.37637/ab.v3i2.619

Saputra, R., Arwiyanto, T., and Wibowo, A. 2015. Uji aktivitas Antagonistik Beberapa Isolat *Bacillus* spp. terhadap Penyakit Layu Bakteri (*Ralstonia solanacearum*) pada Beberapa Varietas Tomat dan Identifikasinya (Antagonistic activity test of Several *Bacillus* spp. Isolates. on Bacterial Wilt Disease (*Ralstonia solanacearum*) on Several Tomato Varieties and Identification. in: *Prosiding Sem Nas Masy Biodiv Indon* 1116–1122.

Sembiring, M., Ramadhan, I., and Purba, T. 2020. Isolation and Potentional Test OF Phosphate Solubilizing Bacteria. *Jurnal Budidaya Perkebunan Kelapa Sawit dan Karet* 4(1).

Sharma, S. B., R.Z, S., M.H, T., and T.A, G. 2013. Phosphate solubilizing microbes: sustainable approach for managing phosphorus deficiency in agicultural soils. *Springer Plus* 2(587): 1–14.

Sharon, J., Hathwaik, L., Glenn, G., Imam, S., and Lee, C. 2016. Isolation of efficient phosphate solubilizing bacteria capable of enhancing tomato plant growth. *J Soil Sci Plant Nutr* 16(2): 525–536.

Silaen, N. R. 2015. Aktivitas Mikroba Pelarut Fosfat dalam Meningkatkan Kelarutan Fosfat Alam dan Memperbaiki Pertumbuhan Sorgum Manis (Phosphate Solubilizing Microbial Activity in Increasing Natural Phosphate Solubility and Improving Sweet Sorghum Growth). Institut Pertanian Bogor.

Walida, H., Harahap, F. S., Hasibuan, M., and Yanti, F. F. 2019. Isolasi Dan Identifikasi Bakteri Penghasil IAA Dan Pelarut Fosfat Dari Rhizosfer Tanaman Kelapa Sawit (Isolation and Identification of IAA Producing Bacteria and Phosphate Solvents from the Rhizosphere of Oil Palm Plants). *BIOLINK (Jurnal Biologi Lingkungan Industri Kesehatan)* 6(1): 1–7. DOI: 10.31289/biolink.v6i1.2090

Wang, H., Liu, R., You, M. P., Barbetti, M. J., and Chen, Y. 2021. Pathogen biocontrol using plant growth-promoting bacteria (PGPR): Role of bacterial diversity. *Microorganisms* 9(9): 1–18. DOI: 10.3390/microorganisms9091988

Widiantini, F., Yulia, E., and Nasahi, C. 2018. Potensi antagonisme senyawa metabolit sekunder asal bakteri endofit dengan pelarut metanol terhadap jamur *G. boninense* Pat (Potential Antagonism of Secondary Metabolite Compounds From Endophytic Bacteria Using Methanol Solvent Against *G. boninense* Pat). *Agrikultura* 29(1): 55. DOI: 10.24198/agrikultura.v29i1.17870

Wulandari, N., Irfan, M., and Saragih, R. 2020. Isolasi Dan Karakterisasi Plant Growth Promoting Rhizobacteria Dari Rizosfer Kebun Karet Rakyat (Isolation and Characterization of Plant Growth Promoting Rhizobacteria from the Rhizosphere of Smallholder Rubber Plantations). *Dinamika Pertanian* 35(3): 57–64. DOI: 10.25299/dp.2019.vol35(3).4565

Yang, Y., Wang, N., Guo, X., Zhang, Y., and Ye, B. 2017. Comparative analysis of bacterial community structure in the rhizosphere of maize by high- throughput pyrosequencing. 1–11.

Yuliani, Sri Rahayu, Y., and Kusuma Dewi, S. 2021. Phenolic Compounds in Cambodian Leaves and Flowers (Plumeria acuminata Ait.) at Various Times Decomposition. *E3S Web of Conferences* 328: 08017. DOI: 10.1051/e3sconf/202132808017

Zain, Z., Irwin, I., Andi, U. F., and Putro, J. D. 2020. Program Pendampingan Disain Kawasan RTH dan Resapan Air di TPU Muslim Al-lkhlas Kelurahan Sungai Bangkong Kota Pontianak (Assistance Program for the Design of Green Open Space and Water Infiltration at the Al-lkhlas Muslim Cemetery, Sungai Bangkong Village, Pontianak City). *Dinamisia : Jurnal Pengabdian Kepada Masyarakat* 4(3): 509–518. DOI: 10.31849/dinamisia.v4i3.3916

Żychowski, J. 2021. Selected elements in the soils covering mass graves from world wars i and ii in Southeastern Poland. *Minerals* 11(3): 1–17. DOI: 10.3390/min11030275

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Coconut Husk And Eggshell Liquid Organic Feltilizer Effect On Lettuce Growth And Calcium Levels

Widya Husnul Khotimah, Aminah asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Coconut husks
Calcium
Egg shells
Liquidorganic feltilizer
Lettuce

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Coconut husks and eggshells are common wastes found in society, but they are used less, so they often accumulate. Liquid organic fertilizer (POC) is a solution formed from plant residues, agro-industrial waste, animal dirt, and human dirt that has a content of more than one element. This research aims to find out the effectiveness of the supply of liquid organic fertilizer from coconut seeds and egg shells against the increase in calcium (Ca) and the growth of lettuce plants (*Lactuca sativa l*). The research was conducted at FKIP Muhammadiyah University of Surakarta's Green House Education Biology from January–April 2023. The study used the complete random design (RAL) method of 3 repetitions and two factors: the POC administration concentration used P_0 (POC 0 ml), P_1 (POC 100 mL), and P_2 (POC 150 mL), and the time interval for POC W_1 (once every 3 days), and W_2 (once every 5 days). The results of the research showed that the highest growth and increase in calcium being seen with the treatmentof P_2W_2 (150 ml POC and once every 5 days).

1. INTRODUCTION

Vegetables are a commodity that can support food security in Indonesia. Nationally, vegetable production increases every year. According to the Central Bureau of Statistics (BPS), total vegetable production in Indonesia amounted to 14.80 million tons in 2021, so the demand for vegetables production continues to increase as the population grows. Therefore, in the agricultural sector especially horticulture, specialised vegetables have great opportunities for meeting food needs as a source of vitamins and fibre necessary for health and improving the quality of human resources.

One of the most common types of vegetables consumed by people is lettuce *(Lactuca sativa l).* In addition, lettuce is a vegetable that is easily found in traditional markets or supermarkets. Green vegetables such as lattuce contain a lot of beta-carotene that can protect the body from various diseases and have complete antioxidants to boost the body's immune system. According to (Supriati, 2014) the vitamin content in this lettuce includes vitamins A, C, and E, as well as some types of minerals such as calcium, potassium, magnesium, float acid, iron, phosphorus, and sodium.

Liquid organic fertilizer (POC) is a solution formed from the breakdown of organic materials derived from residues of plants, agro-industrial waste, animal waste, and human waste containing more than one element (Tanti et al., 2020). The benefits of liquid organic fertilisers, in addition to being made of natural materials, make the fertilizer environmentally friendly and non-toxic. Other

advantages are fast work time, being easily soluble in the soil, the ability to repair the structure of soil particles, and ease of absorption by plants (Dita et al., 2022).

Organic fertilizers are liquid with coconut husks raw materials as a waste utilisation that is found in many societies, but its processing is less than the maximum, so a small number of societies make use of cocoa sabut waste. The coconut sable has the elements needed by plants, such as potassium (K), calcium (Ca), sodium (Na), magnesium (Mg), and phosphorus (P) (Suripto et al, 2018). Therefore, coconut seeds can be used as liquid organic fertilizer. Application of coconut soap organic fertilizer from liquid organic soap waste can increase the harvest yield more optimally (Purnamasari et al., 2022).

In addition, the use of eggshells in fertilizer materials is less understood by society. According to research (Dewi, 2021), the POC of the eggshell has a pH content and macro-charge elements (0,19 % N, 6,09 ppm P, 1408,90 ppm K, 1158,33 ppm Ca, and 454,54 ppm Mg). From the results of the analysis, there are elements of potassium in the eggshell POC and elements of nitrogen, phosphorus, calcium, and magnesium. Proved by research (Fatimah et al., 2021), the administration of liquid organic fertilizer of chicken eggshells and nitrogen against the average dry weight of pakcoy showed that treatment D (60 % POC of eggshell + 6 g of nitrogen) gave the best results against the height of the pakcoy plant of 18.97 g. Chicken egg shells have a high calcium content, with each gram of eggshell containing 380–381 mg of calcium (Brun et al., 2013).

The timing of the administration of organic fertilizers made from eggshells and coconut husks to plants is monitored to avoid deficiency and excess fertilizer doses. According to the results of research (Wardana, 2016), the administration of a dose of goat cage fertilizer affects the growth of lettuce plants. With a dose size on goat fertilizer of 20 tons/ha, equivalent to 4 kg/plot, that gives the best results on the observation variable of the number of leaves of the vegetable, and a time interval of application every 5 days provides the best result on the variable observation of the diameter of the stem, the height of the plant, and the amount of the leaves. In addition to the composition content of the liquid organic fertilizer used, the right time and dose of fertilizer play a role in optimal growth. The purpose of this study was to determine the effectiveness of applying liquid organic fertilizer made from coconut husk and eggshells to affect the growth and increase of lettuce plant calcium levels.

2. MATERIALS AND METHODS

2.1. Time and place of research

The research was conducted at FKIP Muhammadiyah University of Surakarta's Green House Education Biology and BPSMB Surakarta, Test and Certification Hall of Goods from January–April 2023.

2.2. Research tools and materials

The tool used in this research is bascom, digital scales, mistar, 8-liter bucket, knife, measuring glass, spectofotometer, Erlenmeyer 250 ml, 50 ml measuring labyrinth, documentation tool, stripes, and polybags. The materials used in this study were coconut seals, chicken egg shells, EM4, lettuce seeds, coal, and water.

2.3. The experimental plan

This type of research is experimental. The environmental design used is a complete random design (RAL) with three repetitions. Two types of treatment Factor 1: Liquid Fertilizer (P); Factor 2: Fertilizer Time (W):

P_0W_0 (Control) = Only water every days
P_1W_1 = POC 100 ml + once every 3 days
P_2W_1 = POC 150 ml + once every 3 days
P_1W_2 = POC 100 ml + once every 5 days
P_2W_2 = POC 150 ml + once every 5 days

2.4. Production of liquid organic fertilizers

The initial step in making liquid organic fertilizer involves preparing all the tools and materials used. Next, prepare a bucket to insert 2000 g of dried eggshells that have been finely crushed, 1000 g of finely dried coconut husks, 500 g of red sugar, enough EM4, and 50 litters of water. Homogenise until flat, then close the bowl tightly and make sure no air gaps enter. Then, incubate the fertilizer for a week. Check your pH after a week.

2.5. Giving fertilizer to plants

Liquid organic fertilizer is administered to the plant in doses of 100 ml and 150 ml with a fertilising interval of once every 3 days, and once every 5 days. Observation is carried out once every 7 days.

2.6. Test for calcium levels

The procedure for testing calcium using the CPC (O-Cresolpthlein-Complexone) method is based on (National Standardization Agency, 1992): Weigh 1 g of lettuce and place it in a porcelain cup or 100-ml pyrex glass cup. Add with a pipette 100 ml of a solution of magnesium nitrate in ethanol, mixed with a mixer bar. Remove the blender bar and rinse it with 95% ethanol. Evaporate ethanol over a water bath while stirring occasionally, then heat over an electric bath (covering the glass cup with a watch glass). Move the glass cup into a barrel at a temperature of 2000 °C, gradually raise the temperature to 5000 °C for 2 hours, and blur all night at 450–5000 °C. Remove the glass from the barrel and leave it on the asbestos. If there are still carbon residues, after cooling, add 1 ml of water and 2 ml of HNO3 p.a., and then dry over the water boiler. Reheat to a temperature of 5000 °C for 1 hour. Repeat this process until you have white ashes. Add 5 ml of the HCl and HNO3 mixture solution to the ashes through the glass cup wall and heat it over the water boiler until the ashes dissolve. Move the solute quantitatively into a 100-ml measuring labia, then impregnate the labia with boiling water. Filtered with Whatman 540. Working with Blanco using the same agent. Read the absorption of standard solutions, blanko, and lettuce using a spectroscopic photometer. Create a calibration curve with the Y axis as absorption and the X axis as concentration (in ppm). Calculate the calcium content of lettuce.

2.6.1. Calculation of calcium (Ca) levels

The calcium (Ca) content of the vegetable can be calculated using the formula:

$$Calcium\ levels = \frac{C \times P \times V}{W\ (mg/kg)}$$

Where : Calcium levels is calcium content (%), *P* is initial of dilution, *V* is initial volume of solvent (ml), and *W* is weight of lettuce sample (g).

2.7. Data Analysis

The data obtained in this study will be analysed for variants using the Two-Way Anova formula on a complete random drawing (RAL) with SPSS 20.0. It is used to analyze the growth

and calcium levels of salad plants after the administration of liquid fertilizer made from coconut salmon waste and chicken egg shell waste. If the result value is > 0.05, then "there is an effect of concentration on the growth and calcium content of salad plants". If the result value is < 0.05, then "there is no effect on the concentration on the growth and calcium content of lettuce plants".

3. Results and Discussion

Based on the research that has been carried out, the data obtained from the observation of the growth of lettuce plants over four weeks with different fertilizer concentrations and time intervals has different results. The measurement parameters used are the number of leaves, the height of the stem, wet weight, and calcium content. Here are the sensory tests obtained, as follows:

Table 1. Results of sensory testing

Treatment	Rare number of leaves (strands)	Rate of height (cm)	Wet Weight Average of Plants (g)	Average Level of Calcium (%)
P0W0 (Control)	5,33	9**	4**	0,028**
P1W1	5**	10,66	5,33	0,044
P1W2	5,33	11,66	5,66	0,063
P2W1	5,66	12,66	7	0,089
P2W2	7*	16,66*	11,66*	0,129*

Description :
* Plant growth with the highest average value.
** Plant growth with the lowest average value

Figure 1 shows that the sensory test data results in the study have different average values for each parameter. The highest number of leaves in treatment P_2W_2 with 7 leaves, the highest ratio in stems in treatment P_2W_2 with a height of 16.66 cm, the greatest wet-weight ratio of plants in treatment P_2W_2 with a weight of 11.66 g, and the most high calcium treatment ratio in treatment P_2W_2 in celandine with a total of 0.129 % The results of the sensory trial P_2W_2 treatment (POC 150 ml + once every 5 days) showed that the higher the dose of fertilizer and the ideal time for fertilization delivery, the more optimally the vegetable develops in weight, height, and quantity. This is because the supply of liquid organic fertilizer from the combination of coconut seals and egg shells has an effect on the vegetable.

Figure. 1 Lettuce plant height measurement a. P_0W_0 (Control), b. P_1W_1, c. P_1W_2 , d. P_2W_1, e. P_2W_2

3.1. The hight plant

Plant growth can be visualized from the various physical characteristics of plants. One of the parameters that can be used is the length or height of the plant. Based on figure 2, it can be seen

that the high addition of plants is best for the treatment of U1 P_2W_2 (POC 150 ml once every 5 days). While the highest addition of plants is the lowest on the control treatment, which concentrates POC at 0 %. The more fertilized, the faster the plant will grow. However, when the dose in the fertilizer administration is excessive, it can slow growth, and there is potential root damage due to high fertiliser salts. Proper fertilizer can stimulate the growth of new shoots from the roots. (Xu et al., 2020). To show the comparison of high growth of lettuce plants with different treatments can be presented in the graph as follows:

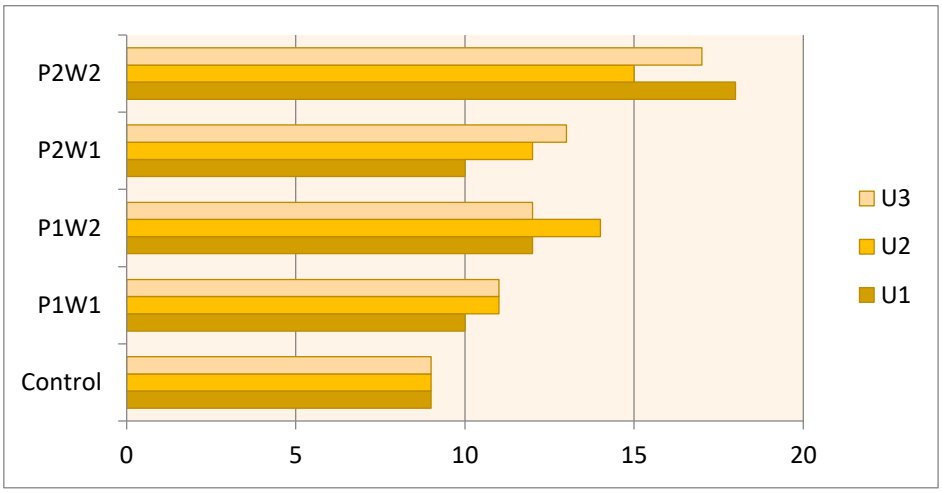


Figure. 2. Graphic chart The hight plant

The high-additional plant data was tested using the two-way Anova test data analysis technique to test the hypothesis. Here are the results of high-hypothesis testing of plants using the Anova Two-Way technique. Based on table 2, it is possible to know the high significance value of the plant 0.044 compared with the level of significance 0.05, so the value obtained 0.044 < 0.05 then It can be understood that the concentration of fertilizer and the time of fertilisation affect the high significance value of the plant lettuce.

Table 2. High Hypothesis Test Results

Tests of Between-Subjects Effects

Dependent Variable: The hight plant

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	99.067[a]	4	24.767	19.553	.000
Intercept	1967.213	1	1967.213	1553.063	.000
Doses_P	18.750	1	18.750	14.803	.003
Time_W	36.750	1	36.750	29.013	.000
Doses_P * Time_W	6.750	1	6.750	5.329	.044
Error	12.667	10	1.267		
Total	2320.000	15			
Corrected Total	111.733	14			

a. R Squared = ,887 (Adjusted R Squared = ,841)

Table 2 shows that treatment in the supply of liquid organic fertilizer and delivery time intervals influenced the high growth of plants. According to the study (Purwadi, 2017), the administration of POC of liquid waste tea and coconut husks to lettuce plants with varied volumes and watering times can significantly affect the height and weight of the plant base. This is because the provision of organic fertilizer in liquid coconut sabbats and egg shells provides the content of hara, N, P, and K that is absorbed by plants and responds to their development (Novianto et al., 2020). The availability of nutrient in plant organs can be fully met by applying liquid organic fertilizer to plants, compared to plants without the supply of fertilizers (Marpaung et al., 2014).

3.2. Number of Leaves

Lettuce is a plant that uses its leaves, so it needs a suitable nitrogen element so that the vegetative phase of the selada plant can be stimulated more dominantly. The leaves are an important organ for growth because they are the main organ for the process of photosynthesis. The number of leaves is closely related to the height of the plant because the leaves are located on the stems of the selada (Manuhuttu et al., 2014). In this study, we obtained data on the number of leaves of plants lettuce with various behaviours as follows:

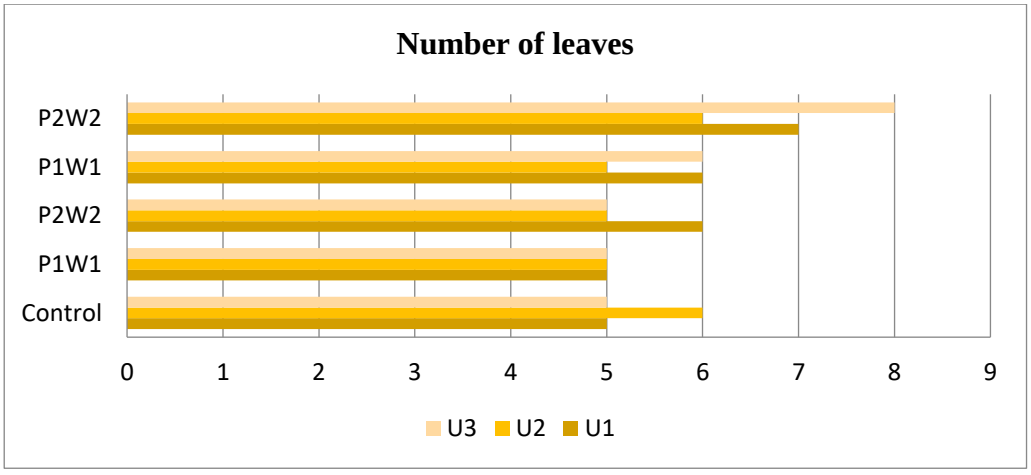


Figure. 3. Graphic chart Number of leaves

Based on the data from the observation results, the number of leaves of the plant varied with the concentration of fertilizer and the intervals of time between the different fertilizers. Based on figure 3, the best results were obtained with the treatment of P_2W_2 (a fertilizer treatment of 150 ml with a time interval of once every 5 days) with an average of 7 strips of leaves on U3. The lowest number of leaves with an average of 5 strings is at POC 0 % and P_1W_1 (POC 100 ml and interval time once every 3 days).

Table 3. the results of hypothesis testing the number of leaves

Tests of Between-Subjects Effects

Dependent Variable: Number of leaves

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	7.333[a]	4	1.833	4.583	.023
Intercept	450.104	1	450.104	1125.260	.000
Doses_P	2.083	1	2.083	5.208	.046
Time_W	4.083	1	4.083	10.208	.010
Doses_P * Time_W	.750	1	.750	1.875	.201
Error	4.000	10	.400		
Total	493.000	15			
Corrected Total	11.333	14			

a. R Squared = ,647 (Adjusted R Squared = ,506)

Based on table 3, it is possible to know the value of significance of the influence of fertilizer concentration and the time interval of fertiliser delivery on the plant height of 0.201 compared with the level of significance of 0.05 so that the sig value of 0.20 > 0.05. It can be understood that fertilising and fertilisation delivery time do not affect the growth of the number of leaves of the vegetable. The number of leaves on the plant is one of the most important visual features that depicts its development and growth. This makes it possible to assess growth and relate it to plant health and potential outcomes. However, there is no evidence that the number of leaves directly affects the growth of plants. (Farjon et al., 2021). This is consistent with research (Maunte, 2018) showing that the POC treatment given to the celery plant did not have a real effect on the parameter of the number of leaves. Due to its low dosage and the hera elements needed by plants in POC, nutritional fulfilment is limited.

3.3. Wet Weight

The wet weight of the plant indicates the water content of the plant tissue. At the end of the observation, the most optimal wet weight is shown at the treatment P_2W_2 (POC 150 ml with a time interval of once every 5 days), while the base weight is low at the control. Due to the fact that the plant lettuce control has a lack of micro-charge elements that function, the element macro-charge is easy to absorb by the soil, influencing the weight of the cells of plants and making their weight not optimal (Fitriani & Haryanti, 2016). Here is the graph of the results of the weight comparison of the bases on the plants of lettuce.

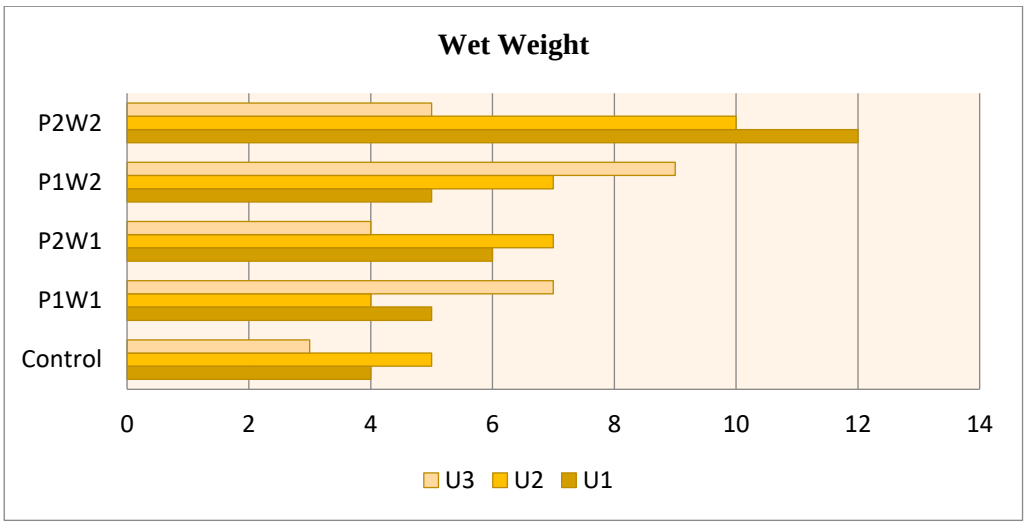


Figure. 4. Graphic chart of wet weight

Based on Figure 4, the wet weight of plants treated with POC U1, U2, and U3 is optimum compared to plants without POC. This is directly compared to the high growth of plants, which is also more optimal on plants given fertilizer treatment than plants without 0 % POC fertiliser. In this study, data were obtained for the highest average value of 11.66 grammes on the treatment of P_2W_2 (POC 150 ml + once every 5 days). And the lowest average value on treatment P_0W_0 with a wet weight of 4 grammes.

Table 4. Hypothesis of Wet Plant Weight

Tests of Between-Subjects Effects

Dependent Variable: wet plan weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	104.933[a]	4	26.233	10.931	.001
Intercept	584.311	1	584.311	243.463	.000
Doses_P	18.750	1	18.750	7.813	.019
Time_W	44.083	1	44.083	18.368	.002
Doses_P * time_W	14.083	1	14.083	5.868	.036
Error	24.000	10	2.400		
Total	809.000	15			
Corrected Total	128.933	14			

a. R Squared = ,814 (Adjusted R Squared = ,739)

Based on Table 4, the results of the test of the hypothesis of the influence of fertilizer concentration and time interval of fertiliser administration on wet weight using the Two-Way Annova technique (sig.) So that less than the level of significance of 0.05 > 0.036, H0 is accepted. There is therefore an interaction between the treatment of fertilizer concentration levels and time intervals of fertiliser administration and the weight of the cellar plant base. Based on research (Shaleh, 2017), there was an influence of the administration of POCs of coconut sable waste and

tauge extract on the wet weight of the teaspoon of salvia, with an average wet weight of 7.19 g, and the height of the plant.

3.4. Calcium

Calcium plays an important role in the human body. Calcium is a global mineral that is found in the body; it accounts for 2 % of the total body mass; 99 % of calcium can be found in hard tissue, teeth, and bones; while 1 % is located in the blood and spreads within the body. (Kurniawan, 2015). Calcium levels in salad plants were tested using spectrophotometry with a wavelength of 422.7nm.

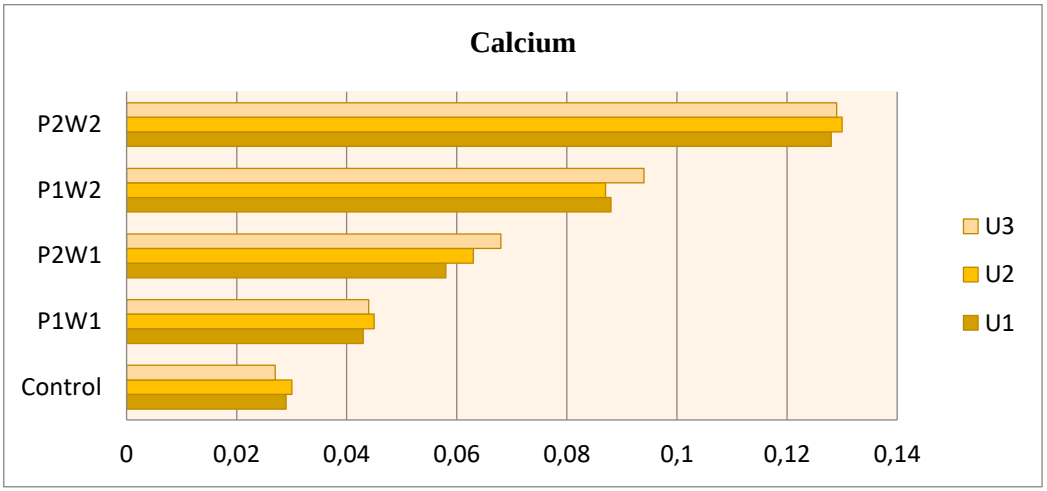


Figure. 5. Graphic chart of Calcium

Based on Figure 5, there is a difference in the amount of calcium in plants with the treatment of POC administration and certain time intervals. In this study, it was found that the highest average rat in the selada plant was 0.129 % in the treatment of P_2W_2 (POC 150 ml and interval once every 5 days). And calcium is lowest with an average of 0.028 %, which is in the POC control plant at 0 % and treatment P_1W_1.

Table 5. The Calcium Hypothesis Test

Tests of Between-Subjects Effects

Dependent Variable: Calcium

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	.019[a]	4	.005	540.813	.000
Intercept	.062	1	.062	7068.152	.000
Doses_P	.003	1	.003	292.223	.000
Time_W	.009	1	.009	1070.849	.000
Doses_P * Time_W	.000	1	.000	35.506	.000
Error	8.733E-005	10	8.733E-006		
Total	.094	15			
Corrected Total	.019	14			

a. R Squared = .995 (Adjusted R Squared = .994)

The results of the test hypothesis of plant calcium levels can be known. The value of significance of the influence of fertilizer concentration and time interval of fertiliser delivery is

0,000 compared with the significance level of 0.05 to the value of sig 0.000<0.05. It can be understood that there is an interaction between the increase in calcium and the fertilizer dosage and the time interval of fertiliser administration. One of the POC ingredients that researchers used to increase calcium is chicken egg shells. Eggs have a high nutrient content. (Hasibuan et al., 2021). In a study (Suhastyo & Raditya, 2021), it was stated that in the shell of chicken eggs there is a high calcium content of as much as 97 %. This is in accordance with research (Wahyuni & Asngad, 2018) showing that the administration of POC saliva waste and chicken egg shell waste can increase the calcium content in sawi plants.

4. CONCLUSIONS

Based on the results of the research that has been carried out, it can be concluded that the application of liquid organic fertilizer from coconut seals and egg shells effectively improves the growth and productivity of the cellar crops grown using polybags, with the highest growth and increase in calcium being seen with the treatment of P_2W_2 (150 ml POC and once every 5 days). This research is basic research developed in the field of the manufacture of liquid organic fertilizers. It's not necessary to conduct further research on the content of elements in the media and fertilizer. You can not he same research with different variables.

5. ACKNOWLEDGMENTS

The author expressed his gratitude to several parties, among them: 1) Muhammadiyah University of Surakarta, which has provided facilities for conducting research 2) Surakarta Testing and Certification Hall of Goods.

6. REFERENCES

Badan Standardisasi Nasional. 1992. SN 01-2891-1992 Uji Kalsium *(Ca)*. Badan Standardisasi Nasional (BSN)

Brun, L. R., Lupo, M., & Rigalli, A. (2013). *Chicken eggshell as suitable calcium source at home*. *April*. https://doi.org/10.3109/09637486.2013.787399

Dewi, I., Basuni, B., & Rahmidiyani, R. Pengaruh Kombinasi Konsentrasi Dan Interval Pemberian Poc Cangkang Telur Terhadap Pertumbuhan Dan Hasil Tanaman Tomat Pada Tanah Gambut. *Jurnal Sains Mahasiswa Pertanian*, *10*(3).

Dita, A., Gau, T., Zamzam, S., Mutmainnah, N., & Qadri, S. N. (2022). *Pemanfaatan Limbah Rumah Tangga Sebagai Pupuk Organik Cair Ramah Lingkungan*. *3*, 37–42.

Farjon, G., Itzhaky, Y., Khoroshevsky, F., & Bar-Hillel, A. (2021). Leaf Counting: Fusing Network Components for Improved Accuracy. *Frontiers in Plant Science*, *12*(June), 1–12. https://doi.org/10.3389/fpls.2021.575751

Fatimah, R. N., Sugiono, D., Universitas, M., Karawang, S., Fakultas, D., Universitas, P., & Karawang, S. (2021). *Jurnal Ilmiah Wahana Pendidikan*. *7*(8). https://doi.org/10.5281/zenodo.5798140

Fitriani, H. P., & Haryanti, S. (2016). Pengaruh penggunaan pupuk nanosilika terhadap pertumbuhan tanaman tomat (Solanum lycopersicum) var. bulat. *Buletin Anatomi Dan Fisiologi*, *24*(1), 34–41.

Hasibuan, S., Nugraha, MR, Kevin, A., Rumbata, N., Syahkila, S., Dhewanty, SA, ... & Shafira, T. (2021). Pemanfaatan Limbah Cangkang Telur Sebagai Pupuk Organik Cair di Kecamatan Rumbai Bukit. *PRIMA: Jurnal Pemberdayaan dan Pelayanan Masyarakat* , *5* (2), 154-160.

Kurniawan, F. B. (2015). Praktikum Kimia Klinik Analis Kesehatan. Jakarta: Penerbit Buku Kedokteran EGC.

Manuhuttu, A. P., Rehatta, H., & Kailola, J. J. . (2014). Pengaruh Konsentrasi Pupuk Hayati Bioboost Terhadap Peningkatan Produksi Tanaman Selada (Lactuca sativa. L). *Agrologia*, *3*(1). https://doi.org/10.30598/a.v3i1.256

Marpaung, AE, Karo, & R, T. (2014). Pemanfaatan Pupuk Organik Cair dan Teknik Penanaman Dalam Peningkatan Pertumbuhan dan Hasil Kentang. *Jurnal Hort*, *24*(1), 49–55.

Maunte, Z. (2018). the Effect of Liquid Organic Fertilizer From Tofu Cake and. *Jurnal Agropolitan*, *5*(1), 70–77.

Novianto, N., Effendy, I., & Aminurohman, A. (2020). Respon Pertumbuhan dan Hasil Tanaman Sawi (Brassica junceea L.) Terhadap Pupuk Organik Cair Hasil Fermentasi Sabut Kelapa. *Agroteknika*, *3*(1), 35–41. https://doi.org/10.32530/agroteknika.v3i1.67

Purnamasari, R. T., Pratiwi, S. H., & Hidayanto, F. (2023). *Effect of coconut husk organic fertilizer from liquid organic fertilizer waste on growth and yield eggplant (Solanum melongena L .)*. *2023*(1), 61–66.

Purwadi, W. (2017). Pertumbuhan Dan Kadar Protein Pada Tanaman Kangkung Darat *(Ipomoea reptanapoir) Dengan Pemberian Pupuk Organik Cair (Poc) Berbahan Dasar Sabut Kelapa Dan Limbah Cair Tahu*. Universitas Muhammadiyah Surakarta.

Suhastyo, A. A., & Raditya, F. T. (2021). Pemanfaatan limbah cair industri tahu sebagai pupuk organik cair (POC) guna mendukung program lorong garden (Longgar) Kota Makassar. *Jurnal Agrosains dan Teknologi*, *6*(1), 1-6.

Statistik, B. P. (2021). Produksi Tanaman Sayuran di Indonesia Tahun 2018-2021.

Shaleh, R. N. (2017). *Pemanfaatan Limbah Sabut Kelapa dan Ekstrak Tauge Sebagai Pupuk Organik Cair Untuk Meningkatkan Kandungan Protein dan Pertumbuhan Tanaman Sawi*. Universitas Muhammdiyah Surakarta.

Tanti, N., Nurjannah, N., & Kalla, R. (2020). Pembuatan Pupuk Organik Cair Dengan Cara Aerob. *ILTEK : Jurnal Teknologi*, *14*(2), 2053–2058. https://doi.org/10.47398/iltek.v14i2.415

Wardhana, I., Hasbi, H., & Wijaya, I. (2016). Respons pertumbuhan dan produksi tanaman selada (lactuca sativa l.) Pada pemberian dosis pupuk kandang kambing dan interval waktu aplikasi pupuk cair super bionik. *Agritrop: Jurnal Ilmu-Ilmu Pertanian (Journal of Agricultural Science)*, *14*(2).

Wahyuni, S. E. T., & Asngad, A. (2018). Pemberian Pupuk Organik Cair Limbah Jerami Padi Dan Limbah Cangkang Telur Ayam Untuk Meningkatkan Kandungan Kalsium Tanaman Sawi. *Seminar Nasional Pendidikan Biologi Dan Saintek II*, *2*, 198–203.

Xu, F., Chu, C., & Xu, Z. (2020). Effects of different fertilizer formulas on the growth of loquat rootstocks and stem lignification. *Scientific Reports*, *10*(1), 1–11. https://doi.org/10.1038/s41598-019-57270-5

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality Of Kirinyuh Leaf Liquid Organic Fertilizer and Coconut Water Waste With Pineapple Skin Bioactivator

Arisa Putri Jihan Nitami, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

KEYWORDS:
Bioactivator, kirinyuh leaves, pineapple skin, waste coconut water, liquid organic fertilizer.

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Liquid organic fertilizer is liquid fertilizer so that plants can absorb it more easily. Liquid organic fertilizer can overcome problems arising from using inorganic fertilizers in the long term. This study aims to determine the quality of liquid organic fertilizer from kirinyuh leaves and coconut water waste by adding pineapple peel as a bioactivator. This study used the experimental method and utterly randomized design consisting of 2 factors with four combinations and three repetitions, namely factor 1 (K): a combination of the essential ingredients of kirinyuh leaves and coconut water waste (K 1: 168 ml: 82 ml & K 2: 82 ml: 168 ml). Factor II (M): Add MOL of pineapple skin (M 1: 100 ml and M 2: 150 ml). The parameters used were sensory tests regarding color, odor, pH and nitrogen, phosphorus, and potassium content. This study uses data analysis: descriptive qualitative, and quantitative. The results showed that liquid organic fertilizer has a greenish-brown color, does not have a solid fermented odor (like tape) and some have an unpleasant odor, and has a pH of 4.00 – 4.67. Based on the POC content test, only three treatments met the quality standards of SNI 19-7030-2004 for nitrogen content, namely K1M1, K1M2, and K2M1.

1. INTRODUCTION

Fertilizer is one of the primary sources of nutrition given to plants or growing media to meet the availability of nutrients that supports plant growth so that it can grow optimally. In addition, fertilizer can also be referred to as an additional material given to the soil, which helps enrich or increase soil fertility chemically, physically, or biologically (Astiti et al., 2022). According to the type, fertilizers can be divided into organic and inorganic fertilizers. However, excessive use of inorganic fertilizers can result in adverse environmental impacts, including a) decreased soil organic matter content, b) soil prone to erosion, c) decreased soil permeability, d) decreased soil microbial populations, e) faster soil drier and finer, f) poor structure, g) low soil organic matter content (Herdiyantoro, 2015). In addition, inorganic fertilizers cannot improve soil quality, unlike organic fertilizers, which can fertilize and enhance soil quality.

Organic fertilizers use ingredients consisting of plant and animal organic matter that has gone through a fermentation process and function to provide nutrients to plants and can improve the soil's physical, chemical, and biological properties (Suwahyono, 2017). Liquid organic fertilizer is a solution of fermentation using organic materials such as plant residues and animal and human wastes, which contain more than one nutrient. In general, liquid organic fertilizers use materials from animal waste such as chicken manure, cow manure, and goat manure. In addition, various debris such as market waste, kitchen waste, fruit peels, corn stalks, straws, banana cobs, tea waste, tofu waste, and others.

Making this liquid organic fertilizer uses a combination of two different ingredients to complement and fulfill the availability of nutrients needed by plants to manufacture liquid organic fertilizer using kirinyuh leaves and coconut water waste. Kirinyuh is a woody weed with ingredients that can be used as a source of organic matter (green manure) (Wiraswati et al., 2021). In addition, the nutrient content of kirinyuh is relatively high, namely 7.76 % nitrogen, 1.10 % phosphorus, and 5.79 % potassium (Napitupulu et al., 2018). Therefore, kirinyuh leaves can be used as liquid organic fertilizer to increase nutrients.

Coconut water is suitable for microbial growth because it contains nitrogen compounds, sugars, minerals, and vitamins (Echdar & Maryadi, 2019). In addition, coconut water contains inorganic ions such as Cl, Cu, Fe, Mg, P, K, Na, and S, amino acids, nitrogen compounds, enzymes, vitamins, and organic acids, which can induce cell division and shoot multiplication (Hidayanti et al., 2022). Furthermore, research (Suryati et al., 2019) regarding using coconut water waste as liquid organic fertilizer states that coconut water contains a lot of potassium, up to 17 %. It also has a sugar content between 1.7 – 2.6 % and 0.07 – 0.55 % protein. In addition, it contains other minerals such as Na, Ca, Mg, Fe, Cu, P, and S.

The process of making liquid organic fertilizer is carried out utilizing fermentation so that the compounds in the materials used can decompose adequately and are easily absorbed by plants. Speed up the fermentation process, and it requires a bioactivator. The waste that will be used in the manufacture of the bioactivator this time is pineapple skin. Pineapple skin contains vitamins A and C, carotenoids, flavonoids, tannins, sodium, alkaloids, calcium, phosphorus, iron, magnesium, and bromelain enzymes (Salasa, 2019). The bromelain enzyme functions to soften cellulose so that it can be used as EM-organic (Sulistiono, 2017). Local microorganisms on pineapple skin are *Rhizobium* Sp., *Azospirillium* Sp., *Azotobacter* Sp., *Pseudomonas* Sp., *Phosphate bacteria*, *Bacillus* Sp., *Azotobacter* Sp. (Supianor et al., 2018). According to (Palupi, 2015), pineapple skin waste can be used in making MOL.

Based on the description above, the aims of this research is to determine the quality of liquid organic fertilizer from kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator. So that researchers are interested in conducting research with the title "**Quality Of Kirinyuh Leaf Liquid Organic Fertilizer And Coconut Water Waste With Pineapple Skin Bioactivator**".

2. MATERIALS AND METHODS

This research was conducted at the Green House Laboratory of the Teaching and Education Faculty, Muhammadiyah University, Surakarta, to manufacture fertilizers and sensory tests. In addition, N, P, and K content tests were carried out at the Laboratory of Soil and Plant Nutrition, Agrotechnology Study Program, Muhammadiyah University, Yogyakarta. The materials used in the manufacture of this fertilizer are young and old kirinyuh leaves, coconut water waste, pineapple skin, water, brown sugar, molasses, leri water, bran, pH stick, and raffia rope. At the same time, the tools used include a 16L jar, 5L jar, blender, basin, digital scale, analog scale, wooden stirrer, inlet, stove, filter, 250 ml measuring cup, 1000 ml measuring cup, knife, gloves, pH indicator, documentation tools.

The procedure for carrying out this research included: 1) Making pineapple skin bioactivator by grinding the pineapple skin using a blender, adding coconut water which had been dissolved with brown sugar and adding rice washing water, then closing the jar and fermenting for 14 days, 2) Then making the extract kirinyuh leaf by crushing the kirinyuh leaves using a blender, filtering the kirinyuh leaf extract and storing the extract in a bottle, 3) Collection of coconut water waste

from the market, 4) Liquid organic fertilizer is made by mixing kirinyuh leaf extract, coconut water waste, and skin bioactivator pineapple according to the measure. Then it is mixed with molasses, bran, leri water and homogenized. After that, it is fermented for 14 days. Then observe the liquid organic fertilizer according to the sensory test, which includes color, odor, and pH.

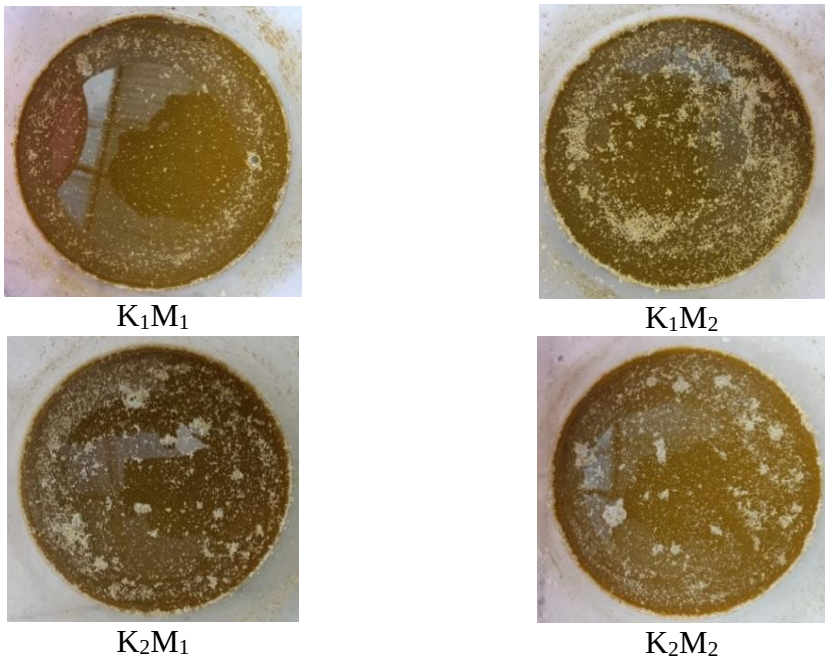
This study used an experimental research type with a completely randomized design (CRD) consisting of 2 factors with four combinations and three repetitions, namely factor 1 (K): a combination of the essential ingredients of kirinyuh leaves and coconut water waste (K 1: 168 ml: 82 ml and K 2: 82 ml: 168 ml). Factor II (M): Add MOL of pineapple skin (M 1: 100 ml and M 2: 150 ml). The data analysis used in this research is descriptive qualitative, and quantitative. This data analysis determines sensory properties (color, odor, pH). In addition, it is used to determine the content of Nitrogen, Phosphorus, and Potassium in statistical form with two-way ANOVA in the manufacture of liquid organic fertilizer by utilizing kirinyuh leaves and coconut water waste and adding skin pineapple as a bioactivator.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Sensory Observation

After fermenting for 14 days, we get the results of liquid organic fertilizer from kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator to get the following results:



K_1M_1 K_1M_2

K_2M_1 K_2M_2

Figure 1. Results of liquid organic fertilizer after fermentation for 14 days

Based on sensory observations, including color, odor, and pH in the liquid organic fertilizer combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator, the sensory test results were as follows:

Table 1. Average sensory test results of liquid organic fertilizer combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

Combination	Observation result		
	Color	Odor	pH
K_1M_1	Greenish brown	The smell of fermentation is not overpowering	4,33
K_1M_2	Greenish brown	The smell of fermentation is not overpowering	4,00
K_2M_1	Dark greenish brown	Bad smell	4,67
K_2M_2	Greenish brown	The smell of fermentation is not overpowering	4,67

Information :
K1M1: Liquid organic fertilizer with 168 ml of kirinyuh leaf extract and 82 ml of coconut water waste with the addition of 100 ml of pineapple skin bioactivator.
K2M1: Liquid organic fertilizer with 82 ml of kirinyuh leaf extract and 168 ml of coconut water waste with the addition of 100 ml of pineapple skin bioactivator.
K1M2: Liquid organic fertilizer with 168 ml of kirinyuh leaf extract and 82 ml of coconut water waste with the addition of 150 ml of pineapple skin bioactivator.
K2M2: Liquid organic fertilizer with 82 ml of kirinyuh leaf extract and 168 ml of coconut water waste with the addition of 150 ml of pineapple skin bioactivator.

.

3.1.2. Content Of Nitrogen, Phosphorus, Potassium

Based on the test results for the content of nitrogen, phosphorus, and potassium in liquid organic fertilizer combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator, the average results are as follows:

Table 2 The intermediate results of the N, P, K content test of liquid organic fertilizer combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

Sample	N total	P total		K total	
	N %	ppm P	% P	ppm	K tot %
K_1M_1	0.71	674.35**	0.07**	812.14	0.08
K_1M_2	0.76	649.26	0.06	772.54*	0.08*
K_2M_1	0.82**	388.39*	0.04*	812.14	0.08
K_2M_2	0.38*	418.49	0.04	1049.74**	0.10**

Description: (*) lowest content, (**) highest content.

3.2. Discussion

3.2.1. Color Parameters

Based on the results of the color parameter research as shown in Table 1 above, it can be seen that the average color sensory test results on liquid organic fertilizer combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator show that the sample has a greenish-brown and dark greenish-brown color. Initially, liquid organic fertilizer has a light brown color. After being fermented, it produces a greenish-brown color. This liquid organic fertilizer has a greenish-brown color, which can be caused by the essential ingredients used. These, namely kirinyuh leaves, can affect the color of the liquid organic fertilizer to greenish-brown. According to Putri (2022) research, the maturity indicator for organic fertilizer according to SNI

19-7030-2004 is brown-black. According to Siregar (2017), the color change to brown or black is caused by the activity of microorganisms that work during fermentation and depends on the materials used in making liquid fertilizer.

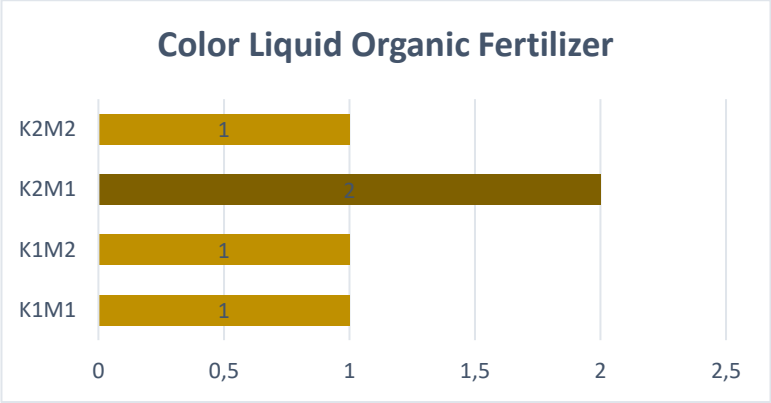


Figure 2. Parameter diagram for the average color of liquid organic fertilizer a combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

3.2.2. Odor Parameters

Based on the results of the research on odor parameters, as shown in Table 1 above, it can be seen that the average results of the sensory odor test on liquid organic fertilizer, a combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator show that there are samples that have a non-stinging fermented odor (such as tape) and one sample have an unpleasant odor, namely K2M1. According to Sucipto & Hendariyono (2018), if liquid organic fertilizer has a tape-like odor, the liquid organic fertilizer is successful. In contrast, if the liquid organic fertilizer smells rotten, it has not succeeded (failed). The failure to make liquid organic fertilizer can be caused by various factors, such as when the jar is not closed tightly, is not stored according to the temperature, and may be too hot or cold (Selviana, 2019).

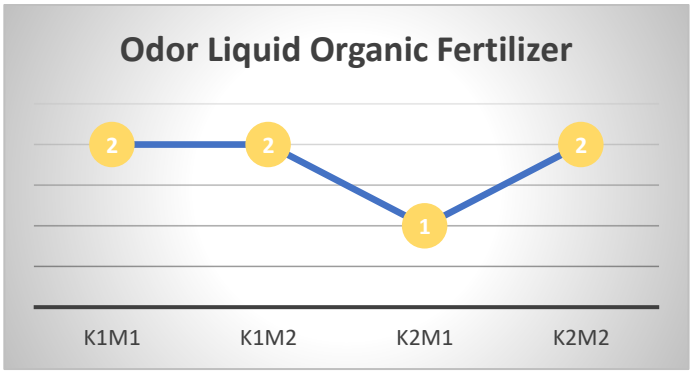


Figure 3. Parameter diagram of the average odor of liquid organic fertilizer a combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

3.2.3. pH Parameters

Based on the results of the research on pH parameters, as shown in Table 1 above, it can be seen that the average results of the sensory pH test on liquid organic fertilizer combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator show

that all samples have a different pH of 4 .00 to 4.67. Initially, all models had a pH of 5; on day 3, several samples experienced a decrease in pH to 4. The activity of microorganisms in decomposing organic matter was marked by an increase or decrease in pH (Firdaus, 2011). The rise in pH is caused by organic materials that are broken down by certain microorganisms to produce simple organic acids so that an acidic atmosphere is created, after which other types of microorganisms will eat these organic acids, which causes the pH level to rise again (Sulfianti et al., 2021). While the decrease in pH because POC becomes acidic, is due to the activity of phosphate-solubilizing bacteria and lactic acid bacteria, which cause the formation of phosphatase enzymes and organic acids, causing the environment to become acidic (Vianti et al., 2022). This liquid organic fertilizer has a different pH, namely 4 – 4,67 . It is under the requirements of the 2011 Decree of the Minister of Agriculture of the Republic of Indonesia concerning the Minimum Technical Requirements for a liquid organic fertilizer pH of 4 – 9 (Ekawandani & Halimah, 2021).

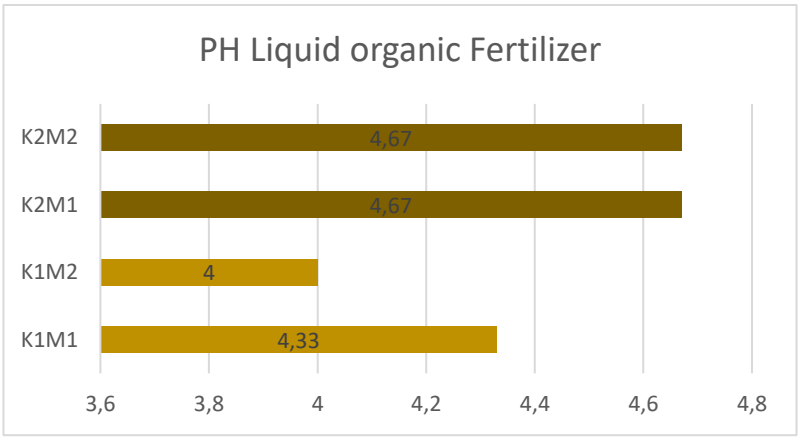


Figure 4. Parameter diagram for the average pH of liquid organic fertilizer combined with kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

3.2.4. Nitrogen Content

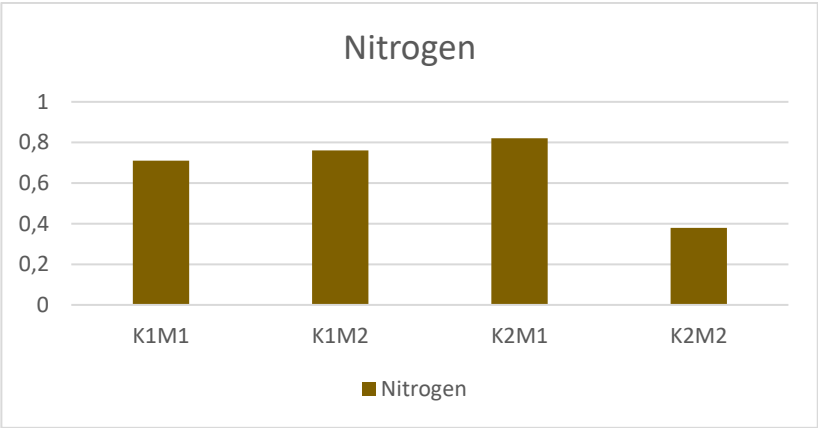


Figure 5. Diagram of the average nitrogen content of liquid organic fertilizer combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

Based on table 2 above shows that each treatment has differences in nitrogen content. The highest average nitrogen content in the K2M1 combination treatment was 0.82 %. Meanwhile, the lowest moderate content was found in the K2M2 combination treatment, which was 0.38%. It is because the speed of the microbes for each treatment in decomposing the fermented material is different, causing the nitrogen content to vary. According to Wijaksono et al. (2016), the more bacteria present in the fermentation process, the more nitrogen content will increase. According to the test results for the nitrogen content, the lowest content was found in treatment M2, which means it had a bioactivator concentration of 150 ml. In contrast, the highest nitrogen content was found in treatment M1, which meant it had a concentration of 100 ml. In line with Prasetio & Widyastuti's research (2020), the higher the activator contained in organic fertilizer, the lower the nitrogen content. Based on SNI 19-7030-2004, liquid organic fertilizer contains at least 0.40 % nitrogen. In this liquid organic fertilizer, one treatment does not meet the quality of SNI 19-7030-2004, namely the K2M2 combination, which has an average nitrogen content of 0.38 %. It can be caused of the content of macronutrients is very dependent on the mixture of organic materials used in making fertilizer (Kasmawan, 2018).

Tests of Between-Subjects Effects

Dependent Variable: Kandungan_Nitrogen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.349[a]	3	.116	1162.750	.000
Intercept	5.347	1	5.347	53466.750	.000
factor_1	.055	1	.055	546.750	.000
factor_2	.114	1	.114	1140.750	.000
factor_1 * factor_2	.180	1	.180	1800.750	.000
Error	.001	8	1.000E-004		
Total	5.696	12			
Corrected Total	.350	11			

a. R Squared = ,998 (Adjusted R Squared = ,997)

Based on data analysis using the two-way ANOVA test, the results show that the probability (sig.) is 0.000 <0.05, then H0 is rejected, which means that there is a significant (significant) difference in the average nitrogen content based on factor 1, namely the addition of kirinyuh leaf extract and coconut water waste, as well as factor 2, namely the addition of pineapple skin bioactivator. The probability value (sig.) = 0.000 is obtained from the Test of Between-Subject Effects table.

3.2.5. Phosphorus Content

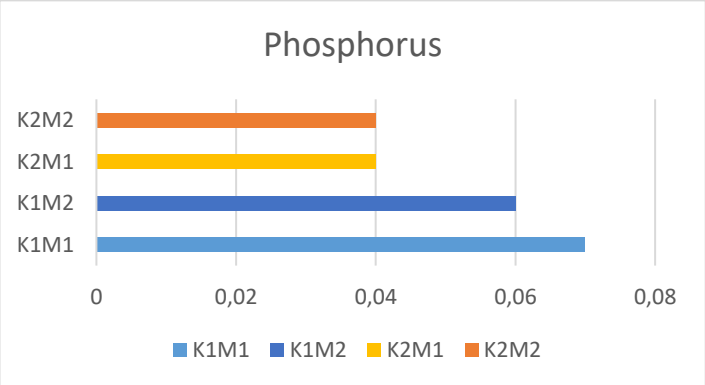


Figure 6. Diagram of the average phosphorus content of liquid organic fertilizer a combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

Based on table 2 above shows that each treatment has a different phosphorus content. The highest average phosphorus content is found in K1M1, which is 674.35 ppm (0.07 %). In comparison, the lowest moderate phosphorus content is in K2M1, equal to 388.39 ppm (0.04 %). Based on SNI 19-7030-2004, liquid organic fertilizer has a minimum phosphorus content of 0.10 %, so all samples of this liquid organic fertilizer do not meet the quality standards of SNI 19-7030-2004 because the phosphorus content has an average of 0.04 – 0.07 %. According to Sari & Alfianita (2019), there is an increase in phosphorus levels because the EM4 activator contains phosphate-solubilizing bacteria, which play a role in helping dissolve phosphate in organic matter resulting in high levels of phosphorus. Meanwhile, there was a decrease in phosphorus levels, presumably because the phosphate bacteria had finished reacting, causing the levels obtained to decrease. According to Sulfianti et al. (2021), the solution's acidity will affect the phosphorus content; the acidity of this solution will increase with the passage of fermentation time to a certain extent. In addition, the low phosphorus content can be caused by the aerobic fermentation process, in which composting by microorganisms is slow because these microorganisms prefer conditions without air so; that microorganisms have yet to develop optimally because the process of decomposition of organic matter runs slowly and produces low phosphorus content. Optimal development of microorganisms for the number of microorganism cells produced, the phosphorus content obtained is greater (Fahlevi et al., 2021).

Tests of Between-Subjects Effects

Dependent Variable: Kandungan_Pospor

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.002[a]	3	.001	6.750	.014
Intercept	.033	1	.033	330.750	.000
factor_1	.002	1	.002	18.750	.003
factor_2	7.500E-005	1	7.500E-005	.750	.412
factor_1 * factor_2	7.500E-005	1	7.500E-005	.750	.412
Error	.001	8	.000		
Total	.036	12			
Corrected Total	.003	11			

a. R Squared = ,717 (Adjusted R Squared = ,611)

Based on data analysis using the two-way ANOVA test, it was found that the probability (sig.) was 0.003 <0.05, then H0 was rejected, which means that there is a significant difference in the average phosphorus content based on factor 1, namely the addition of kirinyuh leaf extract and coconut water waste From the Test of Between-Subject Effects table, the probability value (sig.) = 0.003 is obtained. While factor 2, namely the addition of pineapple skin bioactivator, obtained a probability value (sig.) of 0.412 > 0.05, then H0 was accepted, meaning there was no significant difference in the average phosphorus content. But based on the results table for the average value of the phosphorus content above, there is a real difference.

3.2.6. Potassium Content

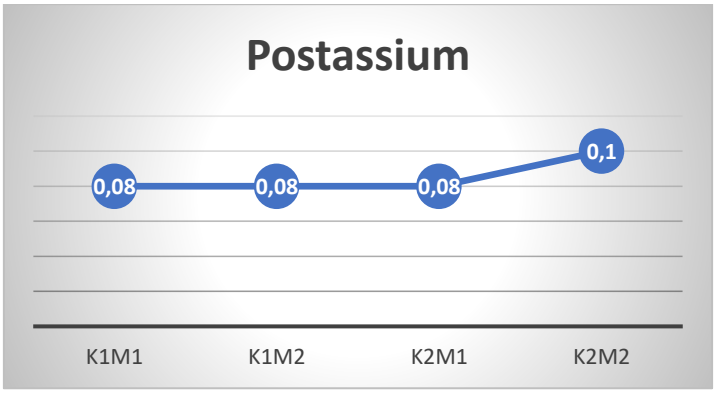


Figure 7. Diagram of the average potassium content of liquid organic fertilizer a combination of kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator

Table 2 shows that each treatment has a different potassium content. The highest average potassium content in the K2M2 treatment was 1049.74 ppm (0.10 %). In comparison, the lowest moderate potassium content is in K1M2, equal to 772.54 ppm (0.08 %). The role of potassium is as a catalyst for microorganisms that function to accelerate fermentation. If the fermentation goes fast, more and more materials are broken down, and the potassium contained can increase (Afifah, I., & Sopiany, 2017). It can be seen that the M2 treatment with 150 ml bioactivator has a higher potassium content than the content obtained from the M1 treatment with 100 ml bioactivator. In line with the research of Fahlevi et al. (2021), the greater the amount of EM4 used, the value of potassium obtained also increases. Based on SNI 19-7030-2004, the potassium content of liquid organic fertilizer is at least 0.20 %, so all samples of this liquid organic fertilizer do not meet the quality standards of SNI 19-7030-2004 because the potassium content has an average of 0.08 – 0, 10%. The reason why the potassium content differed from one sample to another was due to the large amount of EM4 added so that the number of microorganisms also increased during the decomposition process, which resulted in the breaking of carbon chains and the formation of simple carbon chains, increasing the element potassium (Fahlevi et al., 2021).

Tests of Between-Subjects Effects

Dependent Variable: Kandungan_Kalium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.001[a]	3	.000	3.000	.095
Intercept	.087	1	.087	867.000	.000
factor_1	.000	1	.000	3.000	.122
factor_2	.000	1	.000	3.000	.122
factor_1 * factor_2	.000	1	.000	3.000	.122
Error	.001	8	1.000E-004		
Total	.088	12			
Corrected Total	.002	11			

a. R Squared = ,529 (Adjusted R Squared = ,353)

Based on data analysis using the two-way ANOVA test, it was found that the probability (sig.) was 0.122 > 0.05, then H0 was accepted, which means that there was no significant (not significant) difference in the average potassium content based on factor 1, namely the addition of

leaf extract. kirinyuh and coconut water waste. Whereas factor 2, namely the addition of pineapple skin bioactivator, obtained a probability value (sig.) of 0.122 > 0.05, then H0 was accepted, meaning there was no significant difference in the average phosphorus content. The probability value (sig.) = 0.122 is obtained from the Test of Between-Subject Effects table. But based on the results table for the average potassium content value above, there is little real difference.

4. CONCLUSIONS

Based on the results of the study, it was shown that liquid organic fertilizer from kirinyuh leaves and coconut water waste with the addition of pineapple peels as a bioactivator in sensory tests, which included color, odor, and pH had good quality average results according to SNI 19-7030-2004 and the requirements from the Decree of the Minister of Agriculture of the Republic of Indonesia in 2011 concerning Minimum Technical Requirements for organic fertilizers. But some samples do not meet the quality because they have an unpleasant odor, namely K2M1. Meanwhile, based on the liquid organic fertilizer content test, only three treatments met the quality standards of SNI 19-7030-2004 on nitrogen content, namely K1M1, K1M2, and K2M1. In contrast, the phosphorus, potassium, and nitrogen content in the K2M2 treatment did not meet the quality standards of SNI 19-7030-2004.

After reviewing the results and conclusions of this study, the suggestions that can be given are recommended for further research using higher concentrations of ingredients and it is expected to be able to carry out further research on the application of liquid organic fertilizer from kirinyuh leaves and coconut water waste with the addition of pineapple peel as a bioactivator to plant.

5. ACKNOWLEDGMENTS

Thank you to those who have played a role and supported this research so that this research can run smoothly.

6. REFERENCES

Afifah, I., & Sopiany, H. M. (2017). Kandungan Nitrogen Dan Kalium Pupuk Organik Cair Kombinasi Kulit Nanas Dan Daun Lamtoro Dengan Variasi Penambahan Jerami Padi. *Skripsi*, *87*(1,2), 149–200.

Astiti, N. M. A. G. R., Laksmi, R. S., Eryani, G. A. P., & Suprapto, Y. (2022). *Aplikasi pupuk kandnag yang ramah lingkungan dalam perspektif budaya*. Scopindo Media Pustaka.

Echdar, S., & Maryadi. (2019). *Business Ethics And Entrepreneurship: Etika Bisnis Dan Kewirausahaan*. Deepublish.

Ekawandani, N., & Halimah, N. (2021). Pengaruh Penambahan Mikroorganisme Lokal (MOL) Dari Nasi Basi Terhadap Pupuk Organik Cair Cangkang Telur. *BIOSFER : Jurnal Biologi Dan Pendidikan Biologi*, *6*(Volume 6 No 2), 2–9. https://doi.org/10.23969/biosfer.v6i2.4944

Fahlevi, A. Y., Purnomo, Z. T., & Mulia Shitophyta, L. (2021). Pembuatan Pupuk Organik Cair dari Urine Kambing Jawa Randu dan Sampah Organik Rumah Tangga. *Rekayasa*, *14*(1), 84–92. https://doi.org/10.21107/rekayasa.v14i1.7560

Herdiyantoro, D. (2015). Upaya Peningkatan Kualitas Tanah Di Desa Sukamanah Dan Desa Nanggerang Kecamatan Cigalontang Kabupaten Tasikmalaya Jawa Barat Melalui Sosialisasi Pupuk Hayati, Pupuk Organik Dan Olah Tanah Konservasi. *Dharmakarya*, *4*(2), 47–53. https://doi.org/10.24198/dharmakarya.v4i2.10028

Hidayanti, E., Emilda, E., & Supriyatin, T. (2022). Respons Pertumbuhan Tanaman Kacang Hijau (*Vigna radiata*) terhadap Pemberian Pupuk Organik Cair Limbah Air Kelapa dan Keong Mas. *EduBiologia: Biological Science and Education Journal*, *2*(1), 14. https://doi.org/10.30998/edubiologia.v2i1.10222

Kasmawan, I. G. A. (2018). Pembuatan Pupuk Organik Cair Menggunakan Teknologi Komposting Sederhana. *Buletin Udayana Mengabdi*, *17*(2), 67. https://doi.org/10.24843/bum.2018.v17.i02.p11

Napitupulu, A., Marbun, P., & Supriadi. (2018). Pengaruh Pemberian Bahan Organik Kirinyuh (*Eupathorium Odoratum*) dan Titonia (*Tithonia Diversifolia*) Terhadap Sifat Kimia Tanah Ultisol dan Produksi Tanaman Jagung (*Zea Mays* L.). *Jurnal Agroekoteknologi FP USU*, *6*(3), 539–546. http://www.elsevier.com/locate/scp

Palupi, P. N. (2015). Ragam Larutan Mikroorganisme Lokal Sebagai Dekomposter Rumput Gajah (*Pennisetum purpureum*). *Ziraa'Ah*, *40*, 123–128.

Prasetio, J., & Widyastuti, S. (2020). Pupuk Organik Cair Dari Limbah Industri Tempe. *waktu: Jurnal Teknik UNIPA*, *18*(2), 22–32. https://doi.org/10.36456/waktu.v18i2.2740

Putri, K. A., Jumar, J., & Saputra, R. A. (2022). Evaluasi Kualitas Kompos Limbah Baglog Jamur Tiram Berbasis Standar Nasional Indonesia dan Uji Perkecambahan Benih pada Tanah Sulfat Masam. *Agrotechnology Research Journal*, *6*(1), 8. https://doi.org/10.20961/agrotechresj.v6i1.51272

Salasa, A. M. (2019). Aktivitas ekstrak kulit buah nanas (*Ananas comosus* L.) terhadap pertumbuhan Pseudomonas aeruginosa. *Media Farmasi*, *13*(2), 1–5.

Sari, M. W., & Alfianita, S. (2019). Pemanfaatan Batang Pohon Pisang sebagai Pupuk Organik Cair dengan Aktivator EM4 dan Lama Fermentasi. *Tedc*, *12*(2), 133–138. https://scholar.google.co.id/citations?view_op=view_citation&hl=id&user=GI0ef9YAAAAJ&citation_for_view=GI0ef9YAAAAJ:9yKSN-GCB0IC

Selviana, tri eti. (2019). Pengolahan Limbah Nasi Basi Menjadi Pupuk Organik Cair Mikroorganisme Lokal (Mol) Bagi Tanaman. *Program Studi Pendidikan Kimia Fakultas Keguruan Dan Ilmu Pendidikan, UNS*.

Siregar, E. S. (2017). Kualitas Pupuk Organik Cair (Biourin) yang Difermentasi Dengan Penambahan *Starter Effective Microorganism* 4 (EM4). *12345678*, *1*(1), 1–11.

SNI 19-7030-2004. (2004). *Spesifikasi kompos dari sampah organik domestik*. SNI.

Sucipto, E., & Hendariyono, J. (2018). Rancang Bangun Alat Disck Granulator Skala Laboratorium Pembuatan Pupuk Granul Organik Mikro Organisme Lokal (MOL). *Seminar Nasional Hasil Penelitian Dan Pengabdian Masyarakat*, 213–220.

Sulfianti, Risman, & Saputri, I. (2021). Analisis Npk Pupuk Organik Cair Dari Berbagai Jenis Air Cucian Beras Dengan Metode Fermentasi Yang Berbeda Npk Analysis of Liquid Organic Fertilizer From Various Types of Rice Washing Water With Different Fermentation. *Agrotech*, *11*(1), 36–42.

Supianor, Juanda, & Hardiono. (2018). Perbandingan Penambahan Bioaktivator Em-4 (*Effective Microorganisme*) Dan Mol (*Microorganisme Local*) Kulit Nanas (*Anana Comosus* L.Merr) Terhadap Waktu Terjadinya Kompos. *Jurnal Kesehatan Lingkungan*, *15*(1), 567–572. https://www.fairportlibrary.org/images/files/RenovationProject/Concept_cost_estimate_accepted_031914.pdf

Suryati, Misriana, Mellyssa, W., Razi, F., & Hayati, R. (2019). Pemanfaatan Limbah Air Kelapa sebagai Pupuk Organik Cair. *Procceding Seminar Nasional Politeknik Negeri Lhokseumawe*, *3*(1), 58–61.

Suwahyono, U. (2017). *Panduan penggunaan pupuk organik*. Penebar Swadaya Grup.

Vianti, A. S; Erlita, D; Puspitasari, A; Nugraheni, I. A. (2022). *New Product Development Of Liquid Organic Fertilizer From Industrial Liquid Waste Virgin Coconut Oil Using Fermentation Method*. *22*(2), 1–9.

Wijaksono, R. A., Subiantoro, R., & Utoyo, B. (2016). Pengaruh Lama Fermentasi pada Kualitas Pupuk Kandang Kambing (Effect of Fermentation Duration on Goat Manure Quality). *Jurnal Agro Industri Perkebunan*, *4*(2), 88–96.

Wiraswati, hesti lina, Kodir, reza abdul, Saputra, yudha hardianto eka, Anwar, C., & Kinanto. (2021). *Tumbuhan Obat: Ragam dan Potensi Area Reklamasi Tambang Batubara Site Kusan-Girimulya, Kalimantan Selatan*. Penerbit NEM.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Isolation and Characterization of Cellulolytic Bacteria from Bonoloyo, Cemetery

Wanda Datik Risnasari, Erma Musbita Tyastuti, Yasir Sidiq, Triastuti Rahayu*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: tr124@ums.ac.id

KEYWORDS:
Carboxymethyl cellulose
Cellulolitic bacteria
Cellulose
Cemetery
Isolation

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

A public cemetery (TPU) is land provided by the government to bury bodies. The culture of funerals in Indonesia is varied but generally involves being buried in the soil with wrapped clothes, covered wooden boards, and tombs. The material contains cellulose that will be broken down by cellulolytic microorganisms, including bacteria. The exploration of the cellulolytic bacteria of TPU in Indonesia has not been carried out, so this study aims to investigate and identify cellulose bacteria isolates from TPU. This research is a non-experimental study for the isolation of bacteria in the soil of TPU Bonoloyo, Surakarta. A selection of cellulite bacteria is grown in CMC media. Isolates that show cellulolytic activity are identified by observing colonial morphology and Gram coloring. Selection results of cellulolytic bacteria obtained isolates with cellulolytic index (IS) including a high category of 1 isolate (B14), a medium category of 3 isolates (B16, B27, and B45), and 9 low category isolates. The study concluded that 28.8 % showed cellulolytic activity with irregular morphological forms of white dyeing on flat surfaces with flat edges and dominated by gram-negative coccyx-shaped..

1. INTRODUCTION

The public cemetery land (TPU) is the land area provided for the burial of bodies for each person without distinction of religion or group (Diputra & Syaodih, 2017), whose management is regulated in Government Regulation Number 9 of 1987. Funerals in Indonesia have a diverse culture. Muslim bodies are buried in cloth (Ubaidillah et al., 2018). The bodies of Christians and Catholics were buried in clean clothes along with coffins (Dan Dare Arradhika, 2012). The culture of slaughtering bodies in Indonesia is generally buried in the soil.

In the cemetery there is an active process of body decomposition. The decomposition causes changes in the soil. According to (Majgier et al., 2014) the soil layer in the cemetery area underwent degradation and caused chemical changes such as increased organic carbon content, nitrogen, and soil alkaline reactions. However, the degree of change depends on the depth of the grave. Various types of soil microbes are found in large numbers, one of which is soil bacteria capable of degrading cellulose (Maravi & Kumar, 2020). The TPU has the possibility of finding cellulose degradation bacteria because the clothes, wooden boards, and coffins are buried. The buried material contains a high cellulose content of about 42-47% (Fengel & Wejener, 1995).

Cellulolytic bacteria are one of the microbes that break down cellulose into a simpler compound (Yusnia et al., 2019; Nofu et al., 2014). Cellulolytic bacteria are said to be potentially cellulose-degrading because they have a faster growth rate than other microbes and are easily controlled. (Arsyad et al., 2018; Yusnia et al., 2019). Cellulase enzymes play a major role in everything from agriculture to medicine and are also used in academic and industrial research as

they are easily obtainable (Pal et al., 2021; Harjuni et al., 2020). Cellulase enzymes are widely used in various types of industries, including the food and beverage industry, the textile industry, the detergent industry, the pulp and paper industry, the livestock feed industry, and agriculture (Harjuni et al., 2020). In agriculture, the enzyme cellulase can process coffee peel waste (Nurfitriani & Handayanto, 2017), and banana peel waste (Sukmawati, 2018).

From the search that has been done, cellulite bacteria have a lot of potential in various fields. Research related to the isolation of cellulolytic bacteria in Indonesia has been done a lot, among others, from the forest land in Bali (Yusnia et al., 2019), from yellow sugarcane waste (Nofu et al., 2014), from mangrove soil (Remijawa et al., 2020), from fermented weft (Raharjo & Isnawati, 2022), and from garbage soil (Murtiyaningsih et al., 2017). The results of the research on bogor subsoil grass obtained a cellulolytic index between 0.15 and 2.12 and a characterization of the morphology of the round-shaped colony, a glossy fine surface, a flat margin, as well as the elevation of the grass with the colony colors of white, cream, and lymph (Azizah, 2021), and in the study (Murtiyaningsih et al., 2017) of the garbage soil, a cellulolytic index of 0.85 with a predominant colony morfology of white and yellow color and smooth edges.

Publication articles on the isolation of cellulolytic bacteria have not been found after searches on the insulation of cellulitic bacteria from the cemetery. In the previous study, the bacteria were isolated from the cemetery of Bonoloyo, Surakarta, and 45 isolates were obtained (Laspartriana, 2023, not published), but the cellulolytic capabilities were not screened. Therefore, this study aims to select and identify cellulolytic bacterial isolates from TPU Bonoloyo, Surakarta. The results of this study are expected to yield bacterial isolates that have potential cellulolytic abilities. Furthermore, such isolates can be used for a variety of purposes, among them the treatment of organic waste, the alcohol industry, and the paper industry.

2. MATERIALS AND METHODS

1.1. Material

The tools used in this study include: Elenmeyer (*Pyrex)*, reaction tube (*Pyrex*), *autoclave (GEA LS-35LJ), petri dish (Iwaki), incubator (Memmert N55),* oven (*Maspion*), a digital scale (*Durascale DAB-E223*), spatula, *Laminar Air Flow* (LAF), *micropipette* (*Socorex*), *hot plate magnetic stirrer* (*Ciramec+*), reaction tube shelf, a micropipette (*Socorex*).

The materials used in this study include: 45 bacterial isolates from TPU Bonoloyo, which are from the collection of Biology Laboratory FKIP UMS, 70% alcohol, aquades, gloves, bacteriological agar (*Oxoid*), $NaNO_3$, K_2HPO_4, $MgSO_4$, $MnSO_4$, $FeSO_4$, $CaCl_2$. $2H_2O$. *Congo red*, *Carboxymethyl Cellulose* (CMC).

1.2. Methods

The research was conducted at the Biology Laboratory, Faculty of Education and Education Sciences, Muhammadiyah University of Surakarta, from March 2023 until April 2023. This research is a non-experimental study for the isolation of soil bacteria from TPU Bonoloyo, Surakarta.

1.2.1. The rejuvenation in Nutrient Media (NA)

The rejuvenation is done using NA media dissolved in aquades. The medium is sterilized by autoclave at a temperature of 121 ^oC at a pressure of 1 atm for 15 minutes. Each bacterial isolate is taken in as much as 1 loop and occulted on the NA medium, incubated at room temperature for

48 hours (Arifin et al., 2019). Successful rejuvenation is characterized by colonies growing on the media (Wahyuningsih, N.,& Zulaika, 2018).

1.2.2. The production of a solid cellulolytic

The production of a solid cellulolytic medium for the isolation and characterization of cellulose bacteria is achieved by dissolving $NaNO_3$ 2 g; K_2HPO_4 0,5 g; $MnSO_4$. $7H_2O$ 0,02 g; $MgSO_4$ 0,02 g; $FeSO_4$ 0,02 g; $CaCl_2.2H_2O$ 5 g; CMC 0,5 %; and bacteriological agar 10 g in 1 L aquades (Dar et al., 2015). It is then mixed using a magnetic stirrer on a hot plate, adjusted to a neutral pH and sterilized at a temperature of 121 ^oC for 15 minutes.

1.2.3. Testing of Cellulolytic bacterial activity

Bacterial isolates that have grown are then incubated at a temperature of 30 ^oC for 48 hours (Murtiyaningsih et al., 2017). After 48 hours, the bacterial isolate was vaccinated on a 1 % selective CMC medium using the point method (Yusnia et al., 2019) and incubated for 48 hours, after which it was given 0.1 % congo red for 15 minutes and rinsed with NaCl 1 M.

The qualitative index of cellulolytic bacteria is determined by looking at the presence of the clear zone. The value of the cellulolytic index (IS) is calculated by comparing the values of the clear zone diameter and the colony diameter value of bacteria. The cellulolytic index can be calculated using the following formula: (Nababan et al., 2019)

$$IS = \frac{clear\ zone\ diameter - the\ colony\ diameter\ value\ of\ bacteria}{the\ colony\ diameter\ value\ of\ bacteria}$$

1.2.4. Characteristics of Morphology

Macroscopic and microscopical observations carry out morphological characterization. Macroscopic observations include colony shape, elevation, edge, and color of bacteria (Raharjo & Isnawati, 2022). Microscopic observations are carried out with a Gram color test. Gram coloring is done by taking as much as 1 ounce of bacterial insulate diluted in 3 ml of sterile aquades and taking 10 µl then placed on the glass of the object and inspected. Add 1 drop of violet crystal for 1 minute, then wash with running water and dry. After drying, add 1 drop of iodine solution. After 1 minute, wash with running water. The bacteria are then isolated with 95 % ethyl alcohol for 30 seconds and washed with running water. Then the bacterial isolate is added to saffranin for 2 minutes and washed with running water. The preparation is dried by sticking the tissue on the side of the review, then dried, and then the preparation is observed using a light microscope with an enlargement of 1000×. Gram-positive bacteria are marked with purple-colored cells, and Gram-negative bacteria are marked with red cells (Kurniawan et al., 2019).

3. RESULT AND DISCUSSION

1.3. The Cellulolytic Index

According to the findings of the research that has been carried out, TPU Bonoloyo obtained 28.8 % (13 isolates) of cellulolytic bacteria among the 45 collections of bacteria found in the laboratory. The results of cellulite activity from the isolation of CMC-enriched bacteria can be seen in Table 1.

Table 1. The cellulite index of 13 isolates.

Isolated code	Colonial diameter (cm)	Clear zone diameter (cm)	Cellulite index (cm)
B1	0,7	1,9	1,71
B4	0,65	1,7	1,62
B12	1,55	2,9	0,87
B14	0,45	2,5	**4,56**
B16	1	3,55	2,55
B20	1,4	3,35	1,39
B25	1,6	3,75	1,34
B26	1,55	3,15	1,03
B27	1,1	3,65	2,32
B28	1,7	3,4	1,00
B31	0,7	1,75	1,50
B43	1,5	3,3	1,20
B45	0,75	3,25	3,33

1.4. Testing of Cellulolytic Bacteria Activity

Qualitative cellulolytic bacteria test with CMC media was carried out on previously isolated bacterial isolates and 13 isolates were obtained. Based on table 1 it can be seen that B14 isolate has the largest cellulolytic index of 4.56. This indicates that B12 isolates have the ability to degrade cellulose in CMC media to be higher than other isolates. The cellulolytic index value obtained in this study is included in the medium to high category.

The value of the cellulolytic index obtained from this study has a relatively greater value than other studies. In research (Harjuni et al., 2020) showed that cellulolytic enzyme activity from mangrove sediments obtained the highest cellulolytic index of 2.21±1.04 and the lowest cellulolytic index of 0.67±0.29. Cellulolytic bacteria from rice straw isolated by (Azizah, 2021) obtained a cellulolytic index of around 0.15±2.12. And the cellulolytic index value of 0.87 was obtained from fermented feed mixed with water hyacinth, corn cobs, and rice bran (Raharjo & Isnawati, 2022). This shows that bacterial isolates that have the highest cellulase enzyme activity can hydrolyze cellulose to glucose and show a large clear zone around the colony (Harjuni et al., 2020).

Carboxymethyl Cellulose (CMC) is the best substrate for cellulase production because it can induce bacteria to produce cellulase enzymes (Idiawati et al., 2015). The clear zone shows hydrolytic activity by the extracellular enzyme cellulase excreted by bacterial isolates of a certain diameter. The hydrolysis product is in the form of monosaccharide simple sugars and there is no complex bond with *congo red* (Azizah, 2021). Isolates that are able to decompose CMC are shown by the formation of a clear zone around the colony after staining using *Congo red* (**Fig. 1**).

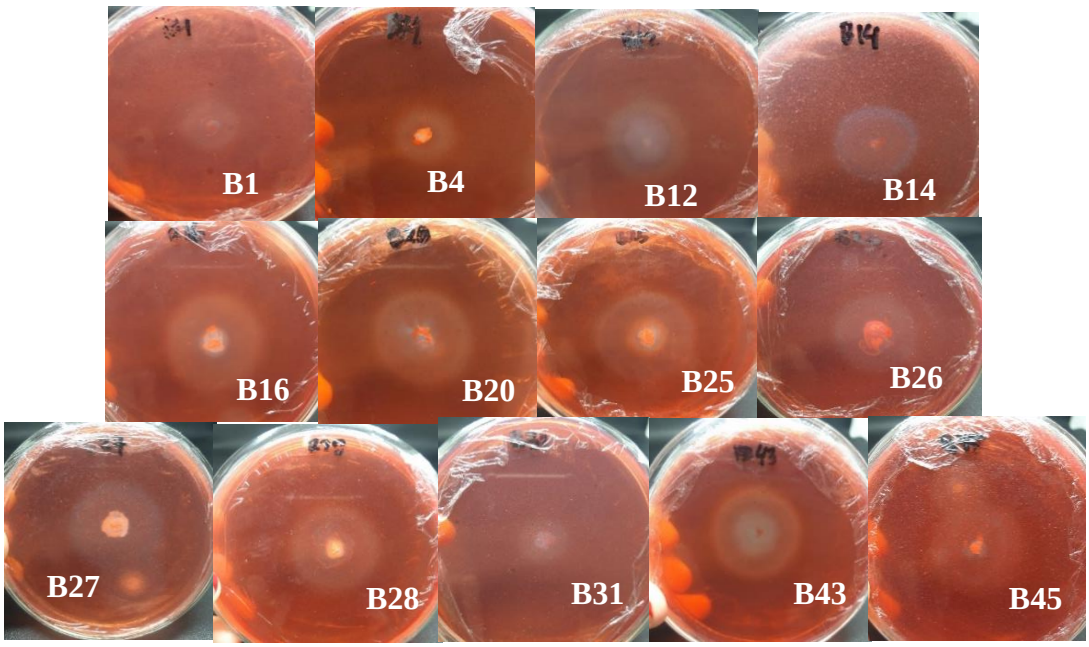


Figure 1. Qualitative cellulolytic bacteria activity test results (*Congo red*)

From the test results of cellulolytic bacteria activity shows different clear zone diameters. The ability of bacteria to break down cellulose can be seen from the difference in the speed of cellulose decomposition which is known to form clear zone areas. The higher the area of the clear zone produced can be assessed, the greater the ability of bacteria to degrade cellulose (Kurniawan et al., 2019). According to (Dar et al., 2015) the clear zone produced by cellulolytic bacteria that have a diameter above 4 cm can be categorized as high degradation rates while low degradation is in the range of 0.5–1.9 cm and medium 2.0–3.9 cm.

Based on the clear zone test results obtained, it shows that B12 isolate has the smallest cellulolytic index value with a value of 0.87 and B14 isolate has the largest cellulolytic index value of 4.56. The results of cellulolytic index testing and measurement can be seen in Table 1. It can be seen that IS (Cellulolytic Index) as many as 9 isolates obtained low degradation rate and as many as 3 isolates obtained medium degradation rate 1 isolate obtained high degradation rate at B14 which produces the largest cellulolytic index. According to (Upadhyay et al., 2012) that for each colony has a different production of clear zone diameters. (Azizah, Nur et al., 2014) added that the greater the cellulase activity index in isolates, the greater the cellulolytic activity produced.

Bacterial isolates with the highest degree of degradation obtained a cellulolytic index value of 4.56 and have the potential to be utilized in the needs of human life. Cellulose-degrading bacteria are needed in human life (Thomas et al., 2018) states bacteria are an important source of cellulase with various industrial and biotechnological applications. The potential of cellulolytic bacteria as cellulose degraders can be utilized for fish feed needs (Khulud, Janatul et al., 2021). Research (Kurniawan et al., 2018) added that cellulolytic bacteria from nature can be a solution to increase the digestibility of feed raw materials containing high fiber or cellulose.

1.5. Characterization of Cellulolytic Bacteria

Cellulolytic bacterial isolates were then observed colony morphology and Gram painting. The morphological features of the colonies of the 13 isolates can be seen in table 3.

Table 3. Morphological characters of cellulolytic bacteria

Isolation Code	Morphological Characters of Bacterial Isolate Colonies					Cell Characters	
	Color	Shape	Size	Edges	Elevation	Shape	Gram
B1	white	circular	small	entire	flat	*Coccus*	-
B4	milky white	irregular	small	undulate	flat	*Coccus*	-
B12	white	circular	medium	entire	Flat	*Coccus*	-
B14	white	circular	small	Entire	flat	*Coccus*	-
B16	milky white	irregular	medium	undulate	flat	*Coccus*	-
B20	white	irregular	medium	undulate	flat	*Coccus*	-
B25	milky white	irregular	medium	undulate	flat	*Coccus*	-
B26	white	circular	medium	entire	flat	*Coccus*	-
B27	yellowish white	irregular	large	undulate	flat	*Coccus*	-
B28	milky white	irregular	medium	undulate	raised	*Coccus*	-
B31	milky white	irregular	small	undulate	flat	*Coccus*	-
B43	white	circular	small	entire	flat	*Coccus*	-
B45	white	circular	small	entire	flat	*Coccus*	-

Table 2 shows that cellulolytic bacterial isolates obtained have a diversity of characters in terms of colonies, but not in terms of cell morphology. Based on cell morphological characters, 13 isolates of cellulolytic bacteria obtained are gram-negative coccus bacteria. Several previous studies supported these results, in a study (Azizah, Nur et al., 2014) showed that cellulolytic bacterial isolates obtained from vermicomposting empty oil palm bunches were gram-negative bacteria.

Colony morphological characterization in 13 isolates had varying colors, shapes, elevations and edges. The morphological characters of the obtained colonies are dominated by white colony color, irregular colony shape, flat colony elevation and entire colony edges. Differences in colony morphology in bacterial isolates are influenced by the isolation method used. This is in line with research (Satwika et al., 2021) that the isolation method used affects the characteristics of the isolates obtained. Bacterial isolates obtained from cemetery soil prove that the soil has potential as a cellulose degrader. However, the bacterial isolate is not yet known species identity, so further tests need to be carried out to determine its identity.

4. CONCLUSIONS

Bonoloyo burial ground, Surakarta is inhabited by bacteria that have potential cellulolytic activity. The morphology of the bacterial colony is dominated by white colony color, irregular colony shape, flat colony elevation and entire colony edge. As a result of Gram staining, the isolate is included in the gram-negative in the form of *coccus*.

5. ACKNOWLEDGMENTS

The author would like to thank several parties, including: 1) Universitas Muhammadiyah Surakarta for providing research funds for the Study Program Leading Research Scheme (PUPS) number: 110.30/A.3-III/LRI/VI/2022, 2) the Head of the Surakarta City Housing Office, who has given permission to take soil samples of TPU Bonoloyo.

6. SUGGESTION

This study obtained potential cellulolytic bacteria isolates, but the species identity is not yet known so further tests need to be carried out to determine the species of cellulolytic bacteria in the burial ground.

7. REFERENCES

Arifin, Z., Gunam, I. B. W., Antara, N. S., & Setiyo, Y. (2019). Isolasi Bakteri Selulolitik Pendegradasi Selulosa dari Kompos (Isolation of Cellulose-degrading Cellulolytic Bacteria from Compost). *Jurnal Rekayasa Dan Manajemen Agroindustri*, *7*(1), 30. https://doi.org/10.24843/jrma.2019.v07.i01.p04

Arsyad, S., Wiyono, S., & Herliyana, E. N. (2018). Screening of Cellulolytic Bacteria Origined from Termite Gut for Decomposing. *Jurnal Silvikultur Tropika*, *09*(3), 217–222.

Azizah, Nur, S., Muzakhar, K., & dan Arimurti, S. (2014). Screening of Cellulolytic Bacteria from Vermicomposting Empty Fruit. *Berkala Sainstek*, *02*(01), 26–30.

Azizah, S. N. (2021). Isolasi dan Karakterisasi Bakteri Selulolitik asal Jerami Padi di Persawahan Bogor Barat (Isolation and Characterization of Cellulolytic Bacteria from Rice Straw in West Bogor Rice Fields). *Jurnal Ilmiah Farmasi Akademi Farmasi Jember*, *2*(1), 19–28. https://doi.org/10.53864/jifakfar.v2i1.18

Dan Dare Arradhika. (2012). Taman Makam Vertikal Di Jakarta " Sebagai Taman Publik Dan Pemakaman Terpadudengan Pendekatan Arsitektur Pragmatik Utopian" (Vertical Cemetery in Jakarta "As an Integrated Public Park and Cemetery with a Utopian Pragmatic Architectural Approach") i–92.

Dar, M. A., Pawar, K. D., Jadhav, J. P., & Pandit, R. S. (2015). Isolation of Cellulolytic Bacteria from the Gastro-intestinal Tract of *Achatina fulica* (Gastropoda: Pulmonata) and their Evaluation for Cellulose Biodegradation. *International Biodeterioration and Biodegradation*, *98*, 73–80. https://doi.org/10.1016/j.ibiod.2014.11.016

Diputra, M., & Syaodih, E. (2017). Prosiding Perencanaan Wilayah dan Kota Identifikasi Permasalahan Tempat Pemakaman Umum di Kota Bandar Lampung (Proceedings of Regional and City Planning Identification of Public Burial Place Problems in Bandar Lampung City), *3*(2), 283–291.

Fengel, D., & Wejener, G. (1995). *Kayu: Kimia, Ultrastruktur dan Reaksi-reaksi (Wood: Chemistry, Ultrastructure and Reactions)*. Gajah Mada University Press.

Harjuni, F., . N., & Effendi, I. (2020). Kemampuan Biodegradasi Bakteri Selulolitik pada Ekosistem Mangrove (Biodegradation Ability of Cellulolytic Bacteria in Mangrove Ecosystems). *Jurnal Ruaya : Jurnal Penelitian Dan Kajian Ilmu Perikanan Dan Kelautan*, *8*(1), 60–68. https://doi.org/10.29406/jr.v8i1.1519

Idiawati, N., Harfinda, E. M., & Arianie, L. (2015). Produksi Enzim Selulase oleh *Aspergillus niger* pada Ampas Sagu (Production of Cellulase Enzymes by *Aspergillus niger* in Sago Dregs). *Jurnal Natur Indonesia*, *16*(1), 1. https://doi.org/10.31258/jnat.16.1.1-9

Khulud, Janatul, L., Febrianti, D., Prasetiyono, E., Robin, R., & Kurniawan, A. (2021). Eksplorasi, Seleksi dan Identifikasi Kandidat Bakteri Selulolitik asal Ekosistem Mangrove Sungailiat, Pulau Bangka (Exploration, Selection and Identification of Candidates for Cellulolytic Bacteria from the Sungailiat Mangrove Ecosystem, Bangka Island). *Jurnal Sains Dasar*, *9*(1), 23–29. https://doi.org/10.21831/jsd.v9i1.38899

Kurniawan, A., Awaludin Prihanto, A., Puspitasari, S., Kurniawan, A., Febriyanti, D., Khulud, L. J., Dewi, Y., Asriani, E., Sambah, A. B., Pertanian, F., Biologi, D., Belitung, B., Kampus, T., Balunijuk, K., Merawang, K., Bangka, P., Kepulauan, B., Belitung, I., Perikanan, F., … Id, A. C. (2018). Bakteri Selulolitik Pada Kayu Lapuk di Mangrove Sungailiat, Bangka dan Tukak Sadai, Bangka Selatan (Cellulolytic Bacteria on Weathered Wood in Sungailiat Mangrove, Bangka and Tukak Sadai, South Bangka). *Prosiding Seminar Nasional Lingkungan Lahan Basah*, *3*(April), 301–305.

Kurniawan, A., Sari, S. P., Asriani, E., Kurniawan, A., Sambah, A. B., Triswiyana, I., & Prihanto, A. A. (2019). Kapasitas Hidrolisis Bakteri Pendegradasi Selulosa dari Ekosistem Mangrove (Hydrolysis Capacity of Cellulose Degrading Bacteria from Mangrove Ecosystem). *Journal of Tropical Marine Science*, *2*(2), 76–82.

Majgier, L., Rahmonov, O., & Bednarek, R. (2014). Features of Abandoned Cemetery Soils on Sandy Substrates in Northern Poland. *Eurasian Soil Science*, *47*(6), 621–629. https://doi.org/10.1134/S1064229314060064

Maravi, P., & Kumar, A. (2020). Isolation, Screening and Identification of Cellulolytic Bacteria from Soil. *Biotechnology Journal International*, *24*(1), 1–8. https://doi.org/10.9734/bji/2020/v24i130092

Murtiyaningsih, H., Hazmi, & Butomo, M. (2017). Isolation and Test of Cellulase Enzyme Activity on Cellulolytic Bacteria from Waste Soil. *Jurnal Agritrop*, *15*(2), 293–308. http://jurnal.unmuhjember.ac.id/

Nababan, M., Gunam, I. B. W., & Mahaputra Wijaya, I. M. (2019). Produksi Enzim Selulase Kasar dari Bakteri Selulolitik (Production of Crude Cellulase Enzymes from Cellulolytic Bacteria). *Jurnal Rekayasa Dan Manajemen Agroindustri*, *7*(2), 190. https://doi.org/10.24843/jrma.2019.v07.i02.p03

Nofu, K., Khotimah, S., & Lovadi, I. (2014). Isolasi dan Karakteristik Bakteri Pendegradasi Selulosa pada Ampas Tebu Kuning (*Bagasse*) (Isolation and Characteristics of Cellulose Degrading Bacteria in Yellow Bagasse (*Bagasse*)). *Protobiont*, *3*(1), 25–33.

Nurfitriani, S., & Handayanto, E. (2017). Yang Diisolasi dari Timbunan Kulit Kopi di Perkebunan Kalibendo , Jawa Timur (Isolated from Coffee Skin Deposits in Kalibendo Plantation, East Java). *Jurnal Tanah Dan Sumberdaya Lahan*, *4*(2).

Pal, K., Sharma, T., & Sharma, D. (2021). An Overview of Cellulase Production and Industrial Applications. *Journal Homepage: Www.Ijpr.Com*, *02*(07).

Raharjo, A. P., & Isnawati. (2022). Isolasi dan Karakterisasi Bakteri Selulolitik pada Pakan Fermentasi Eceng Gondok, Tongkol Jagung, dan Bekatul Padi (Isolation and Characterization Cellulolytic Bacteria from Fermentation Feed of Water Hyacinth, Corncob, and Rice Bran). *Lentera*, *11*(1), 44–51. https://journal.unesa.ac.id/index.php/lenterabio/index44

Remijawa, S. E., Rupidara, N. D. A., Ngginak, J., & dan Radjasa, Karna, O. (2020). Isolasi dan Seleksi Bakteri Penghasil Enzim Ekstraseluler Pada Tanah Mangrove di Pantai Noelbaki (Isolation and Selection of Extracellular Enzyme-Producing Bacteria in Mangrove Soils on Noelbaki Beach). *Jurnal Enggano*, *5*(2), 164–180.

Satwika, T. D., Yulianti, D. M., & Hikam, A. R. (2021). Karakteristik dan Potensi Enzimatis Bakteri asal Tanah Sampah Dapur dan Kotoran Ternak sebagai Kandidat Agen Biodegradasi Sampah Organik (Enzymatic Characteristics and Potential of Bacteria from Soil, Kitchen Waste and Livestock Manure as Candidates for Biodegradation Agents of Organic Waste). *Journal of Biology and Applied Biology*, *4*(1), 11–18.

Sukmawati, S. (2018). Isolasi Bakteri Selulolitik dari Limbah Kulit Pisang (Isolation of Cellulolytic Bacteria from Banana Skin Waste). *Biotropic : The Journal of Tropical Biology*, *2*(1), 46–52. https://doi.org/10.29080/biotropic.2018.2.1.46-52

Thomas, L., Ram, H., & Singh, V. P. (2018). Inducible Cellulase Production from an Organic Solvent Tolerant *Bacillus* sp. SV1 and Evolutionary Divergence of Endoglucanase in Different Species of the genus Bacillus. *Brazilian Journal of Microbiology*, *49*(2), 429–442. https://doi.org/10.1016/j.bjm.2017.05.010

Ubaidillah, M. B., Ristianah, N., Mustofa, I., Jihad, Z. A., Wasi'ah, S., & Fitriah, A. (2018). Pelatihan Ketrampilan Pengurusan Jenazah Perempuan Melalui Metode Simulasi Peer Teaching bagi Ibu-ibu Fatayat Senjayan Gondang Nganjuk (Training on Women's Corpse Management Skills through the Peer Teaching Simulation Method for Fatayat Senjayan Gondang Nganjuk Mothers). *Janaka: Jurnal Pengabdian Masyarakat*, *8*(2), 59–67.

Upadhyay, S. K., Singh, J. S., Saxena, A. K., &, & Singh, D. P. (2012). Impact of PGPR Inoculation on Growth and Antioxidant Status of Wheat Under Saline Conditions. *Plant Biology*, *14*(4).

Wahyuningsih, N.,& Zulaika, E. (2018). Perbandingan Pertumbuhan Bakteri Selulolitik Pada Media Nutrient Broth dan Carboxy Methyl Cellulose (Comparison of Cellulolytic Bacteria Growth in Nutrient Broth Media and Carboxy Methyl Cellulose). *Jurnal Sains Dan Seni ITS*, *7*(2), 7–9.

Yusnia, E. D., Wayan Gunam, I. B., & Semadi Antara, N. (2019). Isolasi dan Skrining Bakteri Selulolitik dari beberapa Tanah Hutan Di Bali (Isolation and Screening of Cellulolytic Bacteria from some Forest Soils in Bali). *Jurnal Rekayasa Dan Manajemen Agroindustri*, *7*(1), 11. https://doi.org/10.24843/jrma.2019.v07.i01.p02

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Application of Project Based Learning Model to Improve Critical Thinking Skills of Students SMA Muhammadiyah 1 Sragen

Tasya Cahya Dwi Purwanti, Rina Astuti*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: rina.astuti@ums.ac.id

KEYWORDS:
Education
Project Based Learning (PjBL)
Critical thinking skills

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The goal of education is to develop each person's potential and competence so they can become good people. This study uses the Project Based Learning (PjBL) instructional model to enhance students' critical thinking abilities. Research types Qualitative description with a one-group pretest-posttest design that is pre-experimental in nature. 29 students make up the sample in this study. Tests and documentation are the tools used to obtain research data. The average posttest scores on each measure of the capacity to think critically have improved, according to the data. It is clear from the t-test findings that there is a significant difference between the pretest and posttest scores because the result was 0.000 < 0.05. The use of the Project Based Learning (PjBL) learning model in class X SMA Muhammadiyah 1 Sragen resulted in a boost in students' critical thinking abilities.

1. INTRODUCTION

The goal of education is to develop each student's potential and skills so they can become good people. Technology-based learning, information, and communication are prevalent in many spheres of life in the 21st century, including education. One of the objectives of education for the twenty-first century is to help students develop the four talents that make up the twenty-first century, known as the four Cs: communication, critical thinking, creativity, and collaboration. collaboration. Students must possess critical thinking abilities as one of their competencies. Students that possess critical thinking abilities can approach challenges in an organized manner, generate creative questions, and create acceptable answers to the issues they encounter.(Carter et al., 2018). Suitable learning frameworks, such as the Project-Based Learning (PjBL) paradigm, can be used to acquire these abilities.

A learning model known as the project-based learning model (PjBL) acknowledges that authentic questions and problems from real-world practice provide learning contexts and allow students to work together on an end product. Project-based learning models can help students develop their ability to analyze, synthesize, do/create, and reflect (Trilek et al., 2016). The use of project-based learning models (PjBL) has a number of benefits, including: a) increasing student learning motivation; b) building student confidence; c) encouraging student collaboration; d) encouraging student participation in learning activities; and e) preparing students to analyze information sources. (Nurul'Azizah & Wardani, 2019).

Some previous studies include (Pratiwi & Setyaningtyas, 2020; Saputro & Rahayu, 2020). The use of the Project Based Learning and Problem Based Learning learning models has different effects on students' critical thinking abilities, with the experimental group's (Project Based

Learning class) average critical thinking ability being higher than the control group's (Problem Based Learning class) average critical thinking ability. Another area of research focuses on the Project-Based Learning (PJBL) strategy, which combines traditional approaches with student learning. The Project-Based Learning (PJBL) model's results demonstrate its efficacy in boosting students' learning outcomes and critical thinking skills.(Kristiyanto, 2020; Sumardiana et al., 2019).

Based on observations made in SMA Muhammadiyah 1 Sragen, Because teachers are not conducting critical thinking skill assessments, pupils' critical thinking abilities are still not at their best. The learning which is frequently employed by teachers to impart material, makes pupils less engaged in the learning process, which results in less optimal understanding of the subject matter. Enhancing critical thinking abilities requires not just student-centered instruction but also a teacher-centered approach to the implementation of learning methodologies (Kurniawati & Astuti, 2022; Yusmanto et al., 2017).

Researchers are very interested in investigating students' thinking skills by using a project-based learning model in biology subjects on biotechnology material as shown from the description above, and by taking the title "Application of Project-Based Learning Models to Improve Critical Thinking Skills of SMA Muhammadiyah 1 Sragen Students".

2. MATERIALS AND METHODS

2.1. Types of research

His employs a qualitative descriptive research design for his study. The one group pretest-posttest design type of the pre-experimental design approach (pseudo-experimental) involves only one group; no other groups or comparisons are used.

Table 2.1 One group pretest-posttest research design

Pretest	Treatment PjBL	Postest
O1	X	O2

Source: (Dr, 2008)

Information:
O1 : Preliminary test before treatment
X : Giving PjBL Model Treatment
O2 : Final Test after Treatment

2.2. Population and Sample

This study was carried out at SMA Muhammadiyah 1 Sragen, which is situated at Sine, Sragen District, Sragen Regency, Central Java, at Jl. Sukowati No. 108. All members of SMA Muhammadiyah 1 class X made up the study's population. Class X-F, the experimental class, which had 29 pupils, served as the sample for this study. Purposive sampling was used in this study's sampling.

2.3. Data analysis

After all the data was collected, analysis of the data was done to assess the class X pupils at SMA Muhammadiyah 1 Sragen's critical thinking abilities utilizing the Project Based Learning (PjBL) instructional approach.

Critical Thinking Ability. Critical thinking indicators in this study there are only 5 indicators. A table of critical thinking markers is provided below.

Table 2.2 Critical-thinking signs

Indicators	Sub indicators
Give a simple explanation	Focus and analyze questions
Build Basic Skills	Observing and considering a report on the results of observations and the credibility of a source
Conclude	Set the strategy and tactics of deduction, induction and decision value
Provide further explanation	identify assumptions
Set strategy and tactics	define an action

As for the method of calculating data using percentage analysis techniques (Susilawati et al., 2020) The following formula is used to determine each critical thinking indicator's average value:

$$\sum \mathbf{SA} = \frac{\sum \mathbf{SP}}{\sum \mathbf{SM}} \times 100\%$$

Information:

$\sum$SA : Percentage of critical thinking ability

$\sum$SP : The total score

$\sum$SM : Total maximum score

The researcher identified the students' critical thinking categories after determining the percentage of pupils who demonstrated critical thinking skills. Giving categories seeks to ascertain the standards of the percentage of critical thinking among students. Table 2.3 illustrates it as follows.

Table 2.3 Categories of Critical Thinking Values

Percentage	Criteria
0 – 20	Not Critical
21 – 40	Less Critical
41 – 60	Pretty Critical
61 – 80	Critical
81 – 100	Very Critical

Source: (Setyorini et al., 2011)

Furthermore, the Paired-Samples T Test formula will be used to assess the collected data. It is required to create a statistical hypothesis first, as shown below, before testing the hypothesis.

Ha = There is a considerable variation in the usual student's critical thinking skills between the pretest and posttest learning results using the Project Based Learning (PjBL) learning model.

Ho = The typical student's critical thinking skills do not significantly differ between the pretest and posttest learning results when using the Project Based Learning (PjBL) learning model.

With the test requirements is sig. (2 tailed) < 0,05 Ha accepted. And Ho accepted if sig. (2 tailed) > 0,05.

3. RESULT AND DISCUSSION

3.1. Result

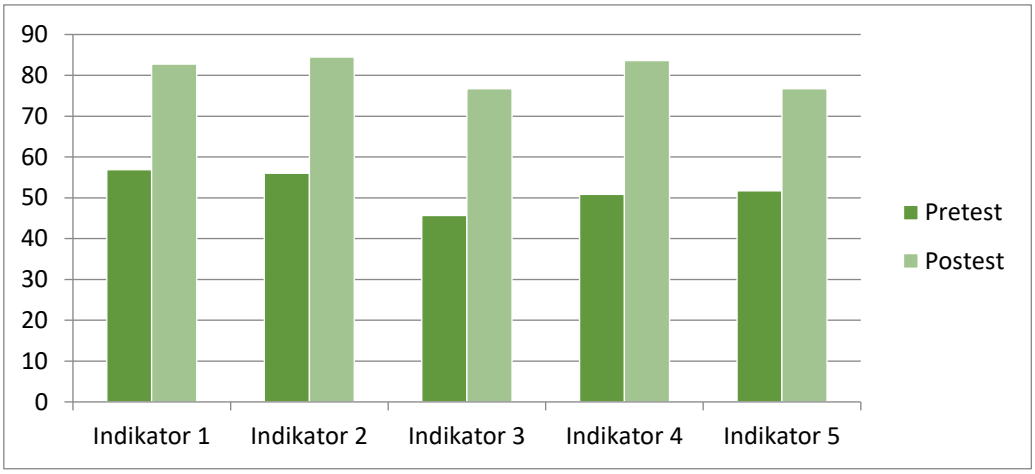


Figure 1. The typical critical thinking indication diagram

The average values for each indicator's pretest and posttest may be seen in the diagram above. The posttest outcomes improve with the use of the Project Based Learning (PjBL) learning model.

The data from the pretest and posttest were examined using the Paired-Samples T Test to see whether or not there was an improvement in the students' critical thinking abilities. Table 3 displays the findings of the analysis.

Table 3. Critical Thinking Ability Analysis Results

Grade	Mean	N	df	Taraf.sig	sig. Normal	sig. Homogen	sig. (2 tailed)
Pretest	52.24	29	28	0.05	0.110	0.212	0.000
Postest	80.86	29	28	0.05	0.140		

3.2. Discussion

The learning environment is described by the learning model. The learning model can be used for a variety of purposes, including creating lesson plans and curricula as well as creating learning materials. (Warsono, 2013). The Project Based Learning (PjBL) learning approach uses issues as the initial step in learning new information based on the experience of concrete life activities. (Fahrezi & Taufiq, 2020). The following are the learning processes for the Project Based Learning (PjBL) Model: deciding on fundamental issues; creating a project design; setting up schedules; keeping track of project progress; assessing project outcomes; and evaluating experience (Yulianto et al., 2017). The benefit of project-based learning (PjBL) is that it is one of the best learning methods for improving students' ability to think critically, make decisions, engage in action, and solve problems. challenges that might help students develop their self-management and self-confidence at the same time (Guo et al., 2020).

According to Figure 1, which demonstrates how the critical thinking skills of class X SMA Muhammadiyah 1 Sragen have developed, the average posttest score of students who used the Project Based Learning (PjBL) learning model falls into the category of very critical. The results of the pretest showed that each student did not meet the minimal completion requirements (KKM). After teacher instruction, group discussion, and finally the use of the Project Based Learning

(PjBL) learning model, which motivates students to learn and makes the material simple to comprehend and remember, the post-test results all meet the Minimum Completeness Criteria (KKM), indicating that students have a good understanding of the material.

The results of the research analysis show that for each measure of critical thinking skills, there is a difference between the outcomes of the pretest and posttest. Five characteristics of critical thinking: giving straightforward explanations, establishing fundamental competencies, drawing conclusions, offering additional explanations, and creating plans and methods. Indicator 1, provides a simple explanation that the pretest average value is 56.90 which is classified as a moderately critical category, while the posttest average value is 82.76 which is classified as a very critical category. In Indicator 2 Building basic skills, the average pretest was 56.03, which was classified as quite critical, while the posttest average score was 84.48, which was classified as a very critical category. In Indicator 3 Concluding the conclusion, the average pretest score is 45.69 which is classified as the Critical Enough category, while the post-test average value is 76.72 which is classified as a critical category. In indicator 4 Making further explanations, the average pretest value is 50.86 belonging to the moderately critical category while the post-test average value is 76.72 belonging to the critical category. In indicator 5 Developing Strategies and Tactics, the average pretest score is 51.72, which is classified as a moderately critical category, while the average post-test score is 76.72, which is classified as a critical category.

The use of the Project Based Learning (PjBL) learning model enhanced the students' capacity for critical thought, according to an analysis of the post-test and pretest average scores.(Ratu et al., 2021) It claims that the Project Based Learning (PjBL) learning style can be used to enhance students' critical thinking abilities and academic results. The very critical category is represented by the average posttest score of 80.86, while the moderately critical category is represented by the average pretest score of 52.24. If the findings of data analysis using the t-test are $0.000 < 0.05$, Ho is rejected and Ha is approved. ndicating that the differences are significant. This means that class X students at SMA Muhammadiyah 1 Sragen can use the project-based learning (PjBL) learning mode to hone their critical thinking skills.

4. CONCLUSIONS

According to an analysis of the average posttest and pretest scores. The class X SMA Muhammadiyah 1 Sragen's capability for critical thought demonstrates a considerable improvement in the learning model known as project-based learning (PjBL). The use of the Project Based Learning (PjBL) learning model in class X SMA Muhammadiyah 1 Sragen resulted in a boost in students' critical thinking abilities.

5. ACKNOWLEDGMENTS

Thanks to my supervisor who gave me extensive personal and professional guidance and taught me a lot about scientific research and life in general and all parties involved in this research I express my appreciation.

6. REFERENCES

Carter, A. G., Creedy, D. K., & Sidebotham, M. (2018). Measuring critical thinking in pre-registration midwifery students: A multi-method approach. *Nurse Education Today*, *61*, 169–174.

Dr, P. (2008). Sugiyono, Metode Penelitian Kuantitatif Kualitatif dan R&D. *CV. Alfabeta, Bandung*, *25*.

Fahrezi, I., & Taufiq, M. (2020). Meta-Analisis Pengaruh Model Pembelajaran Project Based Learning Terhadap Hasil Belajar Siswa Pada Mata Pelajaran IPA Sekolah Dasar. *Jurnal Ilmiah Pendidikan Profesi Guru*, *3*(3), 408–415. http://repository.unusa.ac.id/id/eprint/6662

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research*, *102*, 101586. DOI: https://doi.org/10.1016/j.ijer.2020.101586

Kristiyanto, D. (2020). Peningkatan kemampuan berpikir kritis dan hasil belajar matematika dengan model Project Based Learning (PJBL). *Mimbar Ilmu*, *25*(1), 1–10. DOI: https://doi.org/10.23887/mi.v25i1.24468

Kurniawati, L. W., & Astuti, R. (2022). *Penggaruh Penggunaan Google Classroom terhadap Kemampuan Berpikir Kritis Siswa pada Materi Sistem Ekskresi Kelas XI MIPA di SMA Negeri 1 Plupuh*. *2*(1), 1034–1042.

Nurul'Azizah, A., & Wardani, N. S. (2019). Upaya Peningkatan Hasil Belajar Matematika Melalui Model Project Based Learning Siswa Kelas V SD. *Jurnal Riset Teknologi Dan Inovasi Pendidikan (Jartika)*, *2*(1), 194–204.

Pratiwi, E. T., & Setyaningtyas, E. W. (2020). Kemampuan berpikir kritis siswa melalui model pembelajaran problem based learning dan model pembelajaran project based learning. *Jurnal Basicedu*, *4*(2), 379–388. DOI: https://doi.org/10.31004/basicedu.v4i2.362

Ratu, T., Sari, N., Mukti, W. A. H., & Erfan, M. (2021). Efektivitas Project Based Learning Terhadap Efikasi Diri dan Kemampuan Berpikir Kritis Peserta Didik. *Konstan-Jurnal Fisika Dan Pendidikan Fisika*, *6*(1), 1–10. DOI: https://doi.org/10.20414/konstan.v6i1.74

Saputro, O. A., & Rahayu, T. S. (2020). Perbedaan Pengaruh Penerapan Model Pembelajaran Project Based Learning (PJBL) dan Problem Based Learning (PBL) Berbantuan Media Monopoli terhadap Kemampuan Berpikir Kritis Siswa. *Jurnal Ilmiah Pendidikan Dan Pembelajaran*, *4*(1), 185–193. DOI: https://doi.org/10.23887/jipp.v4i1.24719

Setyorini, U., Sukiswo, S., & Subali, B. (2011). Penerapan model problem based learning untuk meningkatkan kemampuan berpikir kritis siswa SMP. *Jurnal Pendidikan Fisika Indonesia*, *7*(1). DOI: https://doi.org/10.15294/jpfi.v7i1.1070

Sumardiana, S., Hidayat, A., & Parno, P. (2019). Kemampuan berpikir kritis pada model project based learning disertai STEM siswa SMA pada suhu dan kalor. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *4*(7), 874–879. DOI: http://dx.doi.org/10.17977/jptpp.v4i7.12618

Susilawati, E., Agustinasari, A., Samsudin, A., & Siahaan, P. (2020). Analisis Tingkat Keterampilan Berpikir Kritis Siswa SMA. *Jurnal Pendidikan Fisika Dan Teknologi*, *6*(1), 11–16. DOI: http://dx.doi.org/10.29303/jpft.v6i1.1453

Trilek, W., Piriyasurawong, P., & Jeerungsuwan, N. (2016). Collaborative Project–Based Learning via Augmented Reality on m-Learning Model to Enhance Basic ASEAN Community Skills for Thai and the Lao PDR Students. *International Journal of Information and Education Technology*, *6*(10), 813–816. DOI: 10.7763/IJIET.2016.V6.798

Warsono, H. (2013). Pembelajaran Aktif Teori dan Assement, edisi 2. *Bandung: Remaja Rosdakarya*.

Yulianto, A., Fatchan, A., & Astina, I. K. (2017). Penerapan model pembelajaran project based learning berbasis lesson study untuk meningkatkan keaktifan belajar siswa. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *2*(3), 448–453. DOI: http://dx.doi.org/10.17977/jptpp.v2i3.8729

Yusmanto, H., Soetjipto, B. E., & Djatmika, E. T. (2017). The Application of Carousel Feedback and Round Table Cooperative Learning Models to Improve Student's Higher Order Thinking Skills (HOTS) and Social Studies Learning Outcomes. *International Education Studies*, *10*(10), 39–49. DOI: doi:10.5539/ies.v10n10p39

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Kefir Combination Between of Goat's Milk and Skim Milk on Variations of Sugar and Fermentation Duration

Erna Kurniawati, Titik Suryani*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: ts169@ums.ac.id

KEYWORDS:
Acid Total
Cane sugar
Fermentation Duration
Goat's Milk
Kefir
Organoleptic
Palm sugar
Skim Milk

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Kefir is a probiotic bevarage produced by live lactic acid bacteria. One of the innovative ingredients for kefir is goat's milk, skim milk, and variations of sugar (cane sugar and palm sugar). The nutritional content of goat's milk is 2.2% protein, 14.7% fat, and 3% fiber, and 4.80% lactose. The addition of skim milk in the manufacture of kefir can increase the total sugar content. The addition of sugar as a source of nutrition for kefir grain starter bacteria. The purpose of this study was to quality of kefir combination between of goat's milk and skim milk on variations of sugar and fermentation duration. This study used an experimental method and a completely randomized design (CRD) with two factors. The first factor is the variations of sugar (A) palm sugar and cane sugar. Factor II (B) is the variations of fermentation duration for 24 hour, 36 hour, and 48 hour. The results showed that the best total kefir acid content combined with goat milk and skim milk was 0.797%, pH 4 in the A2B1 treatment (30 g cane sugar + 24 hour of fermentation duration). The best organoleptic quality was in the A2B1 treatment (30 g cane sugar + 24 hour of fermentation duration) with a sour taste, white color, tasty flavour, and soft texture.

1. INTRODUCTION

Probiotic bevarage are drinks made with the fermentation process using BAL that can produce organic acids and contain living cells that are able to survive in active conditions in the digestive tract (Elsaputra *et al*., 2016). Probiotic drinks can be consumed by anyone at any time, including children and adults (Aritonang *et al*., 2019). One of the probiotic milk drinks is kefir. Kefir is a fermented milk drink that uses kefir seeds as a starter and contains lactic acid and khamir bacteria (Kintekik, 2018). Kefir is very popular among the public as a probiotic drink because it can prevent and treat various diseases such as heart, kidney, lung, and liver diseases, lower cholesterol, increase appetite, and keep the body fresh (Rahmah *et al*., 2016). Kefir contains proteins with all essential amino acids, vitamins (vitamines A, B1, B2, B5, B6, B7, B9, B12, C and K) and minerals (potassium, calcium, phosphorus, magnesium, iron, zinc, copper, and manganese) (Lararenjana, 2020). According to the Indonesian National Standard (SNI), kefir has a total acidity of about 0.2-0.9%, a pH of 4-4.6, and a protein content of 3.2%. Kefir can be made from various types of milk, including goat's milk.

Goat milk has a relatively high nutritional content, and goat's milk fat and protein are easier to digest (Afrizal, 2019). The nutritional content of goat milk is 22 % protein, 14.7 % fat, 819 mcg vitamin B12, 3 % fiber, 4.80 % lactose, 0.72 % and 87.10 % water (Martharini, 2017). Goat milk contains short chain fatty acids and more easily digestible proteins, and the excess can improve the quality of the kefir produced (Aristya *et al*., 2013). Goat milk has a complete nutritional

content, but is not popular because the goat flavour that dominates the "prengus" flavour comes from short-chain and moderate fatty acids such as kaproat, caprilate, and kaprat (Balia *et al*., 2011). Goat milk has a good chemical composition and provides good benefits for body health because it contains many nutrients that play a role in body health, such as those that repair the digestive tract, act as a metabolic agent, and repair damaged cells (Arief, 2018). The "prengus" flavour in goat milk can disappear during the fermentation process and can also occur when goat's milk kefir needs to be added to skim milk.

Skim milk is milk with a maximum fat content of 1% and a protein content of 35.6% (Anon, 2012). According to Mandei (2019), skim milk has a fat content of 0.50%, protein of 1.10%, ashes of 0.68%, and acidity of 0.8%, skim milk as a source of nitrogen to carry out the growth of microorganisms during fermentation also improves nutritional value. Skim milk can be used as an additive in the manufacture of kefir. Smooth milk can be an alternative to being added to probiotic drinks to improve their consistency and stability. Smooth milk can also add nutritional value and enhance the taste of probiotic drinks (Handayani *et al*., 2016). The primary function of skim milk in probiotic beverages is as a source of nutrients because it contains lactose, which BAL uses as an energy source for growth (Hakiki, 2022).

The quality of kefir is influenced by various factors such as kefir seeds, milk type, type of sugar, time, temperature, and time of fermentation (Gamba *et al*., 2020). Sugar is a source of food or energy for kefir grains. Palm sugar has sucrose 84.31%, manganese, boron, nitrogen, phosphorus, folic acid, vitamin A, and vitamin B1 (Ardiana, 2019). The nutritional content of cane sugar consists of potassium, phosphorus, iron, and vitamin A. 100 g of cane sugar contains energy 394 kcal, protein 0 g, calcium 5 mg, phosphate 1 mg, sodium 1 g, and sodium 94 g (Basigili, 2018). A study by Nisa *et al* (2018) found that lactic acid bacteria used sugar as a source of growth energy and produced metabolites of lactic acids during fermentation, where the more sugar was added, the more substrates were available for bacterial microbes to enhance their activity. Fermentation duration is one of the factors in the process of making kefir. Fermentation duration affects the strength of kefir (Safitri, 2017). The pattern of changes in lactic acids, acetate, and citrate is the same, increasing with storage (Leite *et al*., 2013). The purpose of study was to determine quality of kefir combination between goat's milk and skim milk on variations of sugar and fermentation duration.

2. MATERIALS AND METHOD

2.1. Time and place of research

The study was conducted in February – June 2023 at the Biology Laboratory of the Faculty of Teacher Training and Education of the Universitas Muhammadiyah Surakarta. Testing of pH levels and organoleptic qualities (flavour, taste, color, texture, and acceptability) in the Biology Laboratory of Universitas Muhammadiyah Surakarta, and acid total testing was carried out in the Chem Mix Laboratory Pratama Yogyakarta.

2.2. Materials

Tools used in the manufacture of kefir combination between goat milk and skim milk are stoves, pots, glasses, pH meters, bottles, tablespoons, analytical scales, thermometers, washing soaps, fabrics, writing tools, and other documentation equipment. On the other hand, the ingredients used for kefir are goat milk, skim milk, palm sugar, cane sugar, and kefir grain.

2.3. Research Procedure

The research process includes: 1. Stage of preparation 2. Sterilization of equipment 3. The stage of execution then we test the parameters (pH, organoleptic, and acid total).

2.4. Research Design

This research used an experimental method with research design was Completely Randomized Design (CRD). This study is RAL with 2 factors, namely, type of sugar (A1 = Palm sugar 16 g, A2 = Cane sugar 30 g) and fermentation duration (B1 = 24 hour, B2 = 36 hour, B3 = 48 hour). Testing the acid total content by titration method, presenting it in the form of a table with the final result in the shape of a percentage, and performing an organoleptic test with a questionnaire sheet of 15 panelists. To know the results of organoleptic quality research, the data analysis used by the researchers was qualitative and descriptive. Qualitative descriptions to describe the test results of acid total levels through titration methods and the results of organoleptic quality tests include color, flavour, texture, taste, and acceptability of kefir, assisted by the use of a questionnaire. By analyzing the data can be known the final results of the data of the test results and useful to draw conclusions in the research.

2.5. Analysis Data

Research data were presented in the form of tables. Acid total testing analysis using quantitative descriptive methods. During organoleptic testing, color, texture, taste, flavour and acceptability. Quantitative test data analysis using a two-way variance analysis test (Two Way ANOVA) and qualitative test data analysis using Excel.

3. RESULTS AND DISCUSSION

3.1. Result

Based on the study of pH testing and acid total kefir combination between goat milk and skim milk on variation of sugar and fermentation duration that have been performed on six samples, the following results were obtained:

Table 1. Results of pH and acid total kefir combination between goat milk and skim milk on variation of sugar and fermentation duration.

Treatment	Acid Total (%)	pH
A1B1 palm sugar 16 g and 24 hour	1.131	4**
A1B2 palm sugar 16 g and 36 hour	1.271	3.8
A1B3 palm sugar 16 g and 48 hour	1.344**	3.4
A2B1 cane sugar 30 g and 24 hour	0.797*	4**
A2B2 cane sugar 30 g and 36 hour	1.059	3.6
A2B3 cane sugar 30 g and 48 hour	1.13	3.1*

Description:
* The lowest value
** The highest value

Based on the study of organoleptic quality testing levels of acid total kefir combination between goat milk and skim milk on variations of sugar and fermentation duration that has been carried out on six samples, the following results were obtained:

Table 2. Result of Organoleptic quality kefir combination between goat milk and skim milk on variation of sugar and fermentation duration

No	Treatment	Organoleptic quality (aspect)				
		Taste	Color	Flavour	Textures	Acceptability
1	A1B1 palm sugar + 24 hour	Sour	Brownish white	Tasty	Softly	Less like
2	A1B2 palm sugar + 36 hour	Sour	Brownish white	Tasty	Softly	Less like
3	A1B3 palm sugar + 48 hour	much sour	Brownish white	Tasty	Softly	Less like
4	A2B1 cane sugar + 24 hour	Sour	White	Tasty	Softly	Like
5	A2B2 cane sugar + 36 hour	Sour	White	Tasty	Softly	Like
6	A2B3 cane sugar + 48 hour	Sour	White	Tasty	Softly	Less like

3.2. Discussion

3.2.1 Acid Total

Based on a study of the total kefir acid total test combination between goat milk and skim milk on variations in sugar and fermentation duration carried out on six samples, the results showed that the best acid total value on treatment A2B1 (cane sugar 30 g + 24 hour fermentation duration) was 0.797 % and pH 4. The acid total result of treatment A2B1, according to SNI (2009), was 0.2 – 0.9 % pH of 4-4,6. The decrease in acid total output was affected by bacterial activity. Bacterial activity was influenced by energy sources. The more energy sources available, the more bacterial activity increases, so the acid produced also affects the decrease in the pH of kefir. The total acidity in palm sugar is higher than in cane sugar. Sucrose is a source of energy and carbon that is consumed by BAL and produces acids during the fermentation process of the sugar. Cane sugar content is not higher than palm sugar, so the bacterial activity in kefir added palm sugar is higher than sugar added kefir. Palm sugar contains approximately 84 % more sucrose compared to beet sugar and bit sugar, which are only 20 % and 17 % respectively, so palm sugar is able to provide higher energy than beet and sugar beet (Lempang, 2020). The highest sucrose content was found in palm sugar of 84.31 % compared to cane sugar of 71.89 % (Yudho, 2021). In the study Widya *et al* (2018) also stated palm sugar contains higher sucrose 84 % compared to cane sugar which is 20 %. This is demonstrated by the results of statistical tests with Two Way Annova showed that the significance value obtained of 0,05 (0,000<0,05) means there is a significant influence on the interaction between types of sugars on the acid total of kefir in the combination of goat milk and skim milk. This suggests that there is a real interaction between the types of sugar used. Research by Nisa *et al* (2018) also found that lactic acid bacteria utilized sugar as a source of growth energy and produced the metabolites of lactic acids during fermentation, where the more sugar added, the more substrate available for the microbes, so that their activity increased. The acetic acid formed during fermentation causes a decrease in the pH value. Beverage products are affected by organic acids such as acetic acid and pyruvate acid that form during the fermentation process (Hawusiwa *et al*., 2015).

The fermentation duration is one of the factors affecting the quality of the combination of goat milk and skim milk. The fermentation duration used has a significant effect on the total acid content. Long-term processing of fermentation will cause the pH to decline due to the BAL activity

in breaking down carbohydrates into lactic acid. High acid total content can be caused by the lactic acid bacteria (BAL) that break down glucose into lactate acid, which is available in large amounts, so that the milk acid produced is also increasing. Similarly, the low total acid content can be caused by the fact that the lactic acid bacteria that break down glucose into lactate acid are available in fewer amounts, so the production of lactic acids is also getting lower. This is in line with the opinion of Hidayat *et al*.,(2013) which states that during the fermentation process, lactic acid bacteria will ferment existing carbohydrates to form lactic acids. The formation of these acid total leads to increased acidity and decreased pH values. This is demonstrated by the results of statistical tests with Two Way Annova showing that the significance value obtained of 0,05 (0,000<0,05) means there is a significant influence on the interaction between the fermentation duration and the acid total kefir content of the combination of goat milk and skim milk. This suggests that there is a real interacting relationship between the fermentation duration. According to the Rohmah study (2018) the longer the storage time of certain pH values the more it decreases. The pattern of changes in lactic acid, acetate, and citrate looks the same and increases with the duration of storage (Leite *et al*., 2013). Kartikasari and Nisa (2016) add that the formed lactic acid will be secreted out of the cells and accumulated in the fermentation medium, so that the longer the time of fermentation, the more the total amount of acids will increase and lower the pH. Based on the results of the Two Way Annova statistical test, which shows sig 0.000 <0.05 that there is a significant effect on the total sugar variation and fermentation duration. The results of Duncan's further test showed that the fermentation duration of 48 hour had a significant effect on the acid total of the kefir combination of goat milk and skim milk This is demonstrated in the long-term treatment of the 48 hour fermentation, which produced the highest acid total compared to the 24 hour and 36 hour fermentation treatments.

3.2.2 Organoleptic Quality

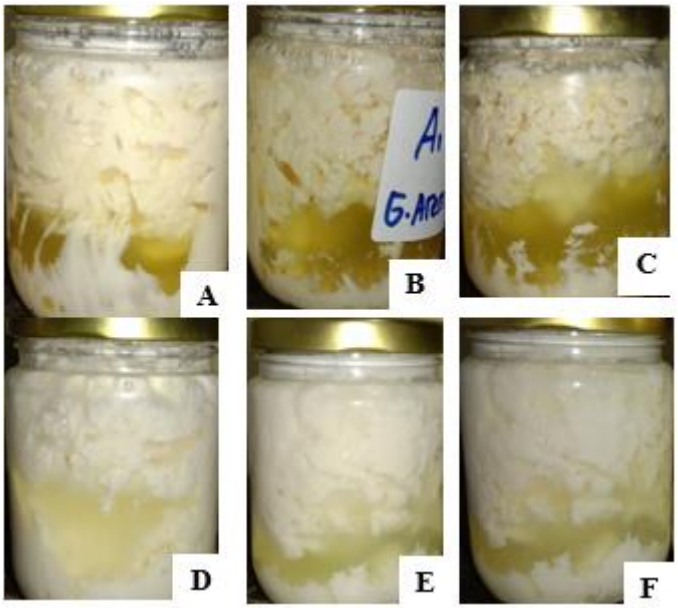


Figure 1. Results of kefir combination between goat milk and skim milk on variation of sugar and fermentation duration

Description:

A. A1B1 palm sugar 16 g + 24 hour

B. A1B2 palm sugar 16 g + 36 hour

C. A1B3 palm sugar 16 g + 48 hour
D. A2B1 cane sugar 30 g + 24 hour
E. A2B2 cane sugar 30 g + 36 hour
F. A2B3 cane sugar 30 g + 48 hour

Based on studies of organoleptic quality testing of kefir combination between goat milk and skim milk on variations of sugar and fermentation duration that have been carried out on six samples, treatment A2B1 (cane sugar 30 g + 24 hour fermentation duration) showed the best results with white color, a sour taste, a tasty flavour, and a soft texture. The results of organoleptic quality treatment A2B1 in accordance with SNI (2009) indicate that the kefir beverage should have a liquid or thick appearance, a typical normal flavour, and a characteristic acid flavour. Based on Table 2, the result indicates that the kefir combination of goat milk and skim milk has a distinctive taste of acid with a characteristic flavour of acid total that is delicious. Consumers are more likely to pay attention to the taste parameters compared to the nutritional content of the product (Putri and Mardesci, 2018). BAL is the main metabolite that plays a role in the formation of acid total which produces an acidic taste (Rohmah and Estiasih, 2019). Rismawati (2015) stated that the smell of a food or beverage product plays an important role in evaluating a product. The resulting characteristic flavour can be felt by the sense of smell depending on the constituent material or different ways of processing can change the resulting flavour. Kefir has a tape-like smell caused by khamir activity in kefir seeds. Harun e*t al*., (2013) added that the smell of fermented milk is due to the presence of acetaldehyde, diasethyl, acetic acid and other acids in small amounts. Acetaldehyde is a chemical compound. The acid smell is derived from the conversion of sugar into alcohol. Khamir breaks down simple sugars into carbon dioxide and a little alcohol which causes the Flavour to tend to be acidic. The “prengus” flavour of goat milk is also no longer scented, due to the process of fermentation and the addition of skim milk. The longer the fermentation, the more acidic the taste will be, and the smell will be more intense.

Based on Figure 1 it is clear that in terms of color, the kefir combination of goat milk and skim milk on the treatment A1B1 (palm sugar 16 g + 24 hour) A1B2 (palm sugar 16 g + 36 hour) , and A1B3 (palm sugar 16 g + 48 hour), The color is chocolate of the equipment can appear due to the basic ingredients of the palm sugar. On the treatments A2B1 (cane sugar 30 g + 24 hour), A2B2 (cane sugar 30 g+ 36 hour), and A2B3 (cane sugar 30 g + 48 hour), the color is white. This is in line with the study by Kinteki *et al* (2018) Changes in visible color are influenced by the fat content and color of different types of sugars. Sugar is brown color so when kefir is differentiated, it produces a bright white color. Cane sugar has a white color, so the resulting kefir is also white. The lactic acid bacteria, or BAL play a role in causing color changes due to the fermentation process. This shows that the kefir produced has met the SNI quality criteria, so it is safe to consume.

Based on Table 2, it is shown that in terms of texture, the combination of goat milk and skim kefir in all treatments has the same texture, which is soft. The composition of goat milk and skim milk kefir has a soft texture due to its low flavor content, which is consistent with the results of the Nurkhoeriyati (2017) study, which stated that the flavor sourness that goat’s dairy kefir possess is lower compared to commercial kefir. Skim milk also affects the texture produced by kefir. This is in line with the study of Lestari (2021), which stated that the higher the total kefir solidity of corn milk, the thicker the texture of the kefir milk products produced. This is also due to the process of milk coagulation due to microbial activity in the starter because of the use of lactose and casein,

resulting in the occurrence of kefir texture changes. The soft texture formed in fermented milk is due to the agglomeration of proteins by the acid produced during the fermentation process.

Based on Figure 1, the average rate of preference for kefir combination of goat milk and skim milk on treatment A2B1 (cane sugar 30 g + 24 hour fermentation duration) is highly preferred by panelis. This is because most panelis love the sour taste, white color, sweet smell, and soft texture that kefir possesses. This is in line with Rohman (2019) research that shows that the taste and smell that appear on kefir will affect the overall preference of panelists toward kefir. Consistency in a food product will affect the level of consumer acceptance. Color, smell, and taste parameters can be said to be a combination of the overall assessment of the appearance (Angraiyati, 2017).

4. CONCLUSIONS

The best acid total kefir combination between goat milk and skim milk on treatment A2B1 (cane sugar 30 g + 24 hour fermentation duration) was 0.797 % and pH 4. It is in accordance with the standard quality of probiotic beverages kefir according to SNI 7552 : 2009 which is the total amount of acid 0.2 – 0.9 % and pH 4 – 4.6.

The best organoleptic quality of kefir on the A2B1 treatment (cane sugar 30 g + 24 hour fermentation duration) has an sour taste, a white color, a tasty flavour, a soft texture, and the level of preference preferred by the panelists. Acid total content and organoleptic quality of the kefir combination between goat milk and skim milk have been in accordance with SNI quality.

5. ACKNOWLEDGMENTS

Thank you to the Biology Education Study Program for providing subsidized assistance in INCOBEST.

References

Al-Baarri, A. N., A. M. Legowo dan T. W. Murti. (2003). Fermentasi sebagai upaya menghilangkan Flavour “prengus” susu kambing. In*donesia Tropis Animal Agriculture Journal* 28 (4): 230-238.

Angraiyati, D., & Hamzah, F. (2017). Daun Pandan Wangi (*Pandanus Amarylifolius Roxb*.,) Terhadap Aktivitas Antioksidan (*Doctoral dissertation*, Riau University).

Anonimus. (2012). Kandungan Nutrisi/GiziSusu Skim. Publikasi Kementerian Kesehatan Republik Indonesia. Jakarta. Available from http://www.organisasi.org/1970/01/is i-kandungan-gizi-tepung-susu-skimkomposisi-nutrisi-bahanmakanan.html. Diakses 17 Juli 2015

Arief, R, W, Novilia, S dan Robet, A. (2018).” Pengenalan Pengolahan Susu Kambing Di Kecamatan Sukadana Kabupaten Lampung Timur”. *Jurnal Teknologi & Industri Hasil Pertanian*. 23 (1).

Aristya, A, L, Anang, dan Ahmad, N, A. (2013).” Total Asam, Total Yeast, Dan Profil Protein Kefir Susu Kambing Dengan Penambahan Jenis Dan Konsentrasi Gula Yang Berbeda”. *Jurnal Pangan dan Gizi*. 4 (7).

Aristya, A. L., A. M. Legowo dan A. N. Al-Baarri. (2013). Karakteristik fisik, kimia, dan mikrobiologis kefir susu kambing dengan penambahan jenis dan konsentrasi gula yang berbeda. *Jurnal Aplikasi Teknologi Pangan* 2(3): 139143.

Aritonang, S. N., Roza, E., & Rosi, E. (2019). Probiotik dan Prebiotik Dari Kedelai untuk Pangan Fungsional. In Indomedia Pustaka

Balia, R. L., H. Chairunnisa., O. Rachmawan dan E. Wulandari. (2011). Derajat keasaman dan karakteristik organoleptik produk fermentasi susu kambing dengan penambahan sari kurmayang diinokulasikan berbagai kombinasi starter bakteri asam laktat. *Jurnal Ilmu Ternak* 11(1): 49-52

Basagili, Muhammad Iqbal. (2018). Kandungan Gula Pasir. https://nilaigizi.com/gizi/detailproduk/1097/nilai-kandungan-gizi-gula-putih-gula-pasir. Diakses tanggal 2 Oktober 2022

Elsaputra., U. Pato., dan Rahmayuni. (2016). Pembuatan minuman probiotik berbasis kulit nanas (Ananas comosus (L.) Merr.) menggunakan *Lactobacillus casei subsp. casei* R-68 yang diisolasi dari dadih. *Jurnal Online Mahasiswa Fakultas Pertanian Universitas Riau*. 3(1): 1-9.

Fidyasari, A., Hafiz, M., Fitria, N., & Rohmah, U. (2019). Khasiat Sari Buah Sirsak Gunung Dan Minuman Probiotik Buah Sirsak Gunung (*Anona montana*) Untuk Menurunkan Kadar Asam Urat. *Jurnal Pangan dan Agroindustri*, 7(3), 49-55

Gamba, R. R., Yamamoto, S., Abdel-Hamid, M., Sasaki, T., Michihata, T., Koyanagi, T., Enomoto, T. (2020). "Chemical, Microbiological, and Functional Characterization of Kefir Produced from Cow's Milk and Soy Milk". *International Journal of Microbiology* 2020: 1-11

Hakiki, Fahmy Kafa., Nocianitri, Komang Ayu., Hatiningsih, Sayi. (2022). "Pengaruh Konsentrasi Susu Skim Terhadap Karakteristik Minuman Probiotik Susu Jagung Manis (*Zea mays* L. Saccharata) Terfermentasi dengan *Lactobacillus rhamnosus* SKG34". *Jurnal Ilmu dan Teknologi Pangan*, 11(3): 420-434

Haryadi., Nurliana dan Sugito. (2013). Nilai pH dan jumlah bakteri asam laktat kefir susu kambing setelah difermentasi dengan penambahan gula dengan lama inkubasi yang berbeda. *Jurnal Medika Veterinaria* 7 (1): 4-7

Handayani, M. N., P. Wulandari. (2016). Pengaruh Penambahan Berbagai Jenis Susu Terhadap Karakteristik Soyghurt. *Jurnal Agrointek*. 10(2): 62-70.

Harun, N., Rahmayuni, dan Y.E. Sitepu. (2013). Penambahan gula kelapa dan lama fermentasi terhadap kualitas susu fermentasi kacang merah (*Phaesolus vulg*).

Hawusiwa, E., Wardani, A., & Ningtyas, D. (2015). Pengaruh Konsentrasi Pasta Singkong (*Manihot esculenta*) dan Lama Fermentasi pada Proses Pembuatan Minuman Wine Singkong. *Jurnal Pangan dan Agroindustri*.

Hidayat, R., Kusrahayu dan S. Mulyani. (2013). Total bakteri asam laktat, nilai pH dan sifat organoleptik drink yoghurt dari susu sapi yang diperkaya dengan ekstrak buah mangga. *Animal Agriculture Journal*2(1): 160-167.

Herlina, E. dan Nuraeni, F. (2014). Pengembangan Produk Pangan Fungsional Berbasis Ubi Kayu (Manihot esculenta) dalam Menunjang Ketahanan Pangan. *J. Sains Dasar*. 3 (2):142-148.

Kartikasari, D. I dan F. C. Nisa. (2014). Pengaruh penambahan sari buah sirsak dan lama fermentasi terhadap karakteristik fisik dan kimia yoghurt. *Jurnal Pangan dan Agroindustri* 2(4): 239-248

Khamidah, A., & Novitasari. (2017). Pemanfaatan sawi dalam pembuatan permen jelly untuk meningkatkan nilai tambah. Research Report Seminar Nasional dan Gelar Produk, 1193–1201. http://research

Kinteki G.A., Heni R. dan Antonius H. (2018). Pengaruh Lama Fermentasi Kefir Susu Kambing Terhadap Mutu Hedonik, Total Bakteri Asam Laktat (BAL), Total Khamir dan pH. *Jurnal Teknologi Pangan*3(1): 42-50

Lararenjana, E. (2020). 7 Manfaat kefir yang baik untuk kesehatan tubuh, sumber probiotik alami. https://www. merdeka.com/jatim. Diakses tanggal 6 Mei 2023.

Leite, A.M.O., Leite D.C.S, Del Aguila E.M., Alvares T.S., Peixoto R.S., Miguel M.A.L, Silvia J.T. and Paschoalin V.M.F. (2013). "Microbiological and Chemical Characteristic of Brazilian Kefir During Fermentation and Storage Processes". *Journal of Dairy Science* 96:4149-4159

Martinez, A. (2016). Inferring the Role of Microorganisms in Water Kefir Fermentation. *International Journal of Food Science and Technology*, 1- 13.

Martharini D. dan I. Indratiningsih. (2017). "Kualitas Mikrobiologi dan Kimiawi Kefir Susu Kambing dengan Penambahan *Lactobacillus acidophilus* FCNN 0051 dan Tepung Kulit Pisang Kapok (*Musa parasbisiaca*)". *Jurnal Agritech* 37(1): 22-29

Nisa, F. C., Kusnadi, J., & Chrisnasari, R. (2018). "Viabilitas dan Deteksi Subletal Bakteri Probiotik pada Susu Kedelai Fermentasi Instan Metode Pengeringan Beku (Kajian Jenis Isolat dan Konsentrasi Sukrosa sebagai Krioprotektan". *Jurnal Teknologi Pertanian,* 1(9) : 40–51.

Putri, R. M. S., & Mardesci, H. (2018). Uji hedonik biskuit cangkang kerang simping (*Placuna placenta*) dari perairan Indragiri Hilir. *Jurnal Teknologi Pertanian*, 7(2), 19–29.

Rahmah, F. A., I. S. Nurminabari dan T. Gozali. (2016). Pengaruh penggunaan jenis gula merah dan lama fermentasi terhadap karakteristik water kefir. *Jurnal Penelitian Tugas Akhir* 10-16.

Rismawati, F. (2015). Pengauh Perbandingan Air dengan Buah Salak dan Konsentrasi Penstabil terhadap Karakteristik Minuman Sari Buah Salak Bongkok (*Salacca edulis, Renw*). Artikel. Program Studi Teknologi Pangan. Universitas Pasundan. Bandung.

Rohmah, F., & Estiasih, T. (2019). Perubahan karakteristik kefir selama penyimpan: Kajian pustaka. *Jurnal Pangan dan Agroindustri*, 6(3), 30–36.

Safitri, M.F. dan Swarastuti, A. (2013). "Kualitas Kefir Berdasarkan Konsentrasi *Kefir grain*". *Jurnal Aplikassi Tenologi Pangan*. 2(2): 87-92.

Standarisasi Nasional Indonesia (SNI). (2009). Minuman Susu Fermentasi Berperisa (SNI 7522:2009). Standarisasi Nasional Indonesia (SNI). Jakarta.

Widia, R., & Kasuma, N. (2018). "Comparison of Salivary pH Before and After Consuming A Solution of Sugar and Palm Sugar In Dentistry Faculty's Student Of Andalas University". *Andalas Dental Journal*, 6(2), 69-78

Yudho, F. H. P. (2021). "Peningkatan Mutu Dan Pemasaran Gula Aren". *JE (Journal of Empowerment),* 2(1), 150-161

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Herbal Tea Combination Between Corn Silk and Stevia Leaf on Variation of Temperature and Drying Duration

Feny Nafiza, Titik Suryani*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: ts169@ums.ac.id

KEYWORDS:
Antioxidant Activity
Corn Silk
Glucose
Herbal Tea
Stevia Leaf

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Herbal tea combination between corn silk and stevia leaf is a functional drink for health and refreshment. Corn silk contains antioxidant compounds or flavonoids that lower blood glucose levels. Stevia leaf as a natural sweetener contain *stevioside, rebaudioside A, rebadioside C, and dulcoside A* which are 200 to 300 times sweeter than sucrose. The aim of this study was to know the levels of glucose, antioxidant activity, and organoleptic quality of herbal tea combination between corn silk and stevia leaf with variations of temperature and drying duration. The study used experimental methods and a complete random design (crd) of two factors, factor I drying temperature 45 °C and 50 °C, factor II drying duration 2 hours and 4 hours. The results of the study showed the highest glucose of herbal tea combination between corn silk and stevia leaf on S2L2 (drying temperature 50 °C and drying duration 4 hours) is 7,212 g/100 g. The optimum antioxidant activity and best organoleptic quality of herbal tea on S1L1 (drying temperature 45 °C and drying duration 2 hours) was 83,696 % and yellow color, sweet taste, herbal tea characteristic scent, and respectively.

1. INTRODUCTION

Herbal tea is one of the functional beverage products derived from herbal plants that can help in the treatment of a disease and as a body refreshing drink (Yamin et al., 2017). Functional beverages are food products with functional characteristics that have a role in protecting or preventing diseases, treating diseases, improving optimal body function, and slowing the aging process. (Trihaditia, 2018). Herbal teas are generally derived from spices or parts of plants such as roots, stems, leaf, flowers, or bulbs, and are consumed in the form of teas that are boiled or boiled with boiling water (Syawal & Laeliocattleya, 2020). One of the innovations that can be made herbal tea from natural ingredients is corn silk as a functional drink that nourishes the body.

Corn silk is a portion that has a shape such as hair or yellow thread and is a collection of the head of the female flower of the corn plant. Corn silk is less utilized in public life, but has many benefits such as the content of antioxidant compounds or flavonoids that can lower blood glucose levels. Antioxidants from natural materials are able to neutralize radicals by giving one electron to the radical to make it non-radical, so it is important to prevent cell damage from free radicals (Hartanto et al., 2018). Antioxidant activity is influenced by many factors such as lipid content, antioxidant concentration, temperature, oxygen pressure and chemical components. The process of antioxidant inhibition varies depending on the chemical structure and variation of the mechanism is a reaction with the lipid free radicals, which form the non-active product (Syawal & Laeliocattleya, 2020).

On corn silk it also contains 2,5 % fatty acids, 0,12 % asparagus oil, 3,8 % rubber, 2,7 % resin, 3,18 % saponins, and 0,05 % alkaloids. Corn silk also contains B vitamins (niasin, riboflavin, and timine) and is rich in minerals. (abu, alumunium, korm, koblat, zat besi, magnesium, mangan, fosfor, kalium, selenium, dan natrium) (Rohmadianto et al., 2019). According to research (Akbar et al., 2019), there are three concentrations of corn silk tea, namely 20, 30 and 40 %. The best organoleptic test result formula is a 40 % corn silk extract with a water, ash, protein, fat, and carbohydrate content of 99.6 %, 0.20 %, 0.14 %, 0 %, and 0.06 % respectively, while the total flavonoid content is 0.03 %. The chemical content of corn silk tea with the addition of stevia leaf is potentially used as a functional drink alternative. In the making of this herbal tea of corn silk there are several factors that determine the quality of food ingredients such as the type of sweetener. There are two types of sweeteners is natural and artificial. Sand sugar or sucrose is a type of natural sweetener that is widely used, but has a high calorie content that can cause obesity and diabetes (Handayani et al., 2017). In an effort to replace sucrose as a drink sweetener by using natural sweeteners such as stevia leaf to be combined in the making of herbal tea corn silk.

The leaf of stevia (*Stevia rebaudiana*) are one type of plant that can be used as a natural sweetener that has a low calorie content and can replace sucrose. Stevia contains *stevioside*, *rebaudioside A, rebaudioside C,* dan *dulcoside A* which are 200-300 times sweeter than sucrose. Stevia has many benefits for the body such as lowering blood pressure, improving kidney function, and acting as an antioxidant (Handayani et al., 2017). Phytochemical compounds in stevia leaf are alkaloids, saponins, tanins, phenolics, flavonoids, triterfenoids, steroids, and glycosides (Tristanto et al., 2017). The sweetness of the stevia plant is caused by three components stevioside (3-10 % of the dry leaf weight), rebaudioside (1-3 %), and dulcoside (0,5-1 %) (Wuryantoro & Susanto, 2014).

Corn silk has many benefits for the health of the body, one of which is beta-sitosterol which is useful for reducing blood cholesterol levels, reducing urine, lowering high blood pressure, acute and chronic kidney infections (Garnida, 2018). However, corn silk also has disadvantages such as a very low sweetness, so this research was carried out by combining stevia leaf as a low-calorie natural sweetener that is healthy for the body. Apart from being used as a low-calorie natural sweetener, stevia is also beneficial for body health, such as stabilizing blood sugar levels in diabetics, stabilizing blood pressure in hypertensive patients, increasing calcium absorption in osteoporosis sufferers, helping symptoms of gingivitis and inhibiting the growth of dental plaque, treating hair dullness and scalp disorders, as well as preventing wrinkles on the face (Edi & Mardiani, 2015). However, stevia leaf have drawbacks, one of which can leave a bitter taste on the tongue after consumption. This may make some people uncomfortable, and can reduce a person's attractiveness to enjoy it. One way that can be done to process the herbal tea combination between of corn silk and stevia leaf is with the process of drying.

Drying is one of the processes of producing or removing most of the water content of a material through the application of heat energy. Drying can reduce water levels thus inhibiting the growth of bacteria, fungi, and reducing the activity of enzymes that can damage materials, thus extending the storage and preservation of foods (Yamin et al., 2017). The drying method can be done in two ways: drying naturally with sunlight and artificially with the help of a dryer such as the oven. The variation of drying temperature and drying duration in herbal tea making can affect the antioxidant content, glucose levels, and organoleptic quality of herbal tea. According to research (Putri, 2016). There is a difference in the antioxidant activity of the tea combination of corn silk and kelor leaf with the highest variation in the temperature of drying in the treatment of the corn silk 0.7 g and the leaf of the kelor 1.3 g with a drying temperature of 55 ℃ with the

antioxidant content of 85,5 %, while the lowest antioxidant activity is found in the dryer technique with a temperature of 45 ℃ of 42.8 %. With the resulting organoleptic qualities of the young brown color, flavor, smell of langu, and receptivity discovery likes. According to research (Garnida, 2018), stated that the life of the chosen corn silk is 8 weeks in both sweet corn and hybrid corn, chosen drying time is 5 hours, with a drying temperature of 60 °C resulting in a 4.31 % ash rate and a vitamin C level of 1.40 %. The interaction of the drying temperature and the type of corn affects the levels of vitamin C, color, taste, and aroma of the herbaceous tea of corn silk. All drying techniques have their respective advantages and weaknesses over antioxidant activity and organoleptic qualities, so you must be skilled and careful in determining the temperature variation and drying duration to be used.

Based on reference searches, research on herbal tea with a combination of corn silk and stevia leaf has not been found in Indonesia, however there have been previous studies on corn silk herbal tea combined with other ingredients such as rosella (Rohmadianto et al., 2019), moringa leaf (Putri, 2016), lime and honey (Trihaditia, 2018). By looking at the content of corn silk and stevia leaf which are beneficial for the health of the body, a herbal tea research was carried out using a combination of corn silk and stevia leaf. The aim of this study was to know the qualities of the herbal tea between corn silk and stevia leaf on variations of temperature and drying duration.

2. MATERIALS AND METHODS

2.1. The Time and Place of Research

The study was an experimental study to test glucose content, antioxidant activity, and organoleptic qualities with variations of drying temperature and drying duration compared to herbal tea combination between with corn silk and stevia leaf. The research site of the making of herbal tea combination between of corn silk and stevia leaf as well as organoleptic quality testing was carried out in Laboratory 3 Biology Faculty of Teacher and Education Sciences University Muhammadiyah Surakarta, while the testing of glucose levels and antioxidant activates herbal tea blend of corn silk and stevia leaf were conducted in the Laboratory of Technology and Food Industry Faculty Technology and Industry University Slamet Riyadi Surakarta. Research activities will take place from February to March 2023.

2.2. Material

The tools used in this study include: digital scale, oven, measuring glass, beaker glass, reaction tube, reacting tube shelf, a micropipet, spectrophotometer, vortex, hot palate, water bath, volumetric flask.

The ingredients used in this study include: corn silk, stevia leaf, water, tea bags, label paper, aluminum foil, arsenomolybdat reagents, nelson reagens, glucose solution, aquadest, filter paper, and DPPH solution.

2.3. Making Herbal Tea Samples

The preparation of herbal tea samples begins with scrubbing corn silk and stevia leaf for 24 hours at a temperature of 27 °C. Then the material is dried using the oven according to the treatment S1L1 (drying temperature 45 °C and drying duration 2 hours), S1L2 (drying temperature 45 °C and draying duration 4 hours), S2L1 (drying temperature 50 °C and draying duration 2 hours), and S2L2 (drying temperature 50°C and draying duration 4 hours). After drying the material is cut small to fine and weighed in the proportion of 1 g of corn silk : 1 g stevia leaf on

each treatment. Herbal tea is then packed in a 5.5 x 7 cm bag, and herbal tea is baked at a temperature of 100 °C within 1-2 minutes.

2.4. Method of Collecting Data

Data collection methods in this study are (1) experimental methods by carrying out experimental preparation of herbal tea of corn silk and stevia leaf, (2) observation methods by observing and recording the results of changes in color, taste, aroma, and receptivity of the herb tea of corn silk and stevia leaf, (3) library methods to help fill in information from references to previous books, journals, scientific works, and scripts, (4) documentation methods for embodying the process to the research results.

2.5. Experimental Design

The experimental design of the study uses the experimental method using the Complete Random Plan (RAL) 2 factor treatment with 3 repetitions. The treatment factors include:
Factor I : Variation in drying temperature (S)
S1 : Temperature 45 ℃
S2 : Temperature 50 ℃

Factor II : Variation in drying duration (L)
L1 : 2 hours
L2 : 4 hours

Thus, the herbal tea preparation combination between of corn silk and stevia leaf with variations of drying temperature and drying duration is as follows:

S1L1 : Drying temperature 45 ℃ and drying duration 2 hours
S2L1 : Drying temperature 50 ℃ and drying duration 2 hours
S1L2 : Drying temperature 45 ℃ and drying duration 4 hours
S2L2 : Drying temperature 50 ℃ and drying duration 4 hours

2.6. Stage of Research Activity

2.6.1. Glucose Level Testing

Weigh 1 g of herbal tea, and in the seduce with 100 ml of boiling water. To make a dilution of the standard solution of glucose, is tubes 1 (0 ml glucosa + 10 ml aquadest), tubes 2 (2 ml glucosis + 8 ml aquadest), tubes 3 (4 ml glucoza + 6 ml aquadest), tubes 4 (6 ml glucoma + 4 ml aquadest), tube 5 (8 ml glucose + 2 ml aquadest), and tube 6 (10 ml glucose + 0 ml aquadest). Then vortex the standard glucose solution to homogeneity. Take 1 ml of the standard solution from each reaction tube, and take 1 ml of the dissolved tea solution. Add 1 ml of Nelson reagent to each tube and homogenize. Close the reaction tube with aluminum foil, boil for 20 minutes, and cool. After cooling, add 1 ml of the arsenomolybdat reagent and homogenize. Add 7 ml of aquadest solution to each reaction tube and homogenize. Test on a spectophotometer with a wavelength of 540 nm and read its absorbance.

2.6.2. Antioxidant Activity Testing

Prepare a sample of herbal tea to be tested. Stir a sample of herbal tea using 100 ml of hot water in a glass cup, then cool. Take 0,2 ml of an herbal tea sample and place it in a reaction tube.

Add 3,8 ml of DPPH solution and homogenize. Close the reaction tube with aluminum foil, then incubate in a dark space and close for 30 minutes. Incubate the solution in the vortex to become homogeneous. Test it on a spectrophotometer with a wavelength of 515 nm and read its absorption.

2.6.3. Organoleptic Quality Testing

Determined respondents of 15 people to evaluate the herb tea of corn silk and stevia leaf objectively. Provide an organoleptic assessment quiz to the researcher and provide instructions on how to fill out the quiz. Ask the researcher to observe and evaluate each sample tested for color, flavor, smell, and receptivity on each sample tested. The completed questionnaires are returned to the researcher for processing and analysis.

3. RESULTS AND DISCUSSION

3.1. Level Glucose dan Antioxidant Activity

The results of the glucose levels and the antioxidant activity of the herbal tea combination between of corn silk and stevia leaf with variation of drying temperature and drying duration are presented in Table 1.

Table 1 The results of the glucose levels and the antioxidant activity of the herbal tea combination between of corn silk and stevia leaf

Treatment	Glucose (reducing sugar) Gram/100 gram	Antioxidant Activity (%)
S1L1	5.11*	83.696**
S1L2	5.5085	80.9495
S2L1	6.0835	76.59
S2L2	7.212**	44.1135*

Note:
*Lowest Content,
**Highest Content

Information:

S1L1 (Drying temperature 45 ℃ and drying duration 2 hours)
S1L2 (Drying temperature 45 ℃ and drying duration 4 hours)
S2L1 (Drying temperature 50 ℃ and drying duration 2 hours)
S2L2 (Drying temperature 50 ℃ and drying duration 4 hours)

Table 1 showed that herbal tea combination between of corn silk and stevia leaf with drying temperature variations and drying duration had results of different levels of glucose and antioxidant activity. The highest glucose levels of 7,212 g/100 g were found in treatment S2L2 (drying temperature 50 °C and drying duration 4 hours), while the lowest glucose levels of 5,11 g/100 g were found in treatment S1L1 (drying temperature 45 °C and drying duration 2 hours). The highest content of antioxidant activity of 83,696 % was found in treatment S1L1 (drying temperature 45 °C and drying duration 2 hours), while the lowest antioxidant activity content of

44,1135 % was observed in treatment S2L2 (drying temperature 50 °C and drying duration 4 hours).

Testing the glucose level in the herbal tea combination between of corn silk and stevia leaf with drying temperature variations and drying duration is carried out using the Nelson-Somogyi method. Based on the table 1, glucose content at treatments S1L1 (drying temperature 45 °C and drying duration 2 hours) and S1L2 (drying temperature 45 °C and drying duration 4 hours) showed the following successive glycose levels as 5.11 g/100 g; and 5.5085 g/100 g. In treatment S2L1 (drying temperature 50 °C and drying duration 2 hours) and S2L2 (drying temperature 50 °C and drying duration 4 hours) showed glucose levels in succession as follows 6,0835 g/100 g; and 7,212 g/100 g. The highest levels of glucose were found in treatment S2L2 (drying temperature 50 °C and drying duration 4 hours) of 7,212 g/100 g, while the lowest levels were at treatment S1L1 (drying temperature 45 °C and drying duration 2 hours) of 5,11 g/100 g.

Based on the results of statistical tests Two Way Anova obtained an R square value showing 0.941 > 0,05, which means there is no significant influence of temperature variation and duration of drying on the glucose levels of the herbal tea combination between of corn silk and stevia leaf. The results of further testing of the concentration of the glucose content of the herbal tea combination between of corn silk and stevia leaf with the Shapiro wilk method obtained the result Asymp Sig. 0,242 > 0,05, it can be stated that H0 is received, meaning there is no influence variation of drying temperature and drying duration.

The cause of the increased levels of glucose in herbal tea is a combination between of corn silk and stevia leaf due to the influence of temperature and the duration of drying of the ingredients. This drying function reduces the level of water, so the tea products of corn silk and stevia leaf can be stored for a long period of time. The higher the temperature of drying and the longer the drying time, the higher the levels of glucose produced. According to (Sundari et al., 2015), The high or low nutritional content of a material depends on the type of material and the temperature used. And in line with research (Engka et al., 2016), The sugars that are dissolved in hot water are called invert sugars, which means that some of the sugars will be broken down into glucose and fructose. Heating done slowly and for a long time will produce more inverter sugar compared to quick and short heating.

The highest levels of glucose in the herbal tea combination between of corn silk and stevia leaf of 7,212 g/100 g were obtained of the drying temperature factor of 50 °C and drying duration 4 hours. The boiling and drying of the saccharose solution results in the sucrose undergoing the reverse or breakdown of saccharoses into glucose and fructose due to the influence of acid and heat which increase the solubility of sugar. In line with research (Prastianti et al., 2016), The highest sugar reduction level (7.9922 g/100 g) is obtained at the ratio of the sugar concentration factor (78.65 %) and the drying temperature (89.99 °C). The variation of such factors can result in the reduction of sugar levels in dried pondoh snakefruit sweet to higher than fresh snakefruit. And backed by research (Wilberta et al., 2021), the average sugar analysis results reduced in nira palm by 5.18 % and in ants sugar palm by 10.31 %. This occurs because of the process of eating, so there is an increase in the sugar content reduction in comparison with nira palm before cooking. Reduction sugar changes can be influenced by various factors, such as heating, where the result of the heating process results in changes in the chemical structure as well as the composition of nira and myrtle palm sugar. Both studies showed that increased temperature and duration of drying resulted in increased levels of reduced sugar as well.

Table 1 also shows the results of antioxidant activity testing on a herbal tea combination between of corn silk and stevia leaf with srying temperature variations and drying duration

performed by the DPPH method. On treatment S1L1 (drying temperature 45 °C and drying duration 2 hours) and S1L2 (drying temperature 45 °C and drying duration 4 hours) showed the results of the antioxidant activity content in succession were as follows 83,696 %; and 80,9495 %. On treatment S2L1 (drying temperature 50 °C and drying duration 2 hours) and S2L2 (drying temperature 50 °C and drying duration 4 hours) showed results of antioxidant activity content in succession as follows: 76,59 %; and 44,1135 %. The highest content of antioxidant activity was found at treatment S1L1 (drying temperature 45 °C and drying duration 2 hours) of 83,696 %, while the lowest frame of antioxidant activity was found in treatment S2L2 (50 °C drying temperature and drying duration 4 hours) of 44,1135 %.

Based on the results of statistical tests Two Way Anova obtained an R square value showing 0.981 > 0.05, which means there is no significant influence of drying temperature variation and drying duration on the antioxidant activity content of the herbal tea combination between of corn silk and stevia leaf. The results of further testing of the concentration of antioxidant activity content of the herbal tea combination between of corn silk and stevia leaf with the method of Shapiro wilk obtained results Asymp Sig. 0,592 > 0,05, it can be stated that H0 was received which means that it is not subject to the influence of temperature variation and duration of drying.

The high test results for antioxidant activity are due to the fact that corn silk contains anti-oxidant compounds such as flavonoids, alkaloids, tanins, and saponins. According to (Kusriani et al., 2017), stated that the chemical content contained in corn plants includes alkaloids, saponins, tanins, flavonoids, phenols, steroids, glycosides, terpenoids, proteins, and minerals. Phenol compounds play a high role in antioxidant activity and sunscreen. Spruce samples and corn silk are potentially a source of antioxidants and natural sunscreen. This is proven in research (Kurnia et al., 2021), it is stated that the ethanol extract of corn silk has antioxidant activity using the DPPH method. The IC50 value of ethanol extracts of corn silk of 7.73 ppm is classified as an antioxidant compared to vitamin C. On research (Aulyawati et al., 2021), It is stated that the ethanol extract of corn silk has antioxidant activity using the DPPH method. The IC50 value of ethanol extracts of corn silk of 7.73 ppm is classified as an antioxidant compared to vitamin C.

The main cause of the decline in antioxidant activity is due to the temperature factor in ovulation. At treatment S1L1 with a forging temperature of 45 °C is the most optimal temperature for producing the highest antioxidant activity. High antioxidant activity can occur due to the optimal temperature, when the drying process exceeds the optimum temperature then the activity of antioxidants will decrease because it can make the enzyme polyphenolic oxidase to experience inactivation. In line with research (Wiratara & Ifadah, 2022), the higher the drying temperature, the higher the enzyme polyphenolic oxidase that undergoes inactivation, affecting the decrease in enzymatic activity and the decreased phenolic damage that occurs.

Too high drying temperatures and too long drying times are also not good for antioxidant activity. The higher the drying temperature used, the lower the antioxidant activity, and it can damage the activity of antioxidants on the simplex. In line with research (Dewi et al., 2022), stated that the use of too high temperatures and too long drying times can cause the occurrence of changes in the characteristics and chemical components contained in materials, such as damage to compounds acting as antioxidants, while too low temperatures and too short drying times are not optimal to inactivate the polyphenolase enzyme so that the polyfenolase enzymes often convert polyphenols into teaflavin and tearubigine compounds, resulting in the antioxidant composites produced are still low. And strengthened by research (Yamin et al., 2017), it has been stated that too long a drying time will decrease antioxidant activity because antioxidants are damaged by heating.

Another factor that causes low antioxidant activity is the sliding process. The function of this peeling process is to lower the water level on corn silk and stevia leaf. The longer the process is used, the lower the antioxidant activity contained in the herbal tea combination between of corn silk and stevia leaf. This is due to the presence of compounds with antioxidant activity that are lost during the peeling process. The longer the sliding time, shows an increasingly decreasing antioxidant activity, this is due to the existence of sources of antioxidants that are lost during the slitting process, and the chemical changes experienced by the source of antioxidants (Kusumaningrum et al., 2020).

3.2. *Organoleptic Quality*

Organoleptic qualities include color, taste, scent, and acceptability to the herbal tea combination between with corn silk and stevia leaf with variations of drying temperature and drying duration presented in Table 2.

Tabel 2. Organoleptic test results include color, taste, scent, and acceptability to the herbal tea combination between of corn silk and stevia leaf.

Treatment	Aspect			
	Color	Taste	Scent	Acceptability
S1L1	Dark yellow	Sweet	Somewhat Typical Herbal Tea	Like
S1L2	Brown	Very sweet	Somewhat Typical Herbal Tea	Like
S2L1	Brown yellow	Very sweet	Special Herbal Tea	Quite like
S2L2	Brown	Very sweet	Special Herbal Tea	Quite like

Information:
S1L1 (Drying temperature 45 ℃ and drying duration 2 hours)
S1L2 (Drying temperature 45 ℃ and drying duration 4 hours)
S2L1 (Drying temperature 50 ℃ and drying duration 2 hours)
S2L2 (Drying temperature 50 ℃ and drying duration 4 hours)

From 15 respondent who tested organoleptic qualities (color, taste, aroma, and receptivity) of an herbal tea combination between of corn silk and stevia leaf with variations in drying temperature and drying duration showed varying results in each treatment. The color of the herbal tea combination between of corn silk and stevia leaf in the treatment S1L1 (drying temperature 45 °C and drying durration 2 hours) is dark yellow, in the process S2L1 (50 °C drying temperature and drying duration 2 hours) it is brown-yellow, whereas in the treatments S1L2 (drying temperature 45 °C and drying duration 4 hours) and treatment S2L2 (drying temperature 50 ℃ and drying duration 4 hours) it is brown. The results of the research on herbal tea flavors combined with corn silk and stevia leaf that the treatment S1L1 (drying temperature 45 °C and drying duration 2 hours) had a sweet taste, whereas the treatments S1L2 (drying temperature 45 °C and drying duration 4 hours), treatments S2L1 (50 °C drying temperature and drying duration 2 hours), and treatments S2L2 (drying temperature 50 °C and drying duration 4 hours) were very sweet. The aroma produced by the herbal tea combination between of corn silk and stevia leaf in each

treatment is different. Treatments S1L1 (drying temperature 45 °C and drying duration 2 hours) and S1L2 (drying temperature 45 °C and drying duration 4 hours) have a rather typical aroma of herbal tea, whereas treatments S2L1 (drying temperature 50 °C and drying duration 2 hours), and treatments S2L2 (50 °C drying temperature and drying duration 4 hours) have a characteristic aroma of herbal tea. And the acceptability of the herbal tea combination of corn silk and stevia leaf from 15 respondents that is in the S1L1 treatment (drying temperature 45 °C and drying duration 2 hours) and treatment S1L2 (drying temperature 45 °C and drying duration 4 hours) had a liking power, whereas in treatment S2L1 (drying temperature 45 °C and drying duration 2 hours) and treatment S2L2 (drying temperature 50 °C and drying duration 4 hours) had good acceptability.

The organoleptic test results for color, taste, aroma, and acceptance of herbal tea combination between with corn silk and stevia leaf with variations in temperature and drying duration can be seen in Figure 1.

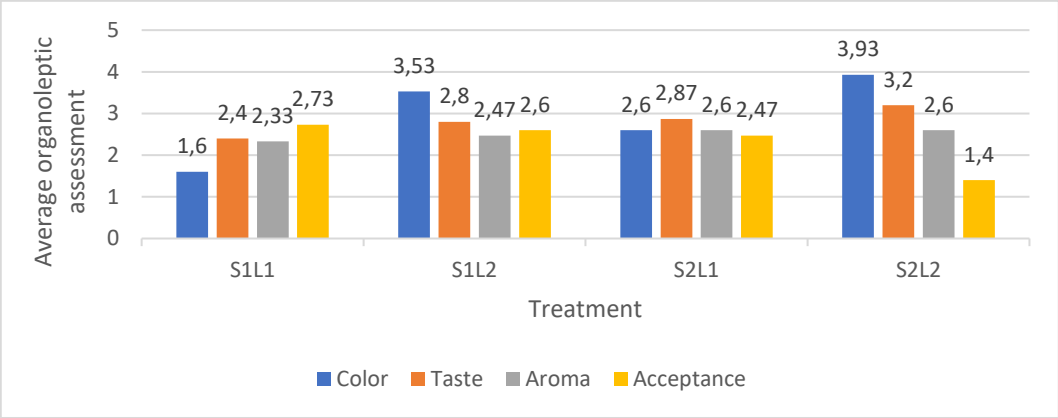


Figure 1. Histogram of Color, Taste, Aroma, and Acceptance Organoleptic Quality Test

Based on Figure 1, the results of the organoleptic quality assessment of 15 respondents produced the highest color for the herbal tea combination of corn silk and stevia leaf in the S2L2 treatment with brown color, while the lowest color assessment was in the S1L1 treatment with dark yellow color. The determination of temperature and duration of drying has a great influence on the color of the produced herbal tea. Herbal tea with longer drying times and high drying temperatures have a more concentrated color compared to a shorter drying times and lower drying temperatures. The color of corn silk tea is caused by flavonoid compounds due to the distinctive properties of flavanoids that can be soluble in water, in addition, the temperature of drying also has a real effect on the color of the corn silk (Garnida, 2018). This is due to the chlorophyll and caretenoid pigments in stevia leaf, and the increased content of tannins if the drying time is longer. In accordance with research results (Hutasoit et al., 2021), it is stated that the colors of T1, T2, T3, and T4 in the cascara teas are consecutively becoming more and more concentrated brown, this is due to the increased tannin content of the teas with a long drying time. According to (Ramlah, 2017), it is stated that the highest levels of flavonoids can be seen from the color of the sediment produced. The more concentrated color indicates high levels of flavonoids with high antioxidant activity. Flavonoids can give a dull yellow color to the shrimp and will turn into dark brown when further oxidation reactions occur (Rohmadianto et al., 2019).

Herbal tea is a combination between of corn silk and stevia leaf with drying temperature variations and drying duration has 4 degrees of taste which is quite sweet, sweet, very sweet, and

bitter sweet. The results of the research on herbal tea flavor combination of corn silk and stevia leaf with the highest score in the S2L2 treatment with a very sweet taste, while the lowest score was in the S1L1 treatment with a sweet taste. This shows that the longer and higher the drying temperature is carried out, the sweeter the resulting sweetness will increase even to provoke the sweetness of bitterness. In line with research (Rohmadianto et al., 2019), stated that the longer the drying time, the corn flavor will be more pronounced because the corn flavor is influenced by the content of antioxidant compounds such as tannins, saponins, and flavonoids. The bitter taste in herbal teas is due to the presence of chemical compounds in the form of tannins and saponins in corn silk or stevia leaf.

The results of the research on the aroma of herbal tea a combination of corn silk and stevia leaf with the highest scoring results in the S2L1 and S2L2 treatments with a distinctive aroma special herbal tea, while the lowest rating was in the S1L1 treatment with a distinctive aroma somewhat typical herbal tea. This shows that the higher the drying temperature used, the more characteristic the aroma of herbal tea is produced. The aroma in the herbal tea of corn silk and stevia leaf can be produced by evaporating volatile compounds. This is in line with the results of the reserach (Garnida, 2018), the aroma produced at the drying temperatures of 60 °C and 70 °C is the aroma of corn, this is due to the optimal output of volatile compounds contained in corn silk. From the results of the study, it can be said that the longer the drying time can more it affects the color and smell of tea. According to (Adri & Hersoelistyorini, 2013) the drying process causes the catechin compounds in the tannins to be oxidized which produces a fragrant aroma in the tea.

Acceptability of herbal tea combination corn silk and stevia leaf involving 15 respondent with the highest rating results in the S2L1 treatment with like acceptance, while the lowest rating was in the S2L2 treatment with acceptance quite like. The longer and higher the drying temperature is done, the lower the acceptability of herbal tea combination between with corn silk and stevia leaf because it has a sweeter to bitter sweet taste. This is due to differences in the color and taste of the herbal tea combination between with corn silk and stevia leaf, but there is a slight similarity in the aroma as seen from the slight difference in numbers. In terms of acceptability, quite like it is caused by the appearance of a bitter taste due to the long drying process, so that the acceptability of the S2L1 and S2L2 treatments decreases. The bitter taste arises due to the content of tannin and saponin compounds in corn silk or stevia leaf. However, it can be said that the treatment stated that the researcher liked the herbal tea combination between with corn silk and stevia leaf. In the results of the researcher's coverage, herbal tea products combination between with corn silk and stevia leaf can be used as an alternative to tea, accompanied by an introduction to the community about the potential of corn silk and stevia leaf to be used as herbal teas as functional drinks that are beneficial for the health of the body. This is in line with research (Widyantari, 2020), states that functional drinks have the main function of providing nutritional intake and sensory satisfaction such as good taste and good texture. And equipped with tertiary functions such as probiotics, increasing intake of certain vitamins and minerals, increasing body stamina, and reducing the risk of certain diseases.

4. CONCLUSIONS

The highest glucose of herbal tea combination between corn silk and stevia leaf on S2L2 (drying temperature 50 °C and drying duration 4 hours) is 7,212 g/100 g. The optimum antioxidant activity and best organoleptic quality of herbal tea on S1L1 (drying temperature 45 °C and drying duration 2 hours) was 83,696 % and yellow color, sweet taste, herbal tea characteristic scent, and respectively. So that the most optimal combination treatment is S1L1 with a low glucose content

of 5.11 g/100 g, antioxidant activity 83,696 %, and organoleptic quality yellow color, sweet taste, herbal tea characteristic scent, and respectively.

5. ACKNOWLEDGMENTS

The author thanks the Biology Education Study Program for providing funding for the Incobest article.

6. REFERENCES

Adri, D., & Hersoelistyorini, W. (2013). Aktivitas Antioksidan dan Sifat Organoleptik Teh Daun Sirsak (Annona muricata Linn.) Berdasarkan Variasi Lama Pengeringan Antioxidant Activity and Organoleptic Charecteristic of Soursop (Annona muricata Linn.) Leaf Tea Based on Variants Time Drying. *Jurnal Pangan Dan Gizi*, *04*(07).

Akbar, C. I., Arini, F. A., & Fauziyah, A. (2019). Teh Rambut Jagung dengan Penambahan Daun Stevia sebagai Alternatif Minuman Fungsional Bagi Penderita Diabetes Melitus Tipe 2. *Jurnal Aplikasi Teknologi Pangan*, *8*(2), 67–73. https://doi.org/10.17728/jatp.3122

Aulyawati, N., Yahdi, & Suryani, N. (2021). Skrining fitokimia dan aktivitas antioksidan ekstrak etanol rambut jagung manis (Zea mays ssaccharata strurf) menggunakan metode DPPH. *Jurnal Kimia & Pendidikan Kimia*, *3*(2), 132–142. https://doi.org/10.20414/spin.v3i2.4101

Dewi, B. K., Putra, I. N. K., & Yusasrini, N. L. A. (2022). Pengaruh Suhu dan Waktu Pengeringan terhadap Aktivitas Antioksidan dan Sifat Sensori Teh Herbal Bubuk Daun Pohpohan (Pilea trinervia W.). *Jurnal Ilmu Dan Teknologi Pangan (ITEPA)*, *11*(1), 1. https://doi.org/10.24843/itepa.2022.v11.i01.p01

Edi, B., & Mardiani, D. (2015). *Panduan Budidaya Stevia Sebagai Penghasil Gula Rendah Kalori*. Koperasi NUKITA.

Engka, D. L., Kandou, J., Koapaha, T., & . (2016). Pengaruh Konsentrasi Sukrosa dan Sirup Glukosa Terhadap Sifat Kimia dan Sensoris Permen Keras Belimbing Wuluh (Averrhoa bilimbi. L). *Teknologi Pertanian Fakultas Pertanian Universitas Sam Ratulangi*, 10.

Garnida, Y. (2018). Pengaruh Suhu Pengeringan Dan Jenis Jagung Terhadap Karakteristik Teh Herbal Rambut Jagung (Corn Silk Tea). *Pasundan Food Technology Journal*, *5*(1), 63. https://doi.org/10.23969/pftj.v5i1.811

Handayani, Z., Prasetyo, J. Y., & Harismah, K. (2017). Uji Organoleptik dan Kadar Glukosa Yoghurt Kulit Semangka dengan Substitusi Pemanis Sukrosadan Ekstrak Daun Stevia (Stevia rebaudiana). *The 6th University Research Colloquium*, 1–10.

Hartanto, G. N., Pranata, F. S., & Swasti, Y. R. (2018). Kualitas dan Aktivitas Antioksidan Seduhan Teh Rambut Jagung (Zea mays) dengan Variasi Lama Pelayuan dan Usia Panen. *Biota : Jurnal Ilmiah Ilmu-Ilmu Hayati*, *3*(1), 12–23. https://doi.org/10.24002/biota.v3i1.1889

Hutasoit, G. Y., Susanti, S., & Dwiloka, B. (2021). Pengaruh Lama Pengeringan Terhadap Karasteristik Kimia dan Warna Minuman Fungsional Teh Kulit Kopi (Cascara) dalam Kemasan Kantung. *Jurnal Teknologi Pangan*, *5*(2), 38–43. www.ejournal-s1.undip.ac.id/index.php/tekpangan.

Kurnia, K., Yunus, M., & Herawati, N. (2021). Uji Aktivitas Antioksidan Ekstrak Etanol Rambut Jagung (Zea mays L.) dengan Menggunakan Metode 2,2-difenil-1-pikrilhidrazil (DPPH). *Chemica: Jurnal Ilmiah Kimia Dan Pendidikan Kimia*, *22*(2), 69. https://doi.org/10.35580/chemica.v22i2.26210

Kusriani, H., Marliani, L., & Apriliani, E. (2017). Aktivitas Antioksidan dan Tabir Surya dari Tongkol dan Rambut Jagung (Zea Mays L.). *Indonesian Journal of Pharmaceutical Science and Technology*, *4*(1), 10. https://doi.org/10.15416/ijpst.v4i1.10428

Kusumaningrum, R., Supriadi, A., & R.J, S. H. (2020). *Karakteristik dan Mutu Teh Bunga Lotus*. 274–282.

Prastianti, L., Budianta, T. D. W., & Utomo, A. R. (2016). Pengaruh Konsentrasi Gula, Waktu Pengeringan, dan Suhu Pengeringan terhadap Kadar Gula Reduksi, Total Fenol, dan Vitamin C, serta Karakteristik Rasa Manisan Salak Pondoh Kering. *Journal of Food Technology and Nutrition*, *15*(2), 87–93.

Putri, F. K. (2016). Aktivitas Antioksidan Dan Kualitas Teh Kombinasi Rambut Jagung Dan Daun Kelor Dengan Variasi Suhu Pengeringan. *Jurnal Publikasi Ilmiah Universitas Muhammadiyah Surakarta*, *3*, 1–11.

Ramlah. (2017). *Penentuan Suhu Dan Waktu Optimum Penyeduhan Daun Teh Hijau (Camellia Sintesis L .) Terhadap Kandungan Antioksidan Kafein ,*.

Rohmadianto, D., Suhartatik, N., & Widanti, Y. A. (2019). Aktivitas Antioksidan Teh Rambut Jagung (Zea mays L. sacharata) Dengan Penambahan Rosela (Hibiscus sabdariffa L) Dan Variasi Lama Pengeringan. *Jurnal Teknologi Dan Industri Pangan*, *3*(2). https://doi.org/10.33061/jitipari.v3i2.2693

Sundari, D., Almasyhuri, A., & Lamid, A. (2015). Pengaruh Proses Pemasakan Terhadap Komposisi Zat Gizi Bahan Pangan Sumber Protein. *Media Penelitian Dan Pengembangan Kesehatan*, *25*(4), 235–242. https://doi.org/10.22435/mpk.v25i4.4590.235-242

Syawal, A. N., & Laeliocattleya, R. A. (2020). Potensi Teh Herbal Rambut Jagung (Zea mays L.) Sebagai Sumber Antioksidan: Kajian Pustaka. *Jurnal Ilmu Pangan Dan Hasil Pertanian*, *4*(1), 1–6. https://doi.org/10.26877/jiphp.v4i1.4056

Trihaditia, R. (2018). Penentuan Nilai Optimasi Dari Karakteristik Organoleptik Aroma Dan Rasa Produk Teh Rambut Jagung Dengan Penambahan Jeruk Nipis Dan Madu. *Agroscience (Agsci)*, *6*(1), 20. https://doi.org/10.35194/agsci.v6i1.266

Tristanto, N. A., Budianta, T. D. W., & Utomo, A. R. (2017). Pengaruh Suhu Penyimpanan Dan Proporsi Teh Hijau: Bubuk Daun Kering Stevia (*Stevia rebaudiana*) Terhadap Aktivitas Antioksidan Minuman Teh Hijau Stevia Dalam Kemasan Botol Plastik. *Jurnal Teknologi Pangan Dan Gizi*, *16*(1), 25–26.

Widyantari, A. A. . S. S. (2020). Formulasi Minuman Fungsional Terhadap Aktivitas Antioksidan. *Widya Kesehatan*, *2*(1), 22–29. https://doi.org/10.32795/widyakesehatan.v2i1.604

Wilberta, N., Sonya, N. T., & Lydia, S. H. R. (2021). Analisis Kandungan Gula Reduksi Pada Gula Semut Dari Nira Aren Yang Dipengaruhi Ph Dan Kadar Air. *Bioedukasi (Jurnal Pendidikan Biologi)*, *12*(1), 101. https://doi.org/10.24127/bioedukasi.v12i1.3760

Wiratara, P. R. W., & Ifadah, R. A. (2022). Karakteristik Teh Herbal Daun Kalistemon (Melaleuca viminalis) Berdasarkan Variasi Suhu dan Waktu Pengeringan. *Jurnal Teknologi Dan Industri Pertanian Indonesia*, *14*(1), 16–22. https://doi.org/10.17969/jtipi.v14i1.21196

Wuryantoro, H., & Susanto, W. H. (2014). Penyusunan Standard Operating Procedures Industri Rumah Tangga Pangan Pemanis Alami Instan Sari Stevia (Stevia rebaudiana). *Jurnal Pangan Dan Agroindustri*, *2*(3), 76–87.

Yamin, M., Ayu, D. F., & Hamzah, F. (2017). Lama Pengeringan Terhadap Aktivitas Antioksidan dan Mutu Teh Herbal Daun Ketepeng Cina (Cassia alata L.). *Jom FAPERTA*, *4*(2), 1–15.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Isolation and Identification of Soil Bacteria in Pracimaloyo Public Cemetery, Kartasura

Bagas Adityaradja, Erma Musbita Tyastuti, Yasir Sidiq, Triastuti Rahayu*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: tr124@ums.ac.id

KEYWORDS:
Bacteria
Bacterial population
Public cemetery
Gram staining

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

In The Pracimaloyo Public Cemetery, the body's decomposition occurs continuously, producing soil nutrients and minerals that affect the growth of bacteria. Bacterial population data from the cemetery area is still very limited, whereas cemeteries hold the risk of contamination with pathogenic bacteria. This research aims to find out how the population and diversity of bacteria in the Pracimaloyo Public Cemetery. Soil samples were taken from the Pracimaloyo cemetery at 2 locations (blocks 8 and 18), each at 20 and 50 cm depth. Soil samples are inoculated in Nutrient Agar media using the spread plate method. After 48 hours, colony counting, colony morphology, and gram staining observations were carried out. The rate of soil bacterial populations in blocks 8 and 18 at a depth of 20 cm was 4.23×10^7 CFU/g and 9.79×10^7 CFU/g, while at depths of 50 cm, it was 1.94×10^7 CFU/g and 1.92×10^7 CFU/g. The morphology of the bacterial colonies is dominated by circular shape, entire margin, flat elevation, and white color. 20 isolates are gram-negative and 16 isolates are gram-positive, the cell form is dominated by the bacillus.

1. INTRODUCTION

Soil is the top layer of the earth that is formed by the rock's corrosion over a long period. This process is due to the role of microorganisms. Bacteria are one of the most common microorganisms found in the soil and the most important elements in soil biological characteristics (Rahman et al., 2020). Soil bacteria also play a role in nitrogen decomposition cycles, soil fertility, and decomposers.

According to the Government Regulation of the Republic of Indonesia No. 9 of 1987, a public cemetery is land used for funeral needs, provided for each person without distinction of race, tribe, religion, and culture of an individual. In Indonesia, the size of land for the burial of bodies is provided at a maximum of 2.5 x 1.5 meters with a depth of at least 1,5 meters from the surface of the ground (Indriana, 2014). Soil in cemeteries can be a risk contributor of pathogenic bacteria causing the disease. Examples of pathogenic bacteria that can be found in the cemetery are *Bacillus* spp., *Escherichia* spp., *Enterococcus* spp., *Staphylococcus* spp., *Penicillium* spp., and *Aspergillus* spp. (Całkosiński et al., 2015).

In the cemetery, the body's decomposition process occurs actively. Decomposition is the PMI (Post-Mortem Interval) phase that occurs as a result of natural processes that cause tissue damage after death. In the process of body decomposition, the decomposition phase is divided into 5 based on changes in the body's physical, the fresh phase, the swollen stage, the active decomposition stage, and the skeletonization change phase (Putra et al., 2021).A healthy human body can release bacteria. Most of these bacteria are not pathogenic and can accelerate the

decomposition of organic matter (Żychowski & Bryndal, 2015). In the process of decomposition of bodies, bacteria play an important role in assisting the decomposition process and maintaining the functioning of soil ecosystems (Całkosiński et al., 2015). As a result of the decomposition carried out by the microorganisms, the organic material derived from the body's decomposition process will move to the soil and the bacteria will dominate the area around the decomposition process, so the bacterial diversity will increase.

The research is located at the Pracimaloyo Public Cemetery, one of the largest cemetery sites managed by the Surakarta City Government, with a total of 19 blocks of the cemetery with an altitude of 106 m. There have been many processes of decomposition of bodies at the cemetery. As a result of the body's decomposition process, nutrients, and minerals will be produced in the soil, which will affect the increase in soil bacterial populations. This research was carried out because of the limited research on soil bacteria in the cemetery. The cemetery can be a potential site for pathogenic bacteria that can contaminate soil and pose a threat to public health. (Abia et al., 2019).

In Indonesia, no research has been found on the population and diversity of soil bacteria in cemeteries. Several studies on the population and diversity of soil bacteria have been conducted in various countries, such as Poland (Całkosiński et al., 2015), South Africa (Abia et al., 2019), and Australia (Żychowski & Bryndal, 2015). This research aims to find out how the population and diversity of bacteria are present in the Pracimaloyo Public Cemetery. This research data is expected to be used as a reference related to the population and diversity of bacteria found in the Pracimaloyo Public Cemetery.

2. MATERIALS AND METHODS

2.1. Research Location

The research is located at Pracimaloyo Public Cemetery, one of the largest cemeteries managed by the Surakarta City Government, located at Makamhaji, Kartasura, Sukoharjo, Central Java. Pracimaloyo Public Cemetery has an altitude of 106 m and coordinates at 7°33'46.02" S, 110°46'25.92" E.

2.2. Tools and materials

The tools used in this research are autoclave (*GEA LS-35LJ)*, hot plate (*Cimarec*$^{+}$), magnetic stirrer, digital analytical balance (*Durascale DAB-E223)*, test tube (*Pyrex*), test tube rack, Laminar Air Flow (LAF), Erlenmeyer tube (*Pyrex*), incubator (*Memmert),* beaker glass (*Pyrex*), bunsen burner, disposable petri dish, stopwatch, sprayer, micropipette (*Socorex 10-100),* binocular microscope (*Olympus CX-21*), inoculating loops, object glass, dryer, vortex (*DLAB MX-S*), and *Colony Counter* (*Funke Gerber*). The main materials used in this research are Pracimaloyo Public Cemetery soil samples, Nutrient Agar (Merck 1.05450.0500), and a Gram stain kit.

2.3. Sampling

Sampling is carried out by digging the soil using a ground drill at blocks 8 and 18, respectively at 20 cm and 50 cm depth. The air temperature and pH soil in block 8 is 33.3°C and 5, then in block 18 is 34.8 °C and 6.5. Furthermore, soil samples are dried and mashed, then stored in plastic and marked according to the block of sampling and its depth. The soil sample is stored in the refrigerator for further use.

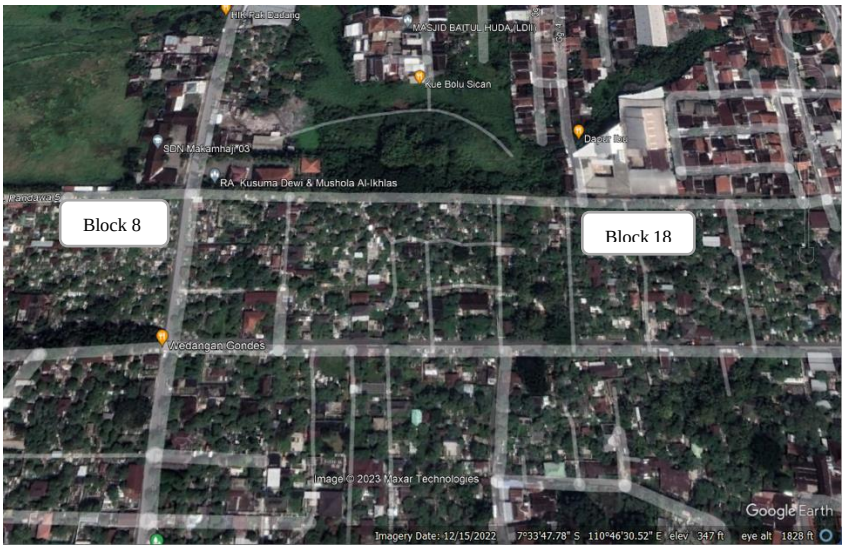


Figure 1. Sample location

2.4. Research Procedure

2.4.1. Serial dilution

Sampling dilution is one of the steps for bacterial suspension diluting intended at lowering the number of microorganisms in the suspension (Yunita et al., 2015). The dilution of the sample is carried out by adding 1 gram soil sample to the diluting reaction tube containing aquadest with a volume of 9 ml, and then the series diluting procedure is completed till the 10^{-7} dilution.

2.4.2. Bacterial isolation

Bacterial isolation is done by spread technique. The advantage of using the spread technique is that microorganisms that grow on the medium can spread evenly on the surface part of the medium (Putriawati et al., 2018). The 10^{-5}, 10^{-6}, and 10^{-7} dilution series were inoculated on a petri dish that already contained a solid nutrient-agar medium, 0.1 ml for each sample. The sample is spread using a drigalski spatula. Furthermore, the petri dish was incubated for 48 hours in the incubator at 37°C temperature (Nor et al., 2018) in reverse position.

2.4.3. Estimation of the bacterial population

The estimation of bacterial populations is done using the Total Plate Count (TPC) method by counting the colonies on the media using the colony counter. The number of bacterial populations is stated as colony-forming units (CFU) (Lestari et al., 2016). On the calculation of bacterial populations using the Total Plate Counter method, to determine the number of initial bacteria before dilution, apply the following formula (Irfan, 2014):

Colony Forming Unit (CFU) / ml = $\left(\frac{1}{sample\ volume}\right) x \left(\frac{1}{dilution\ factor}\right) x$ total $colonies$

2.4.4. Bacteria isolate purification

The purification of bacterial isolates aims to separate the outcomes of the inoculation consisting of various bacteria colonies of different types to produce the colony of pure bacteria isolate. The purification of bacteria isolates is done to obtain a desired type of pure bacteria and then be further grown on the agar slope (Marzuki et al, 2014). The bacterial isolate is purified by moving the bacteria suspension from the incubated petri dish into the agar slope. Bacteria taken

for pure bacterial culture have different morphology and color, resulting in a suspension of pure bacteria for further identification.

2.4.5. Bacteria identification

Identification of soil bacteria is done macroscopically and microscopically. The macroscopic identification of bacteria is done by observing the morphology of the bacterial colony, such as the shape, margin, elevation, and color of the colony. The microscopical identification is carried out by Gram staining. The process of Gram staining is carried out by making bacterial smears on the glass of objects, followed by adding gram A (violet crystal), gram B (mordan), gram C (alcohol), and gram D (safranin). Gram staining results were observed using a microscope to find the gram type and cell shape data from bacteria (Walida et al., 2019).

3. RESULTS AND DISCUSSION

3.1. Soil Bacteria Population

Table 1. Soil bacteria population

Block	Air temperature (°C)	Soil pH	Depth (cm)	Bacterial colonies population (*CFU/g*)
8	33.3	5	20	4.23×10^7
			50	1.94×10^7
18	34.8	6.5	20	9.79×10^7
			50	1.92×10^7

Based on Table 1, in Block 8, the highest soil bacteria population is found at a depth of 20 cm (4.23×10^7 CFU/g), and the lowest soil bacterial population is found at a depth of 50 cm (1.94×10^7 CFU/g). In Block 18, the highest soil bacteria population is found at a depth of 20 cm (9.79×10^7 CFU/g), and the lowest soil bacterial population is found at a depth of 50 cm (1.92×10^7 CFU/g).

Pracimaloyo Public Cemetery is one of the largest public cemeteries in Kartasura, there have been a lot of decomposition processes in that cemetery. Due to the process of body decomposition, the bacterial populations in the cemetery may increase with the availability of organic material. This is because most of the bacteria in the soil belong to anaerobic bacteria that rely on organic material in the soil to produce food and energy. Anaerobic bacteria play an important role in soil because they can degrade dead organic matter into elements returned to the soil such as N, P, K, Ca, Mg, and others (Zahidah & Shovitri, 2013).

Bacterial growth can be influenced by several environmental factors, such as soil temperature and soil pH (Mandala et al., 2021). Soil pH conditions determine the microorganism population in the soil. At a pH of 5.5 – 7, bacteria that decompose the organic material will grow optimally (Rukmana et al., 2020). Soil pH in the block 8 is 5 and in the block 18 is 6.5, based on this, bacteria will grow well in both blocks. The availability of organic material can also affect the bacterial populations found in the soil (Prasetya, 2021). Too much organic material in the soil will cause low oxygen levels because the decomposition process needs oxygen to happen. (Yuningsih et al., 2014). Based on this, the deeper the soil, the lower the oxygen levels in it, this is because in the cemetery there are many processes of decomposition of bodies that produce organic material. Because of the low levels of oxygen, anaerobic bacteria will be found more as they get deeper in

the soil, and aerobic bacteria will rarely be found.

The majority of bacterial populations are found on the surface of the soil with a depth of 20 cm. The least bacterial population is found in soil with a depth of 50 cm. In the research conducted by Irfan (2014), more soil bacterial populations were found on the surface (0 cm and 25 cm) compared to the depths of 75 cm and 100 cm. The use of inadequate bacterial isolation techniques often only grows the few anaerobic bacteria that are commonly found because anaerobe bacteria have significant differences in oxygen tolerance and low oxygen levels are essential for them to reproduce (Nagy et al. 2018).

Anaerobic bacteria are so sensitive to different levels of oxygen that they require excellent cultural conditions, such as anaerobe media and environments. Based on this, the reason why there is a significant difference in bacterial populations at a depth of 50 cm compared to a depth of 20 cm is that most bacteria present in the 50 cm depth soil layer belong to anaerobic bacteria and cannot be grown easily with simple bacteria isolation techniques. It requires a suitable environment for anaerobic bacteria to live and grow. In addition, the media also influences the growth of anaerobic bacteria. Mediums that do not correspond to the characteristics of anaerobic bacteria will cause inhibition of the growth of the bacteria (Ristiati et al., 2014).

3.2. Bacteria Identification

After the isolation of the bacterial colony, the result is 36 bacteria isolates that will be further observed to be identified, 30 isolates from a depth of 20 cm and 6 isolates from 50 cm. Identification of bacteria here includes observation of the morphology of bacterial colonies and gram staining. The results are shown in Table 2.

Table 2. Bacteria colonies morphology and gram staining observation result

Isolate	Colony shape	Margin	Elevation	Color	Gram type	Cell shape
P-1	rhizoid	rhizoid	flat	cream	positive	bacillus
P-2	rhizoid	rhizoid	flat	white	positive	coccus
P-3	circular	entire	flat	cream	negative	bacillus
P-4	irregular	undulate	flat	white	negative	bacillus
P-5	filamentous	lobate	flat	yellow	negative	bacillus
P-6	irregular	lobate	raised	white	negative	bacillus
P-7	irregular	entire	raised	yellow	positive	bacillus
P-8	circular	entire	raised	yellow	positive	coccus
P-9	circular	entire	flat	white	negative	bacillus
P-10	circular	entire	raised	white	positive	bacillus
P-11	circular	entire	flat	white	positive	coccus
P-12	filamentous	lobate	flat	yellow	negative	bacillus
P-13	circular	entire	raised	yellow	negative	coccus
P-14	irregular	entire	flat	white	negative	coccus
P-15	circular	entire	flat	yellow	negative	bacillus
P-16	circular	entire	raised	white	negative	coccus
P-17	circular	entire	flat	orange	negative	coccus
P-18	circular	entire	flat	yellow	negative	coccus
P-19	circular	entire	raised	cream	negative	coccus
P-20	circular	entire	flat	white	positive	bacillus
P-21	circular	entire	flat	yellow	positive	bacillus
P-22	filamentous	lobate	flat	white	negative	bacillus

Isolate	Colony shape	Margin	Elevation	Color	Gram type	Cell shape
P-23	irregular	erose	flat	white	positive	bacillus
P-24	irregular	lobate	flat	white	negative	bacillus
P-25	irregular	lobate	flat	white	positive	bacillus
P-26	rhizoid	rhizoid	flat	white	negative	bacillus
P-27	circular	entire	flat	yellow	positive	coccus
P-28	filamentous	filamentous	flat	white	positive	bacillus
P-29	circular	entire	flat	orange	negative	bacillus
P-30	circular	entire	convex	white	positive	bacillus
P-31	circular	entire	flat	white	negative	bacillus
P-32	circular	entire	raised	brown	positive	bacillus
P-33	circular	entire	flat	yellow	negative	coccus
P-34	irregular	lobate	flat	white	positive	bacillus
P-35	irregular	undulate	raised	white	negative	bacillus
P-36	circular	entire	flat	cream	positive	coccus

3.2.1. Observation of bacteria colonies morphology

Bacterial colonies are a group of bacterial cells that can be observed directly (Holderman et al., 2017). Observation of bacterial colony morphology is one of the stages in the isolation of bacteria that aims to facilitate the process of identification to determine the type of bacteria based on the characteristic of the bacterial colony. The morphology of the bacterial colony was observed by observing the shape, margin, elevation, and color of the selected bacteria colony.

In the observation of bacteria colony morphology, from the observation of the shape of the colonies, there were 20 circular colonies, 9 irregular colonies, 4 filamentous colonies, and 3 rhizoid shaped colonies. Based on the observation of the margin type of the colony, there were 21 colonies with entire margin type, 8 colonies with lobate margin type, 2 colonies with undulate margin type, 1 colony with filamentous margin type, 3 colonies with rhizoid margin type, and 1 colony with erose margin type. In the elevation type observation of the colony, there were 26 colonies with flat elevation, 9 colonies with raised elevation, and 1 colony with convex elevation. In the color morphology observation, 19 colonies were white, 10 colonies were yellow, 4 colonies were cream, 2 colonies were orange, and 1 colony was brown.

3.2.2. *Gram staining observation*

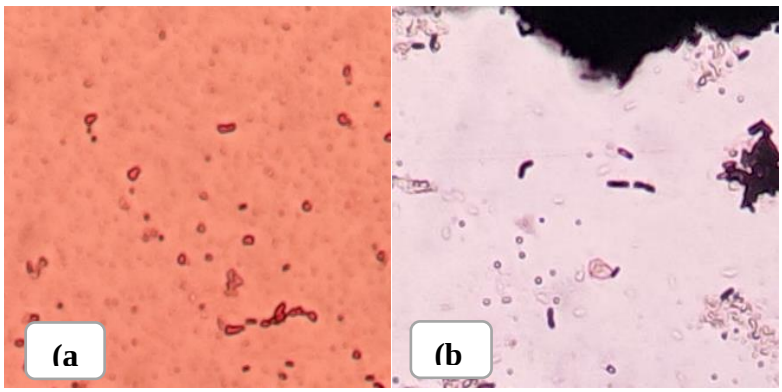


Figure 2. Gram staining result, (a) P-18 and (b) P-23

In the observation of gram staining, several variations of gram type and cell shape of soil bacteria were found. As can be seen in Figure 2, (a) is an isolate of P-18, which has a gram-negative bacterial type and coccus cell shape, and (b) is a P-23 isolate, which has a gram-positive bacteria type and bacillus cell shape. Based on Table 2, in the observation of the gram type of bacteria, 20 isolates are gram-positive bacteria and 16 isolates are gram-negative bacteria. This result is similar to Chairani et al. (2016) that there are more gram-negative bacteria found in soil than gram-positive bacteria. Furthermore, in research conducted by Fitriani et al. (2016), gram-negative bacteria are also dominant in soil from the gram staining process.

In the process of gram staining, the bacteria cells will become purple color when the bacteria are gram-positive bacteria and the bacteria cells will be red when they are gram-negative bacteria (Rohde, 2019). The difference between gram-positive and gram-negative bacteria is that gram-positive bacteria have thick cell walls and thin cell membranes. gram-negative bacteria have a thick layer of cell membrane without the presence of cell walls in the outer layer (Paquete, 2020).

Based on their shape, bacterial cells are divided into three basic forms, namely round (coccus), rod shape (bacillus), and spiral (spirilla) (Sohilauw, 2023). In the cell shape observation, there are 24 bacillus isolates and 12 coccus isolates. This result is similar to Li et al. (2022) *Bacillus* is the dominant form of bacteria found in the soil. In addition, the research of Dewi et al (2017) stated that bacillus is also the dominant form of bacterial cells found in gram staining. This can happen because the bacillus has the ability to form endospores as a form of adaptation to protect bacteria from extreme threats in the soil (Zeigler & Nicholson, 2017), such as changes in nutrient level, water, and temperature (Handayani et al., 2023).

4. CONCLUSIONS

The Pracimaloyo Public Cemetery had an average bacterial population of 4.47×10^7, with block 18 at a depth of 20 cm having the highest bacterial population (9.79×10^7). Different bacterial colony shapes, margins, elevations, and color morphologies were discovered based on the 36 isolates that were observed. Additionally, the majority of the isolates belong to the gram-negative type of bacteria at 55.56% percent and bacillus shape at 66.67 % percent. More research is required to understand more of the anaerobic bacterial population in the cemetery.

5. ACKNOWLEDGMENTS

Thanks to the Universitas Muhammadiyah Surakarta who has given the research fund PUPS, number: 110.30/A.3-III/LRI/VI/2022. Furthermore, thank you to the DISPERUM KPP Surakarta for giving permission to take soil samples at the Pracimaloyo Public Cemetery and to Mr. Jayadi, who has accompanied the process of sampling in the Pracimaloyo Public Cemetery.

6. REFERENCES

Abia, A. L. K., Alisoltani, A., Ubomba-Jaswa, E., & Dippenaar, M. A. (2019). Microbial life beyond the grave: 16S rRNA gene-based metagenomic analysis of bacteria diversity and their functional profiles in cemetery environments. *Science of The Total Environment, 655*, 831–841. https://doi.org/10.1016/j.scitotenv.2018.11.302

Całkosiński, I., Płoneczka-Janeczko, K., Ostapska, M., Dudek, K., Gamian, A., & Rypuła, K. (2015). Microbiological Analysis of Necrosols Collected from Urban Cemeteries in Poland. *BioMed Research International, 2015*, 1–7. https://doi.org/10.1155/2015/169573

Chairani, O., Budiarti, R. S., & Kartika, W. D. (2016). Identifikasi Bakteri Tanah di Kebun Botani Biologi FKIP Universitas Jambi. *BIO-SITE| Biologi Dan Sains Terapan*, *2*(1).

Dewi, A. K., Meylina, L., & Rusli, R. (2017). Isolasi bakteri dari tanah mangrove Rhizopora sp. di kota bontang. *Proceeding of Mulawarman Pharmaceuticals Conferences*, *5*, 59–68.

Fitriani, F., Meylina, L., & Rijai, L. (2016). Isolasi dan karakterisasi bakteri penghasil antibiotik dari tanah sawah. *Proceeding of Mulawarman Pharmaceuticals Conferences*, *4*, 125–132.

Handayani, K., Royanti, V., & Ekowati, C. N. (2023). INDEKS KEANEKARAGAMAN BAKTERI BACILLUS SP. DARI TANAH KEBUN RAYA LIWA. *Gunung Djati Conference Series*, *18*, 46–52.

Holderman, M. V, de Queljoe, E., & Rondonuwu, S. B. (2017). Identifikasi bakteri pada pegangan eskalator di salah satu pusat perbelanjaan di kota Manado. *Jurnal Ilmiah Sains*, *17*(1), 13–18.

Indriana, D. R. (2014). PENGELOLAAN DAN PENGEMBANGAN TEMPAT PEMAKAMAN UMUM (TPU) MUSLIM DI KOTA PONTIANAK. *Jurnal TEKNIK-SIPIL*, *14*(2).

Irfan, M. (2014). Isolasi dan enumerasi bakteri tanah gambut di perkebunan kelapa sawit PT. Tambang Hijau Kecamatan Tambang Kabupaten Kampar. *Jurnal Agroteknologi*, *5*(1), 1–8.

Lestari, N. W., Budiharjo, A., & Pangastuti, A. (2016). Bakteri heterotrof aerobik asal saluran pencernaan ikan sidat (Anguilla bicolor bicolor) dan potensinya sebagai probiotik. *Asian Journal of Tropical Biotechnology*, *13*(1), 9–17.

Li, X., Zhang, Z. Y., Ren, Y. L., Liang, Z. Q., & Han, Y. F. (2022). Diversity and Functional Analysis of Soil Culturable Microorganisms Using a Keratin Baiting Technique. *Microbiology*, *91*(5), 542–552.

Mandala, M., Rachmawati, A., Sari, P. T., & Indarto, I. (2021). *Populasi Bakteri Penambat Nitrogen pada Lahan Sub Optimal di Kabupaten Situbondo, Jawa Timur*.

Marzuki, I., Noor, A., Nafie, N. La, & Djide, M. N. (2014). Isolasi dan identifikasi bakteri shimbion spons penghasil enzim amilase asal pantai melawai balikpapan. *Jurnal Ilmiah "dr. Aloei Saboe*, *1*(2), 11–18.

Nagy, E., Boyanova, L., & Justesen, U. S. (2018). How to isolate, identify and determine antimicrobial susceptibility of anaerobic bacteria in routine laboratories. *Clinical Microbiology and Infection*, *24*(11), 1139–1148. https://doi.org/10.1016/j.cmi.2018.02.008

Nor, T. A., Indriarini, D., & Koamesah, S. M. J. (2018). Ji aktivitas antibakteri ekstrak etanol daun pepaya (carica papaya l) terhadap pertumbuhan bakteri escherichia coli secara in vitro. *Cendana Medical Journal (CMJ)*, *6*(3), 327–337.

Paquete, C. M. (2020). Electroactivity across the cell wall of Gram-positive bacteria. *Computational and Structural Biotechnology Journal*, *18*, 3796–3802. https://doi.org/10.1016/j.csbj.2020.11.021

Prasetya, R. (2021). Pengaruh Kedalaman Muka Air Tanah Terhadap Pertumbuhan Dan Produksi Serta Mutu Fisiologis Benih Kedelai (*Glycine max* (L) Merril) Yang Dihasilkan. *Dinamika Pertanian*, *37*(2), 157–166.

Putra, A. B., Amin, I. F., Fitriyasa, R. D., Najma, N., & Safitry, O. (2021). Memperkirakan saat Kematian (Postmortem Interval) Menggunakan Temuan Mikrobiom pada Setiap Tahap-Tahap Penguraian (Decomposition). *Jurnal Forensik Dan Medikolegal Indonesia*, *2*(1), 111–122.

Putriawati, P., Inayati, N., & Agrijanti, A. (2018). Inventarisasi *Bacillus thuringiensis* Dengan Metode Cawan Sebar Pada Habitat Hidup Larva Anopheles Sp Pada Tanaman Eceng Gondok (Eichornia Crassipes) Di Kabupaten Lombok Tengah. *Jurnal Analis Medika Biosains (JAMBS)*, *5*(2), 91–95.

Rahman, G. K. M. M., Rahman, M. M., Alam, M. S., Kamal, M. Z., Mashuk, H. A., Datta, R., & Meena, R. S. (2020). Biochar and Organic Amendments for Sustainable Soil Carbon and Soil Health. In *Carbon and Nitrogen Cycling in Soil* (pp. 45–85). Springer Singapore. https://doi.org/10.1007/978-981-13-7264-3_3

Ristiati, N. P., Nurlita, F., & Mulyadiharja, S. (2014). Analisis Mikrobiologis Bakteri Anaerobik Sebagai Indikator Pencemaran Pada Muara Tukad Buleleng, Di Perairan Kampung Tinggi, Kabupaten Buleleng. *Seminar Nasional Riset Inovatif II*, 937–955.

Rohde, M. (2019). The Gram-Positive Bacterial Cell Wall. *Microbiology Spectrum*, *7*(3). https://doi.org/10.1128/microbiolspec.GPP3-0044-2018

Rukmana, A., Susilawati, H., & Galang, G. (2020). Pencatat pH Tanah Otomatis. *Jurnal Penelitian Dan Pengembangan Teknik Elektro Telekomunikasi Indonesia*, *10*(1).

Sohilauw, I. S. S. (2023). *Menelisik Bakteri Vibrio Pada Ikan Cakalang (Katsuwonus pelamis)*. CV Literasi Nusantara Abadi. https://books.google.co.id/books?id=zGu0EAAAQBAJ

Walida, H., Harahap, F. S., & Dalimunthe, B. A. (2019). Isolasi Dan Uji Antagonis Mikroorganisme Lokal (Mol) Rebung Bambu Terhadap Cendawan Fusarium sp. *Jurnal Agroplasma*, *6*(2), 1–6.

Yuningsih, H. D., Anggoro, S., & Soedarsono, P. (2014). Hubungan bahan organik dengan produktivitas perairan pada kawasan tutupan eceng gondok, perairan terbuka dan keramba jaring apung di Rawa Pening Kabupaten Semarang Jawa Tengah. *Management of Aquatic Resources Journal (MAQUARES)*, *3*(1), 37–43.

Yunita, M., Hendrawan, Y., & Yulianingsih, R. (2015). Analisis kuantitatif mikrobiologi pada makanan penerbangan (Aerofood ACS) garuda Indonesia berdasarkan TPC (Total Plate Count) dengan metode pour plate. *Jurnal Keteknikan Pertanian Tropis Dan Biosistem*, *3*(3), 237–248.

Zahidah, D., & Shovitri, M. (2013). Isolasi, karakterisasi dan potensi bakteri aerob sebagai pendegradasi limbah organik. *Jurnal Sains Dan Seni ITS*, *2*(1), E12–E15.

Zeigler, D. R., & Nicholson, W. L. (2017). Experimental evolution of *Bacillus subtilis*. *Environmental Microbiology*, *19*(9), 3415–3422. https://doi.org/10.1111/1462-2920.13831

Żychowski, J., & Bryndal, T. (2015). Impact of cemeteries on groundwater contamination by bacteria and viruses – a review. *Journal of Water and Health*, *13*(2), 285–301. https://doi.org/10.2166/wh.2014.119

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

LOF Kirinyuh Leaves and Liquid Waste Tempeh with Pineapple Peel Bioactivator: Sensory and Macronutrient Content

Nur Jati Sekaringsih, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Central Java, Indonesia
*Corresponding Author. E -mail address: aa125@ums.ac.id

KEYWORDS:
liquid organic fertilizer, kirinyuh leave, liquid waste tempeh, pineapple peel, bioactivator

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Liquid organic fertilizer is a liquid organic material that contains plant nutrients. Using liquid organic fertilizers can satiate the nutritional needs of plants and reduce the application of chemical fertilizers, which if used for an extended period, can damage the soil's organic structure. The purpose of this study is to determine the quality of liquid organic fertilizer made from kirinyuh leaves and tempeh liquid waste by adding a bioactivator derived from pineapple rind. The method applied is experimental, and use Completely Randomized Design with two factors. The first component is a mixture of kirinyuh leaves and tempeh effluent (K_1=168 ml: 82 ml, K_2=82 ml: 168 ml), and the second component is a bioactivator derived from ananas peel (B_1=100 ml, B_2=150 ml). Utilizing two-way ANOVA, qualitative and quantitative descriptive data research was conducted. Our field experiments showed that the N content was the highest in the treatment of K1B2 (1.02%), the P content was higher in the treatment of K_2B_1 (0.06 %), as well as the K content was highest in the treatments of K_2B_1 and K_2B_2 (0.10 %). The sensory quality of the average liquid organic fertilizer is brown, has a tapai aroma, and has a pH 4.6 – 5.

1. INTRODUCTION

The agricultural industry is constantly searching for ways to improve crop yields. Beginning with selecting superior seedlings, pesticide or insecticide application, and fertilization. Applying fertilizers to plants plays a role in meeting nutrient requirements and is crucial for soil fertility to boost plant productivity. Organic fertilizers are distinguished from inorganic fertilizers based on their origin. In general, when carrying out fertilization activities, farmers utilize chemical fertilizers because they are deemed more practical, simple to obtain, and cost-effective, and their benefits can be felt rapidly. According to the Regulation of the Minister of Agriculture of the Republic of Indonesia, Number 36/Permentan/SR/10/2017 on Registration of Inorganic Fertilizers, chemical fertilizers, also known as inorganic fertilizers, are produced through chemical, physical, or biological engineering methods and are manufactured in industrial settings or fertilizer production facilities.

Inorganic fertilizers are always accompanied by environmental issues, both for the soil and consumers. According to Maghfoer (2018), the continuous application of inorganic fertilizers without balancing the dosage can alter the soil's physical, chemical, and biological properties, even reducing soil fertility. Furthermore, using inorganic fertilizers can degrade the texture and structure of the ground, resulting in erosion and acidification caused by leaching. In addition, excess inorganic fertilizers can contaminate water and air, posing a threat to living organisms in the area surrounding the applied inorganic fertilizers.

To reduce the excessive use of inorganic fertilizers, specifically using fertilizers derived from organic materials such as animals or plants. Nuro et al. (2016)stated that the application of organic fertilizers can influence the chemical properties of the soil by creating a nutrient balance. In addition to improving the soil's physical properties, applying organic fertilizers increases soil aggregation, thereby increasing its water-holding capacity.

Both agricultural and non-agricultural materials can be utilized to produce organic fertilizers. The composition of nutrients in organic fertilizers is also contingent on the origin of organic fertilizers' fundamental constituents. Organic fertilizer is divided into two categories based on its physical state: solid organic fertilizer and liquid organic fertilizer. Each of the two options has different benefits. Liquid organic fertilizer has the use of loosening the soil's structure, enhancing water absorption, and supplying plant nutrients (Dewi et al. 2016).

Kirinyuh (*Eupatorium odoratum*) is a plant found in the wild that is not extensively utilized. This plant is a menace or an opportunity for the environment due to its abundant availability. As a competitor for nutrient and water absorption, Kirinyuh will inhibit the development of other plants if it is allowed to grow densely. However, kirinyuh also has the potential to be used as fertilizer. Leaves of kirinyuh contain 4.41 % nitrogen and 3.06 % potassium (Okalia et al. 2023). According to Jeksen (2017), liquid fertilizer derived from kirinyuh leaves contained 0.046 % nitrogen, 0.020 % phosphorus, and 0.160 % potassium.

In addition to kirinyuh, industrial waste can be incorporated into producing liquid organic fertilizer. One of the industrial residues that can be utilized is tempeh liquid waste, which can supplement the nutrient content of liquid fertilizer with nitrogen (N), phosphorus (P), and potassium (K). Prasetio (2020), reported that tempeh effluent contained 0.42 % protein, 0.13 % fat, 0.11 % carbohydrates, 98.87 % water, 13.60 ppm calcium, 1.74 ppm phosphorus, and 4.55 ppm iron. Tempeh industrial liquid waste has yet to be optimally utilized because it is considered to have no economic value, so it is disposed of in the sewer. The direct disposal of tempeh's by products can have adverse environmental effects.

In producing organic fertilizers, microorganisms in the bioactivator aid in the decomposition process. Pineapple rind waste is readily available as a bioactivator. Masengi et al. (2020) state that fermented pineapple peels will generate lactic acid bacteria that contribute to plant growth. In addition to enhancing organic decomposition and the formation of soil humus, lactic acid bacteria can also stimulate plant growth. According to Raman et al. (2022) the quality of liquid organic fertilizer is determined by the physical, biological, and chemical characteristics generated.

Based on the preceding context, the research questions are as follows: What is the quality of the liquid organic fertilizer (LOF) combination of kirinyuh leaves and tempeh liquid waste with the addition of pineapple rind as a bioactivator, as measured by sensory indicators and NPK content? The purpose of research is to determine the macronutrient content and sensorial quality of liquid organic fertilizer derived from kirinyuh leaves and tempeh liquid waste with pineapple peel bioactivator.

While the benefits of this research are that it is anticipated that the results will provide information to 1) Researchers to increase their knowledge and understanding of the use of waste that has yet to be optimally utilized to produce liquid organic fertilizer. 2) With the addition of pineapple peel bioactivator, kirinyuh leaves and tempeh liquid waste can be used as fundamental ingredients in producing liquid organic fertilizer.

2. RESEARCH METHODS

This study was conducted from February to April 2023 at the Green House Laboratory of the Teaching and Education Faculty at Muhammadiyah University of Surakarta and the Soil and Plant Nutrition Laboratory of the Agrotechnology Study Program at Muhammadiyah University of Yogyakarta. The tools needed in this study are jars, blenders, basins, scales, pans, stoves, measuring cups, blades, pH indicators, distillation, titrations, test tubes, spectrophotometer (420 nm), flame photometer, and documentation. While the materials used in this study included kirinyuh leaves, tempeh liquid waste, pineapple peel, brown sugar, molasses, coconut water, leri water, bran, pH sticks, concentrated H_2SO_4, Zn, aquades, salt, N_2OH 45%, H_3BO_3 4%, HNO_3, $HClO_4$, HCl 0.1 N, ammonium heptamolybdate vanadate, concentrated extract P.

This study employed a factorial Completely Randomized Design (CRD) with two factors and four treatments, with three repetitions. The first factor combined kirinyuh leaf extract and tempeh effluent with K_1 = 168 ml: 82 ml and K_2 = 82 ml: 168 ml proportions. The second factor was the addition of bioactivators derived from pineapple peel, specifically B_1 = 100 ml and B_2 = 150 ml.

The research implementation included the production of inventories of pineapple peel bioactivator, kirinyuh leaf extract, and tempeh liquid waste, the production of liquid organic fertilizer, as well as sensory observations and nitrogen, phosphorus, and potassium content testing. Observational data obtained were analyzed using qualitative and quantitative descriptive statistics in the form of a two-way analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

3.1. Sensory Observation

Researchers and ten panelists evaluated liquid organic fertilizer composed of kirinyuh leaves, tempeh liquid waste, and pineapple peel bioactivator based on color, aroma, and pH levels. Observation sensory employs all five senses, including a sense of vision (color) and sense of scent (aroma), whereas pH measurement employs an indicator and pH stick. The following table displays the outcomes of sensory observations.

Table 1. Nutrient observation of organic liquid mixture kirinyuh leaves and waste liquid tempeh with the addition of fermented pineapple rind for 14 days.

Combination	Parameter		
	Color	Aroma	pH
K_1B_1	Greenish brown	Tape aroma	5
K_1B_2	Brown	Tape aroma	4.8
K_2B_1	Brown	Not sting	4.9
K_2B_2	Brown	Tape aroma	4.6

Description:

K_1B_1 : Liquid organic fertilizer with a concentration of 168 ml of kirinyuh leaf extract and 82 ml of tempeh liquid waste with the addition of 100 ml of pineapple peel bioactivator

K_1B_2 : Liquid organic fertilizer with a concentration of 168 ml of kirinyuh leaf extract and 82 ml of tempeh liquid waste with the addition of 150 ml of pineapple peel bioactivator

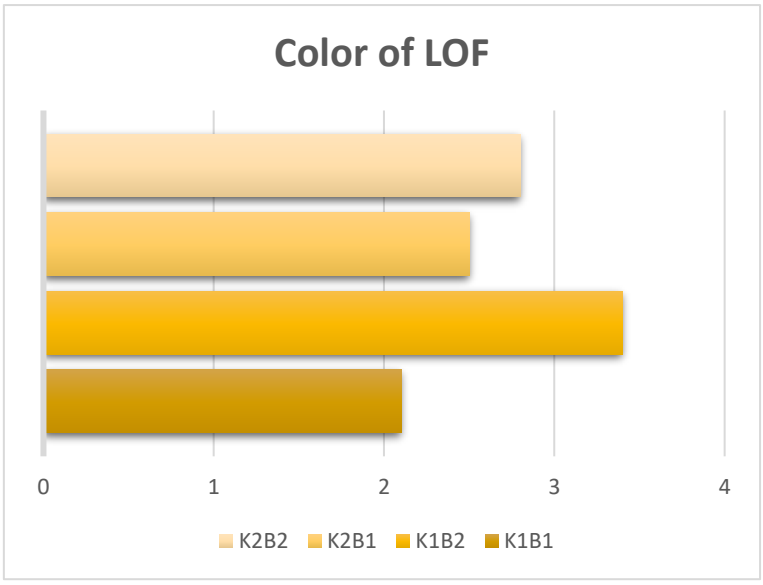
K_2B_1 : Liquid organic fertilizer with a concentration of 82 ml of kirinyuh leaf extract and 168 ml of tempeh liquid waste with the addition of 100 ml of pineapple peel bioactivator

K_2B_2 : Liquid organic fertilizer with a concentration of 82 ml of kirinyuh leaf extract and 168 ml of tempeh liquid waste with the addition of 150 ml of pineapple peel bioactivator

Based on the table data, it can be seen that the sensory observations in the treatment samples showed differences in color, aroma, or pH sensory.

3.1.1. Color parameters

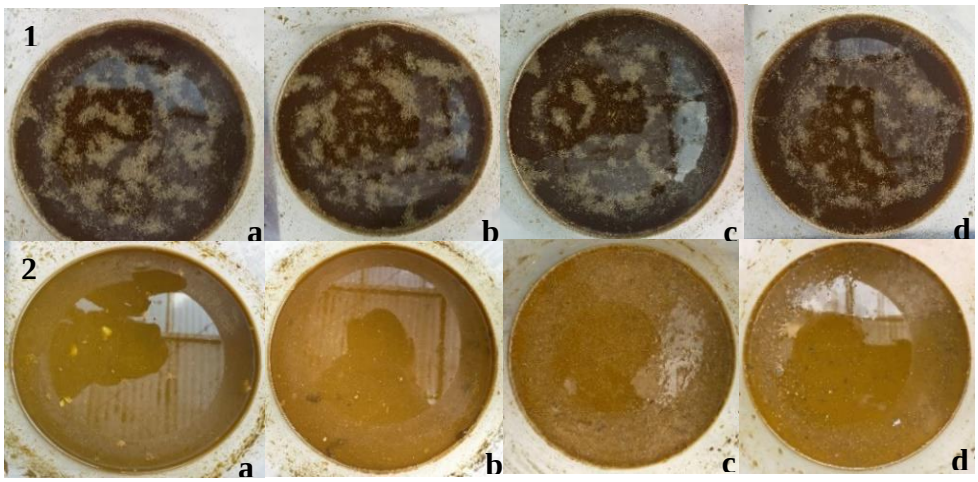
One of the criteria for determining the quality of liquid organic fertilizer is its color. The liquid organic fertilizer produced was greenish brown to brown in color, according to color observations. The colors generated by liquid organic fertilizer comprised of kirinyuh leaf extract, tempeh liquid waste, and pineapple peel bioactivator are depicted in the diagram below.



Description: 1 = brownish yellow, 2 = greenish brown, 3 = brown, 4 = blackish brown

Figure 1. Color observation diagram of kirinyuh leaf liquid organic fertilizer and tempeh liquid waste with the addition of pineapple peel bioactivator

According to the diagram, the color of each sample of liquid organic fertilizer containing a combination of kirinyuh leaves and tempeh liquid waste with the addition of pineapple peel bioactivator is distinct. Brown was the color produced by the K_1B_2, K_2B_1, and K_2B_2 treatments. According to Tanti et al. (2020), the color of an excellent liquid fertilizer ranges from yellowish brown to brown, indicating a successful fermentation process. In contrast, the K_1B_1 treatment resulted in a greenish-brown color. This can be caused by fertilizer that has not reached its full maturity. In addition, materials with higher concentrations than other treatments, such as kirinyuh leaf extract, can cause the color of the fertilizer to be greenish brown. According to Ekawandani (2018) research, the color of vegetable refuse fertilizer remains brown. Figure 2 demonstrates the results of observing the color of liquid organic fertilizer.



Description: 1 = before fermentation; 2 = after fermentation;
a= K_1B_1 ; b= K_1B_2 ; c= K_2B_1 ; d= K_2B_2

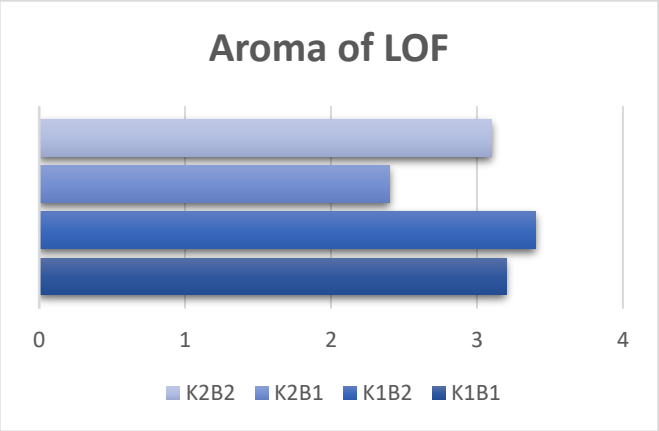
Figure 2. Color sensory observations on liquid organic fertilizer from kirinyuh leaves and tempeh liquid waste with the addition of pineapple peel bioactivator

Figure 2 demonstrates that after 14 days of fermentation, liquid organic fertilizer derived from kirinyuh leaves and tempeh liquid waste, with the addition of a bioactivator derived from pineapple rind, changes color from brown to black to brown to greenish brown. Additional ingredients, such as molasses and bran, can influence the color of liquid organic fertilizer at the outset of the manufacturing process.

The pigment change in liquid organic fertilizer may be caused by the activity of microorganisms involved in fermentation. This is in line with the findings of Andriany et al. (2018), which state that during the fermentation process, organic matter is decomposed by microbial activity, which absorbs water, oxygen, and nutrients from organic matter, which then decomposes and releases CO_2 and O_2. Arifah, (2022) also explained that the color change in liquid organic fertilizer is caused by microorganisms using sufficient oxygen to isolate heat, which causes the essential ingredients to decrease.

3.1.2. Aroma parameters

The maturation of liquid organic fertilizer can also be determined by its aroma. If the decomposition process succeeds, liquid organic fertilizer will produce a distinct fermentation odor. Figure 3 describes the aroma generated by kirinyuh leaf liquid organic fertilizer and tempeh liquid waste with the addition of pineapple peel bioactivator.



Description: 1 = stale, 2 = not sting, 3 = tape aroma, 4 = sting

Figure 3. Aromatic observation diagram for kirinyuh leaf liquid organic fertilizer and tempeh liquid waste containing pineapple peel bioactivator

Kirinyuh leaf liquid organic fertilizer and tempeh liquid waste with the addition of pineapple peel bioactivator prior to fermentation have a unique leaf extract fragrance derived from the aroma of kirinyuh leaves. On day 3, the aroma of the liquid organic fertilizer changed to an unpleasant odor, and on day 14, the K_1B_1, K_1B_2, and K_2B_2 treatments had a distinct fermented fragrance, known as tape aroma. The activity of microorganisms from bioactivators that carry out the fermentation process can result in alterations to the aroma generated. According to Irawan (2022), the presence of the aroma of tape in liquid organic fertilizers is also influenced by the activity of anaerobic microorganisms such as molds, yeast, and bacteria that degrade organic matter into compounds that plants readily assimilate. Therefore, the odor of tapai liquid organic fertilizer can be used to indicate the quality of liquid organic fertilizer. This is supported by Endah et al., (2015), who found that liquid organic fertilizer scents like tapai, unifying that the liquid organic fertilizer produced is of high quality. In the meantime, the K_2B_1 treatment had a faint odor, indicating that the fermentation process aided by microorganisms had concluded. Usman et al. (2022) reported that *Lactobacillus* can decompose sucrose into lactic acid so that a highly pungent odor is diminished.

3.1.3. pH parameters

The pH is measured using a pH indicator following the sensory observations of color and smells. In addition to color and aroma, potential hydrogen (pH) is an essential quality parameter for liquid organic fertilizer. Therefore, pH measurements were taken every three days for fourteen days. Before determining the pH, liquid organic fertilizer made from kirinyuh leaves and tempeh liquid waste was combined with a bioactivator made from pineapple peel. For the pH measurement to be accurate, the dissolved content in liquid organic fertilizer must be consistent and homogenous.

The pH of liquid organic fertilizer mixed with kirinyuh leaves and tempeh liquid waste with the addition of pineapple peel bioactivator at the commencement of the fermentation process is 5. A level of either too low or too high acidity will inhibit plant growth. According to Karoba et al. (2015), if liquid organic fertilizer conditions are too acidic or alkaline, plants assimilate nutrients less efficiently, resulting in stunted plant growth. Figure 4 displays the pH measurement results from this study.

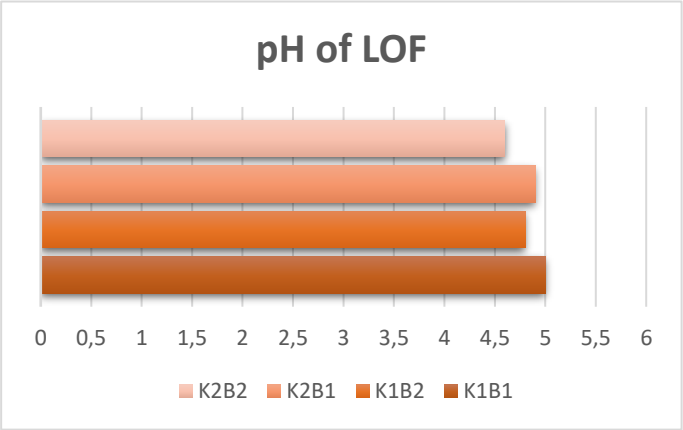


Figure 4: Chart of pH measurements of kirinyuh leaf liquid organic fertilizer and tempeh liquid effluent with pineapple peel bioactivator

Figure 4. illustrates how this is the case. According to the measurement results, the pH values of liquid organic fertilizer made from kirinyuh leaves and tempeh liquid waste with the addition of pineapple peel bioactivator were 5; 4.8; 4.9; and 4.6 for treatments K_1B_1, K_1B_2, K_2B_1, and K_2B_2, respectively. In this instance, the pH meets the quality standards for liquid organic fertilizer specified in Regulation The Minister of Agriculture RI Number 70/Permentan/SR.140/2011 regarding quality standards for liquid organic fertilizer with a standard pH range of 4-9. The proliferation of microorganisms caused the 14-day decrease in pH. According to Kurniawan et al. (2017), the increase or decrease in acidity in fertilizers caused by bacterial activity.

In addition, the K_2B_2 treatment demonstrated the lowest potential hydrogen (pH) level, which was 4.6. Due to the corrosive and high concentration of tempeh liquid waste, liquid organic fertilizer with a low pH is produced. According to Cundari et al. (2022), tempeh liquid waste has a very high concentration, is viscous, acidic, brownish yellow, and has an offensive odor. In addition, lactic acid bacteria in the bioactivators of pineapple epidermis also contribute to a low pH. Jaelani et al. (2015) confirmed that the potential hydrogen (pH) during fermentation is affected by the number of lactic acid bacteria; the greater the number of lactic acid bacteria, the lower the pH during fermentation.

3.2. Content of Macro Nutrients

Based on the results of macro-nutrient experiments involving nitrogen (N), phosphorus (P), and potassium (K) liquid organic fertilizer combination of kirinyuh leaves and tempeh liquid waste with the addition of pineapple peel bioactivator, the following average is calculated:

Table 2. The results of the nutrient content of N, P, and K organic fertilizer liquid combination leaf residue and waste liquid tempeh fermented for 14 days with the addition of bioactivator pineapple peel.

Treatment	Macro Nutrient		
	N (%)	P (%)	K (%)
K_1B_1	0.93	0.06*	0.08
K_1B_2	1.02*	0.05	0.09
K_2B_1	0.82	0.05	0.10*
K_2B_2	0.82	0.05	0.10*

Description: (*) highest result

The presence of macronutrients such as nitrogen, phosphorus, and potassium is dependent on the amount of organic matter present. According to Ramadhan et al., (2015)organic matter provides nutrients and C-organic. For example, the liquid organic fertilizer composed of kirinyuh leaves, tempeh liquid waste, and pineapple rind bioactivator contains the following nutrients:

3.2.1. Nitrogen Content

Nitrogen is one of the essential nutrients for plant growth. Plants absorb nitrogen compounds like NO_3^- (nitrate) and NH_4^+ (ammonium). As for the test results for the N content of organic fertilizers liquid combination leaf refuse And waste liquid tempeh with bioactivator: Pineapple epidermis can be seen in Figure 5:

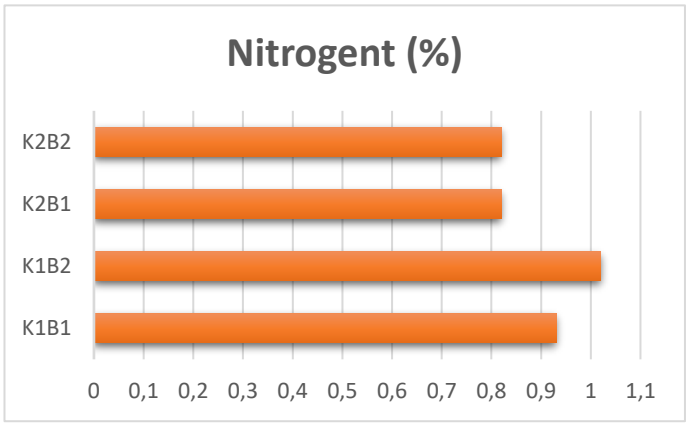


Figure 5. Diagram of nitrogen content in liquid organic fertilizer derived from kirinyuh leaves and tempeh liquid waste with the addition of pineapple peel bioactivator

The K_1B_2 treatment had the maximum nitrogen content at 1.02 %, while the K_2B_1 and K_2B_2 treatments had the lowest nitrogen content at 0.80 %. The N content of liquid organic fertilizer increases proportionally to the concentration of kirinyuh leaf extract. This is probably due to the high nitrogen content of kirinyuh leaves. Lodo et al. (2022) explained that kirinyuh is a source of organic matter due to its high nutrient content in nitrogen. This liquid fertilizer meets the nitrogen content requirements for organic liquid fertilizers. According to SNI 19-7030-2004, the minimal nitrogen content quality standard is 0.4 %. In addition, the accompanying table explains the effect of liquid organic fertilizer from kirinyuh leaves and tempeh liquid waste with the addition of pineapple peel bioactivator on nitrogen content.

Table 3. Two-way analysis of variance (ANOVA) of nitrogen content

Tests of Between-Subjects Effects					
Dependent Variable: Nitrogen					
Source	**Type III Sum of Squares**	**df**	**MeanSquare**	**F**	**P.**
Corrected Model	.084 [a]	3	.028	17,277	001
Intercepts	9,666	1	9,666	5948354	.000
combination	072	1	072	44,354	.000
Bioactivator	006	1	006	3,738	089
Combination * Bioactivator	006	1	006	3,738	089

Error	013	8	002
Total	9,763	12	
Corrected Total	.097	11	

a. R Squared = .866 (Adjusted R Squared = .816)

To determine the effect of the combination of ingredients, addition of bioactivator, and interaction between the combination of ingredients and addition of bioactivator, a two-way ANOVA was used to analyze the mean of Table 3. The results indicated that combining kirinyuh leaves and tempeh effluent affected nitrogen content ($p < 0.05$). Sukri et al. (2019) explained that combining organic matter and fertilizers could increase the soil's nutrient availability. However, adding a bioactivator during liquid organic fertilizer production did not affect the nitrogen content ($p > 0.05$). In addition, the interaction between the combination of constituents and the addition of bioactivators did not affect the nitrogen content ($p > 0.05$).

3.2.2. Phosphorus (P) Content

Phosphorus (P) is an essential element for plant growth. Phosphorus deficiency can result in stunted plant growth, weakened and little stems, and disturbances in plant metabolism. Figure 6 illustrates the phosphorus nutrient content of liquid organic fertilizer mixtures containing waste liquid tempeh and bioactivator pineapple rind.

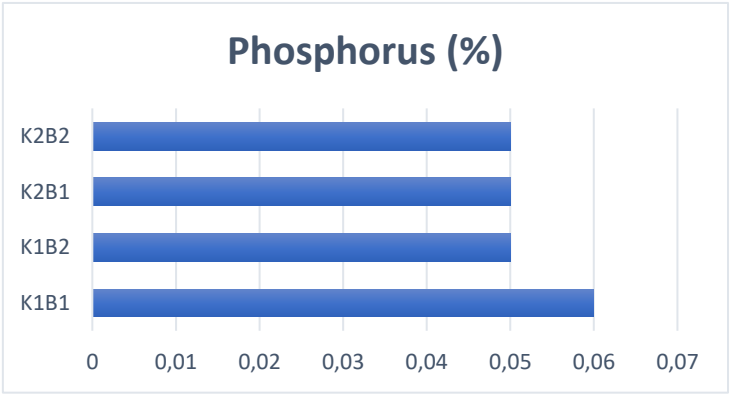


Figure 6. Phosphorus content diagram in kirinyuh leaf liquid organic fertilizer and tempeh liquid waste with the addition of pineapple peel bioactivator

According to Figure 6, the P content of liquid organic fertilizer in this study varied between 0.05 and 0.06 %. K_1B_1 has the greatest concentration of phosphorus at 0.06%. While the K_1B_2, K_2B_1, and K_2B_2 treatments contained the same amount of phosphorus, 0.05 %, the K_1B_2 and K_2B_2 treatments contained 0.06 %. According to SNI 19-7030-2004, however, the phosphorus content of liquid organic fertilizer is more significant than 0.10 %. This indicates that the liquid organic fertilizer composed of kirinyuh leaves, tempeh liquid waste, and pineapple peel bioactivator does not meet the minimum phosphorus content requirements.

Oktiawan et al. (2015) state that phosphorus must be broken down into $H_2PO_4^-$ and HPO_4^- before plants can assimilate it. The 14-day fermentation process decomposes the organic matter's organic components into elements that plants can assimilate. However, prolonged fermentation can deplete the nutrient content of liquid organic fertilizer. This is supported by the findings of Kusumadewi et al. (2019), who found that the duration of fermentation affects the amount of phosphorus nutrients present. The longer the fermentation time, the more nutrients are consumed

by the activity of microorganisms; consequently, the availability of nutrients will eventually be depleted, resulting in the demise of the microorganism. In addition, phosphorus concentrations will increase as the activity of microorganisms involved in decomposing organic compounds decreases during this phase. Therefore, the movement of microorganisms in decomposing organic compounds will reduce, producing less phosphorus. In the meantime, the following table illustrates the effect of the combination of constituents, the addition of bioactivators, and their interaction.

Table 4. Two-way analysis of variance (ANOVA) of phosphorus content

Tests of Between-Subjects Effects					
Dependent Variable: Phosphorus					
Source	**Type III Sum of Squares**	**df**	**MeanSquare**	**F**	**P.**
Corrected Model	.000 [a]	3	7.500E-005	.750	.552
Intercepts	.033	1	.033	330,750	.000
combination	7.500E-005	1	7.500E-005	.750	.412
Bioactivator	7.500E-005	1	7.500E-005	.750	.412
Combination * Bioactivator	7.500E-005	1	7.500E-005	.750	.412
Error	001	8	1.000E-004		
Total	.034	12			
Corrected Total	001	11			
a. R Squared = .220 (Adjusted R Squared = -.073)					

The two-way ANOVA test in Table 4 demonstrates that the combination of kirinyuh leaves and tempeh liquid waste had no effect ($p > 0.05$) on the phosphorus content of liquid organic fertilizer. Likewise, adding a bioactivator to the phosphorus content of liquid organic fertilizer had no significant effect ($p > 0.05$) on the phosphorus content. This is because pineapple peel contains lactic acid microorganisms, which function to produce acid in fermented substances. According to Lerner et al. (2021), adding bioactivators can increase plant tolerance to water stress and plant resistance to diseases and parasites. Moreover, there was no average difference in the interaction between the combination of ingredients and the addition of the bioactivator, indicating that the interaction between the combination of ingredients and the addition of pineapple peel bioactivator had no effect ($p > 0.05$) on the phosphorus content of liquid organic fertilizer made from kirinyuh leaves and tempeh liquid waste with the addition of bioactivator peel pineapple. This can be attributed to the relatively low phosphorus content of organic matter. Anggraini et al. (2019) explained that the composition of the nutrients in organic fertilizers could be affected by the variety of materials used and the production method.

3.2.3. Potassium (K) Content

Potassium is another nutrient that plants need to increase their resistance. The presence of microorganisms and their activities affect potassium concentrations in compost. Figure 7 displays the results of measuring the potassium content in a mixture of kirinyuh leaves, tempeh liquid waste, and pineapple peel bioactivator used as a liquid organic fertilizer.

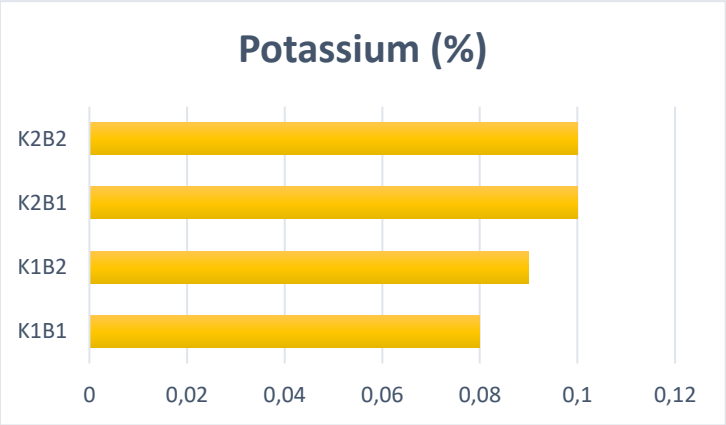


Figure 7. Diagram of potassium content in kirinyuh leaf liquid organic fertilizer and tempeh liquid waste with pineapple peel bioactivator

The potassium content of liquid organic fertilizer was lower in the K_1B_1 and K_1B_2 regimens, as shown in Figure 7. In contrast, the K_2B_1 and K_2B_2 treatments were 0.10 % larger than the others. According to SNI 19-7030-2004, the K content of liquid organic fertilizer is more significant than 0.20 %. This indicates that the combination of kirinyuh leaves, tempeh liquid waste, and pineapple peel bioactivator does not meet the minimum potassium criteria. The low potassium content of kirinyuh leaf liquid organic fertilizer and tempeh liquid waste with pineapple peel bioactivator can be attributed to the activity of microorganisms in decomposing organic matter. Microorganisms utilize potassium as a catalyst for their metabolic processes (Nur et al. 2016). The following table explains the effect of liquid organic fertilizer on potassium content.

Table 5. Two-way analysis of variance (ANOVA) of potassium content

Tests of Between-Subjects Effects					
Dependent Variable: Potassium					
Source	Type III Sum of Squares	df	MeanSquare	F	P.
Corrected Model	.001 [a]	3	.000	1,100	.404
Intercepts	.103	1	.103	410,700	.000
combination	001	1	001	2,700	.139
Bioactivator	7.500E-005	1	7.500E-005	.300	.599
Combination * Bioactivator	7.500E-005	1	7.500E-005	.300	.599
Error	002	8	.000		
Total	.106	12			
Corrected Total	003	11			
a. R Squared = .292 (Adjusted R Squared = .027)					

Table 5's two-way analysis of variance (ANOVA) test indicates, with a 95% confidence level, that the combination of constituents has no significant effect on the potassium content of

liquid organic fertilizer ($p > 0.05$). For example, adding a bioactivator derived from pineapple rind did not affect potassium content ($p > 0.05$). Likewise, adding pineapple peel bioactivator did not affect ($p > 0.05$) on the potassium content of kirinyuh leaf and tempeh wastewater liquid organic fertilizer. A possible cause of the low potassium content is a flawed fermentation process. Conversely, a successful fermentation procedure will result in a high potassium content (Sulfianti et al. 2021).

4. CONCLUSION

The combination of kirinyuh leaves and tempeh liquid waste, with the addition of a pineapple peel bioactivator, produced a liquid organic fertilizer with acceptable levels of nitrogen, phosphorus, and potassium. K_1B_2 treatment had the highest nitrogen content, at 1.02 %, and already met the standard quality. The K_1B_2 treatment's sensory characteristics were brown in color, tapai-flavored, and had a pH of 4.8. The K_1B_1 treatment with a 0.06 % phosphorus content had greenish-brown sensory properties, a tape aroma, and a pH of 5. The maximum potassium content was found in the K_2B_1 and K_2B_2 treatments, at 0.10 % each. Sensory qualities of K_2B_1's were brown, not overpowering, and had a pH of 4.9, while K_2B_2's sensory qualities were brown, tape aroma, and had a pH of 4.6. Phosphorus and potassium concentrations produced by kirinyuh leaf liquid organic fertilizer and tempeh liquid waste with pineapple peel bioactivator did not meet quality standards. To produce liquid organic fertilizers that meet SNI standards, it is recommended to increase the materials' concentration, shorten the fermentation time to 7 days, or use materials rich in potassium and phosphorus.

5. REFERENCES

Andriany, A., Fahruddin, F., & Abdullah, A. (2018). Effect of Bioactivators Types On The Rate of Teak Tectona Grandis L. F., Leaf 'Seresah' Decomposition, In The Campus Unhas Tamalanrea. *Bioma : Jurnal Biologi Makassar*, *3*(2), 31–42. https://doi.org/10.20956/bioma.v3i2.5820

Anggraini, L., Kuswoyo, V. A., & Marsya, M. A. (2019). Production Of Liquid Organic Fertilizers From Market Waste With Comparison Of Results Using Tofu Water Bioactivators and EM4. *1*(1), 13–17.

Arifah, D. A., & Asnur, P. (2022). Processing of Kepok Banana Peel Waste Into Liquid Organic Fertilizer. *Agroteknologi*, *1*(1), 20–27.

Cundari, L., Suhendra, A. A., Indahsari, S. R., Asnari, M., Afrah, B. D., Gunawan, A., & Alfatih, M. M. (2022). Activated Carbon Efficiency of Eichornia crassipes on Tempe Liquid Waste Processing. *JST (Jurnal Sains dan Teknologi)*, *11*(2), 403–410. https://doi.org/10.23887/jstundiksha.v11i2.49422

Dewi, N. K., Kiswardianta, R. B., & Huriawati, F. (2016). Utilization of Seagrass Litter as Raw Material for Liquid Organic Fertilizer Manufacturing Process of Liquid Organic Fertilizer Seagrass Litter. *Proceeding Biology Education Conference*, *13*(1), 649–652.

Ekawandani, N., & Kusuma, A. A. (2018). Composing Organic Waste (Cubis and Banana Peel) Using EM4. *Jurnal TEDC*, *12*(1), 38–43.

Endah, A. S., Suyadi, A., & Budi, G. P. (2015). Testing Some Methods of Production of Bioactivators for Improving the Quality of Liquid Organic Fertilizers. *AGRITECH*, *XVII*(2), 122–128.

Irawan, D. L., & Asngad, A. (2022). *Azolla mycrophylla* And Leaves Of Kerosen As Liquid Organic Fertilizer (POC) With The Addition Of A Bioactivator Of Bamboo Grain. *SNPBS VII*, 57–67.

Jaelani, A., Widaningsih, N., dan Eko Mindarto. (2015). The effect of Storage Length of Fermented Palm Frond by Trichoderma sp to pH, Crude Protein and Crude Fiber Content. *Ziraa'Ah, 40*(03), 232–240.

Jeksen, J., & Mutiara, C. (2017). Analysis Of Liquid Organic Fertilizer Quality Of Some Types Of Leguminosa Plants. *Jurnal Pendidikan Mipa*, *7*(2), 124–130. http://jurnal.lppmstkiptsb.ac.id/index.php/jpm/article/view/139

Karoba, F., Nurjasmi, R., & Suryani, S. (2015). Effect of pH Difference on Growth and Outcome of the Kailan Plant (*Brassica oleraceae*) Nft Hydroponic System (Nutrient Film Tecnique). *Jurnal Ilmiah Respati Pertanian*, *7*(2), 529–534.

Kurniawan, E., Ginting, Z., & Nurjannah, P. (2017). The Use Of Goat Urine In The Manufacture Of Liquid Organic Fertilizer Versus The Quality Of Macro Hara Elements (NPK). *Eddy Kurniawan Zainuddin Ginting Putri Nurjannah*, *1*(2407 – 1846), Hlm. 1-10. Fakultas Teknik. Universitas Muhammadiy. jurnal.umj.ac.id/index.php/semnastek

Kusumadewi, M. A., Suyanto, A., & Suwerda, B. (2019). Nitrogen, Phosphorus, Potassium, and pH of Liquid Organic Fertilizers from Market Fruit Waste Based on Time Variation. *Sanitasi: Jurnal Kesehatan Lingkungan. 11*(2), 92–99.

Lerner, A. W., Guimarães, V. F., Brito, T. S., Röske, V. M., Cecatto, R., Silas, A., Silva, L., & Weizenmann, J. C. (2021). Inoculation Methods Of Azospirillum Brasilense Associated To The Application Of Soil Bioactivator In The Maize Crop. *11*, 67–75. https://doi.org/10.26814/cps2021009

Lodo, D. F., Osa, D. B., Sulistijo, E. D., Studi, P., Fakultas, P., Universitas, P., & Cendana, N. (2022). Effect of Kirinyuh (*Chromolaena odorata*) Organic Mulch Thickness on Nutrient Content of Brachiaria Hybrid Grass cv. Mulato Third Harvest. *Jurnal Peternakan Lahan Kering*. 4(4), 2461–2466.

Maghfoer, M. D. (2018). *Environmentally Friendly Eggplant Fertilization Techniques.* UB Press.

Masengi, K. I. E. G., Siampa, J. P., & Tallei, T. E. (2020). Encapsulation of the Lactic Acid Bacteria from Pineapple Skin (*Ananas comous*) Fermentation with Staining of Telang Flowers (*Clitoria ternatea*). *Jurnal Bios Logos*, *10*(2), 86. https://doi.org/10.35799/jbl.10.2.2020.29047

Nur, T., Noor, A. R., & Elma, M. (2016). Manufacture Of Liquid Organic Fertilizer From Household Organic Waste With Bioactivator EM4 (Effective Microorganisms). *Konversi: 5*(2), 44–51. https://doi.org/10.20527/k.v5i2.4766

Nuro, F., Priadi, D., & Mulyaningsih, E. S. (2016). Effects of Organic Fertilizer on. *Prosiding Seminar Nasional Hasil-Hasil PPM IPB*, *January*, 28–39.

Okalia, D., Nopsagiati, T., & Marlina, G. (2023). Manufacture Of Liquid Organic Fertilizer From The Effectivity Study Of Human Green Puppes (*Chromolaena odorata*) In The Substitution Of N and K On Jung Plants (*Zea Mays*) In Territorial Ultraslimitation Of Houset Organic Wasts With Bioactivator EM 4. *Jurnal Agro Indragiri*, *8*(1), 1–10. https://doi.org/10.32520/jai.v8i1.2453

Oktiawan, W., Sarminingsih, A., Purwono, & Afandi, M. (2015). Organic Puppy Manufacturing Strategy Commercial Fruit From Semarang's Home Cutting Animals. *Jurnal Presipitasi*, *12*(2), 89–94.

Peraturan Menteri Pertanian. (2011). *PUPUK ORGANIK, PUPUK HAYATI DAN PEMBENAH TANAH (PERMENTAN NOMOR 70/PERMENTAN/SR.140/10/2011)*.

Prasetio, J., & Widyastuti, S. (2020). Liquid Organic Fertilizer From Tempe Industry Waste. *WAKTU: Jurnal Teknik UNIPA*, *18*(2), 22–32. https://doi.org/10.36456/waktu.v18i2.2740

Ramadhan, M. F., Hidayat, C., & Hasani, S. (2015). Effect Of Organic Matter And Amf On Growth And Yield Of Chili Plants (*Capsicum annum* L.) Landung Varierty On Post-Excavation Soil C. *Jurnal Agro. 2*(2): 50-57.

Raman, J., Kim, J. S., Choi, K. R., Eun, H., Yang, D., Ko, Y. J., & Kim, S. J. (2022). Application of Lactic Acid Bacteria (LAB) in Sustainable Agriculture: Advantages and Limitations. *International Journal of Molecular Sciences*, *23*(14). https://doi.org/10.3390/ijms23147784

SNI 19-7030-2004. (2004). *Composite Specifications from Domestic Organic Waste SNI 19-7030-2004*.

Sukri, M. Z., Firgiyanto, R., Sari, V. K., & Basuki, B. (2019). Combination of Cattle Manure, Humic Acid and Mycorrhiza on Mycorrhizal Root Infection in Chili Pepper and Availability of Udipsamments Soil Nutrients. *Jurnal Penelitian Pertanian Terapan*, *19*(2), 142. https://doi.org/10.25181/jppt.v19i2.1450

Sulfianti, Risman, & Inang Saputri. (2021). NPK Analysis Of Liquid Organic Fertilizer From Various Types Of Rice Washing Water With Different Fermentation Methods. *Jurnal Agrotech*, *11*(1), 36–42. https://doi.org/10.31970/agrotech.v11i1.62

Tanti, N., Nurjannah, N., & Kalla, R. (2020). Production Of Liquid Organic Fertilizers By Aerobic Method. *ILTEK : Jurnal Teknologi*, *14*(2), 2053–2058. https://doi.org/10.47398/iltek.v14i2.415

Usman, D., Anggo, N. S., Uno, W. D., Retnowati, Y., Kumaji, S. S., & Isra, M. (2022). Ananas (*Ananas comosus* L. Merr) As an Organic Fertilizer. (*SemanTECH 2022*), 152–154.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Glucose Levels and Organoleptic Quality Probiotic Tepache of Pineapple Peel on Variation of Sugar and Fermentation Duration

Qurota A'yuni Nuha Sabira, Titik Suryani*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
E-mail address: ts169@ums.ac.id

KEYWORDS:
Fermentation
Pineapple peel
Probiotic
Sugar
Tepache

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The probiotic beverage tepache is a variety of natural or processed functional products that contain bioactive compounds with specific physiological functions for health. Pineapple peel is one of the plant base ingredients that can be used as a base for probiotic beverages. The levels of antibacterial compounds, carbohydrates, and sugars in pineapple peel are sufficient to be an essential medium for the growth of Lactic Acid Bacteria (LAB) in probiotic beverages. This research was aimed to determine the glucose levels and organoleptic quality of probiotic beverages tepache of pineapple peel on variation of sugar and fermentation duration. This research used experimental method Completely Randomized Design (CRD) with two-factors, Factor 1 was variation of sugar (G) palm sugar and granulated sugar. Factor 2 was the variation of fermentation duration (F) 3 and 5 days. The results of the research showed that the tepache of pineapple peel had the highest glucose levels in the treatment of G1F1 (palm sugar 100 g with 3-days fermentation duration) at 12,2 %. The best organoleptic quality of tepache pineapple peel was in G2F1 treatment (granulated sugar 100 g with 3-days fermentation duration) with light yellow color, tepache-specific aroma, and sour flavor.

1. INTRODUCTION

Probiotic beverages are a type of functional food with physiological benefits for the body's health. In addition, it can reduce the risk of hypercholesterolemia, hypertension, diabetes, and obesity, and suppress inflammation in the intestines (Refita, 2021). Furthermore, certain functions of probiotic beverages may reduce lactose intolerance reactions and inhibit the proliferation of diarrhea-causing pathogens (Sultan, 2022). Dairy fermentation products such as yogurt and kefir are the most well-known probiotic beverages. However, fermented milk beverages are relatively more expensive and can trigger lactose intolerance in some individuals. To accomplish this, other plant-based alternatives must be used as raw materials in producing probiotic beverages so that they can be made at a price that is more affordable and relatively safe for public health. Oranges, apples, guava, and pineapples can be used as the base components for probiotic beverages, then further developed through extensive research. Tepache is one of the probiotic beverages produced by the pineapple peel.

Tepache is a traditional Mexican beverage made possible by developing functional products and nutritious ingredients. The pineapple rind accounts for 25 % of the fruit's weight. 81,72 % of pineapple peel is water, 20.87 % of crude fiber, 17.53 % of carbohydrates, 4.41 % of protein, and 13.65 % of reduced sugar (Setyawati & Rahman, 2017). Due to its high glucose content, pineapple peel is an essential medium for developing Lactic Acid Bacteria (LAB). Pineapple peel contains flavonoids, tannins, saponins and bromelain. Bromelain is effective against both aerobic and

anaerobic bacterial isolates (Putri et al., 2016). The fermentation of pineapple peel with lactic acid microorganisms produces an alternative functional beverage. Tepache is produced by placing fruit flesh and pineapple peel in a container with brown sugar to encourage spontaneous fermentation (Ojeda-Linares et al., 2021).

Palm and granulated sugar are the forms of sugar used by the community. The top of the palm tree stalk is tapped to obtain palm sugar. The sap water from the lead is heated to a shallow moisture content (6 %) so that the sap will harden throughout the water-cooling process. Palm sugar contains vitamin B complex, glucose, and mineral salts (Lalisang, 2018). Palm sugar has a lower glycemic index value than granulated sugar, measuring 35 glycemic index with a total of 368 calories per 100 g of ingredients, compared to granulated sugar's glycemic index value of 58 with a total of 400 calories per 100 g of ingredients. This glycemic index regulates triglyceride levels in the blood (Aprilia & Suryana, 2022).

Granulated sugar is refined, dehydrated sucrose crystal sugar derived from sugar cane. Several steps are involved in producing granulated sugar: preparation, grinding, sap purification, crystallization, centrifuging, and drying. Due to the minimal production process and low temperatures, the phytonutrient content of palm sugar is more stable than granulated sugar. The addition of pineapple peel and sugar in a ratio of 3:1 results in a balanced flavor between the acidic pineapple peel and the sweet sugar; the aroma and color of golden brown enhance the appealing qualities of tepache beverages (Sukriadi et al., 2022). High concentrations of sucrose in palm sugar and granulated sugar nourish lactic acid bacteria, affecting their activity during fermentation.

The fermentation duration depends on the incubation period of lactic acid bacteria and determines the properties of the fermented beverage. Several variables, including microbial population, pH, substrate, temperature, alcohol concentration, oxygen, salinity, water, and fermentation duration, affect the fermentation process (Widyantara et al., 2020). The longer the duration of the fermentation process, the lower the pH in a fermented beverage, the concentrations of lactic acid, acetic acid, butyric acid, and propionic acid increase as pH decreases. The production of acid results from the conversion of glucose to alcohol. (Simanjuntak et al., 2017). This increase in sourness reduces the panelists' evaluations of flavor. The bacterial curve during the lengthy fermentation period has three phases. During the logarithmic phase, the number of bacteria increases; during the stationary phase, the number of living and deceased bacteria equals; and during the death phase, the number of lactic acid bacteria decreases (Masengi et al., 2020).

In Indonesia, probiotic tepache beverages have not been the subject of thorough studies. In the research conducted by Hujjatusnaini et al., 2022, pineapple peel tepache probiotic beverage was combined with a LAB starter in the form of *Lactobacillus casei* and sugar concentration solutions of varying concentrations. Probiotic beverage tepache pineapple peel with added sugar can undergo spontaneous fermentation due to the presence of microorganisms such as *Lb. Plantarum, Leuconostoc mesenteroides*, and yeast *Saccharomyces cerevisiae* var. *boulardii* in the pineapple peel. (Romero-luna et al., 2017) The pineapple peel tepache probiotic beverage is usually made with piloncillo sugar, a form of brown sugar. This research aims to determine the glucose level and organoleptic quality of probiotic tepache pineapple peel on variations of sugar types (palm and granulated sugar) and fermentation durations (three days and five days fermentation).

2. MATERIALS AND METHODS

This research was conducted in February 2023 at the UMS Biology Laboratory on Ahmad Yani Tromol Street, Post 1, Pabelan Kartasura. In the meantime, testing for glucose levels was conducted in March 2023 at the Chem-Mix Pratama Laboratory in Bantul, Yogyakarta. Manufacturing pineapple peel tepache fermented beverages requires 1000 ml glass jars, 500 ml plastic measuring cups, test containers, digital scales, pH meters, water baths, vortices, centrifuges, and spectrophotometers. Probiotic beverages tepache pineapple peel was produced with honey pineapple peel, honey pineapple flesh, palm sugar, granulated sugar, and distilled water.

This research employs an experimental method. The experimental design was a Complete Randomized Design (CRD) with two factors: sugar type (G1 = 100 g of palm sugar, G2 = 100 g of granulated sugar) and the duration of fermentation (F1 = 3 days, F2 = 5 days). The research was conducted in the following stages: 1. sterilization of equipment, 2. preparation of materials and tepache solution, 3. production of tepache, 4. pH measurement, 5. glucose level testing, 6. organoleptic test. A pH meter is utilized for the pH test. The parameter test: glucose levels and organoleptic quality. The glucose level test is carried out by the spectrophotometric, Nelson-Somogy method at 540 nm absorption wave. The data was collected using experimental techniques, surveys, literature, and documentation, while organoleptic quality and acceptability tests were analyzed qualitatively and descriptively using questionnaire sheets conducted on 15 panelists with an age range of 20 – 25 years. Quantitative descriptive methodologies applied to glucose levels testing analysis. The organoleptic test consists of color, aroma, flavor, and acceptability with hedonic scale. Quantitative data analysis utilizing two-track variance, the Kruskal-Wallis test, and qualitative data utilizing Microsoft Excel.

3. RESULTS AND DISCUSSION

The results of a research conducted on the pH and glucose levels of probiotic beverages tepache pineapple peel on variation of sugar and fermentation duration show the following values:

3.1. pH and Glucose Analysis of Probiotic Beverage Tepache Pineapple Peel on Variations of Sugar Types and Fermentation Duration.

Table 1. pH Values and Glucose Levels of Probiotic Beverage Tepache Pineapple Peel on Variations of Sugar Types and Fermentation Duration.

No	Treatment	pH	Glucose (%)	Annotation
1	G1F1	3.4**	12.22**	Palm sugar 100 g with a fermentation duration of 3 days
2	G1F2	3.3	8.46	Palm sugar 100 g with a fermentation duration of 5 days
3	G2F1	3.2	8.43	Granulated sugar 100 g with a fermentation duration of 3 days
4	G2F2	3.14*	5.91*	Granulated sugar 100 g with a fermentation duration of 5 days

*Notes: *) pH value and lowest glucose level*

***) pH value and highest glucose level*

Table 1. shows that the glucose levels of pineapple peel tepache on sugar and fermentation duration variations have different values. The highest glucose concentration in pineapple peel tepache treated with G1F1 was 12.22 % per 100 g of palm sugar fermented for three days. In contrast, the lowest glucose level of pineapple peel tepache in the G2F2 treatment is 5.91 % per 100 g of granulated sugar after five days of fermentation. Within Table 1. the concentration of glucose decreases. The longer pineapple peel tepache is fermented, the lower its glucose concentration. The glucose decrease caused by Lactic Acid Bacteria (LAB) has not effectively decomposed the sucrose levels. Lactic Acid Bacteria is in its beginning growth phase (lag phase), an adaptation phase on the third day. Lactic Acid Bacteria begin experiencing rapid growth (exponential phase) on the fourth day. During the exponential phase, additional glucose substrate must be converted into lactic acid to sustain the growth and division of bacterial cells, resulting in a decrease in glucose levels. This phase involves the division or proliferation of bacteria because optimal conditions exist (Astuti et al., 2020). On day five, treatment with G1F2 and G2F2 decreased glucose levels. The glucose decrease indicates that bacteria are in an exponential growth phase, in which sucrose is broken down into glucose and glucose is converted into lactic acid and other organic acids used for bacterial growth. The decrease in glucose explains that bacteria and microorganisms require sugar as a carbon source for nutrition, which is then converted into organic acids and alcohol (Puspitasari et al., 2017).

The type of sugar in probiotic tepache pineapple peel affects the glucose levels in the beverage. Due to the hydrolysis of sucrose into simpler sugar components such as glucose and fructose under acidic conditions, reduced sugar levels decrease (Diniyah et al., 2013). This explains why G1F1 and G1F2 treatments have higher glucose concentrations than G2F1 and G2F2 treatments. Palm sugar has a more significant concentration of sucrose than granulated sugar. One hundred grams of palm sugar contain 84.31 percent sucrose, whereas 100 g of refined sugar contain 71.89 percent (Hendry et al., 2021). The cooking process in palm sugar can inhibit the activity of the invertase enzyme, resulting in less harm to the produced sucrose and a lesser decrease in pH value (Wilberta et al., 2021). During the fermentation process, the pH value serves as an indicator because it affects the tepache's aroma, flavor, and acceptability. The optimal pH for LAB activity in acidic conditions is 4 (Hujjatusnaini et al., 2022). Therefore, the optimal pH range for pineapple peel tepache is between 2.8 and 3,8. All formulations of pineapple peel tepache beverage achieve the minimum pH value of tepache, with G1F1 having the highest pH at 3.44 and G2F2 having the lowest pH at 3.14. The LAB fermentation process converts carbohydrates into lactic acid, increasing lactic acid and decreasing pH (Rizal & Nurdin, 2020). Therefore, the more fermentation duration, the lower pH of pineapple peel tepache. Additionally, the variety of sugar determines the pH of pineapple peel tepache. Sucrose concentration is a nutrient for LAB that regulates the increase in lactic acid and decrease in pH (Dipu et al., 2016).

According to the results of statistical studies, the influence of glucose levels with variations in sugar types and fermentation duration has a probability value of 0.012 at a level of Sig. based on the significance level of $0.012 < 0.05$, this indicates that glucose levels significantly affect sugar type and fermentation duration variations.

3.2. Organoleptic Quality of Probiotic Beverages Tepache Pineapple Peel on Variations of Sugar Types and Fermentation Duration

The results of organoleptic quality of probiotic beverages tepache pineapple peel on variations of sugar types and fermentation duration there are color differences as shown in figure 1. as follows:

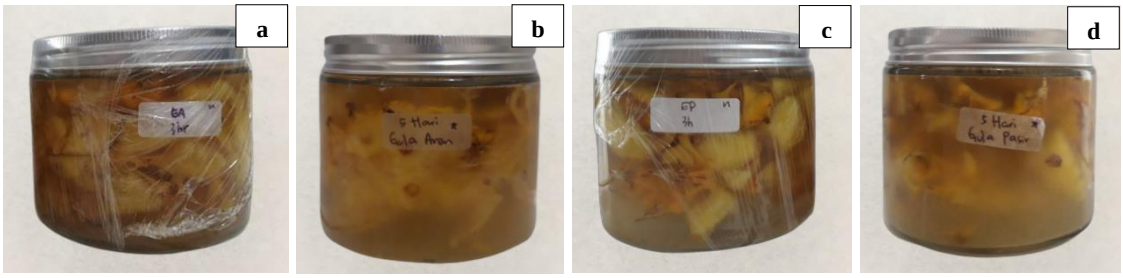


Figure 1. The organoleptic color quality of tepache beverages pineapple peel on variations sugar and fermentation duration: (a) G1F1; (b) G1F2; (c) G2F1; (d) G2F2.

The organoleptic quality of probiotic beverages tepache pineapple peel on variations of sugar and fermentation duration with aspects of aroma, flavor and acceptability can be seen in Figure 2. as follows:

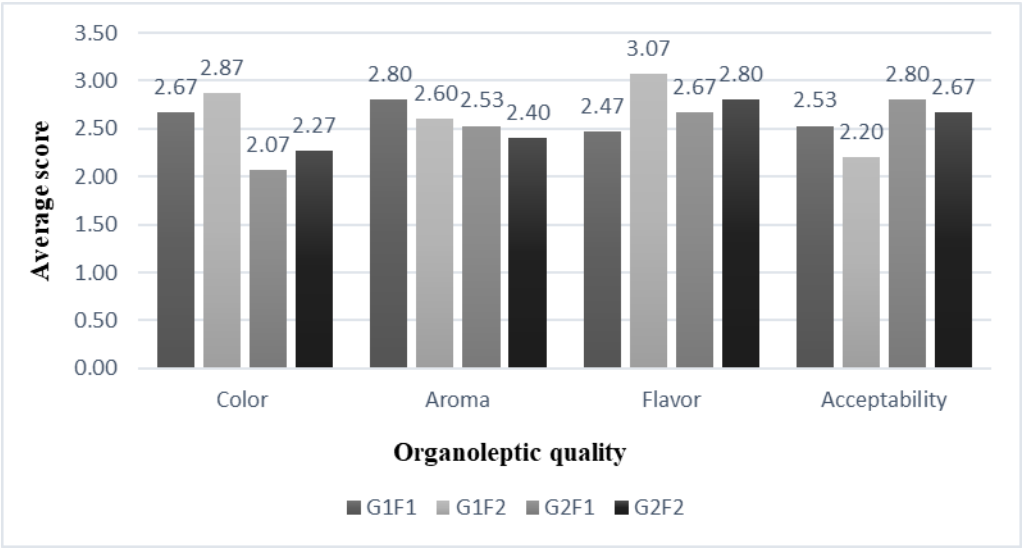


Figure 2. Results of Probiotic Beverages Organoleptic Quality Tepache Pineapple Peel on Variations of Sugar Types and Fermentation Duration.

3.2.1. Color

The color quality of G1F1 and G1F2 treatments for pineapple peel tepache beverages is brownish yellow, whereas G2F1 and G2F2 treatments are light yellow. In light yellow color, the G2F1 treatment (100 g of granulated sugar with a 3-days fermentation duration) was favored by panelists for its superior color quality. The color of pineapple peel tepache is determined by the variety of pineapple peel and sugar used as ingredients. The treatment of G1F1 and G1F2 has a brownish-yellow color due to the effect of the brown color of palm sugar. On the other hand, due

to the effect of clear cane sugar sap, the G2F1 and G2F2 treatment has a light yellow color, resulting in the white color of granulated sugar (Milaniyah et al., 2022).

3.2.2. Aroma

The aroma quality of pineapple peel tepache beverage treated with G1F1, G1F2, and G2F1 is characterized by the aroma of tepache. However, the G2F2 treatment (100 g of granulated sugar with a 5-days fermentation duration) has a tepache-specific aroma. The panelists found the aroma of pineapple peel tepache to be fresh and aromatic, as is typical of pineapple peel. Due to LAB metabolism, lactic acid gives probiotic products a typical aroma (Utami, 2018). This indicates the more fermentation duration, the sharper aroma and the lower panelists' preference for the aroma.

3.2.3. Flavor

Figure 2. shows the flavor characteristics of the pineapple peel tepache beverages. According to the results of organoleptic tests, the average preference of panelists for the flavor of tepache pineapple peel probiotic beverages ranges between 2.47 and 3.07 (quite acidic - acidic). The G2F1 treatment (100 g of granulated sugar with 3-days a fermentation duration) resulted in the highest flavor value of 2.67 (acidic). The flavor of the probiotic beverage tepache pineapple peel is affected by the ingredients used as its base (Kusuma et al., 2019). Each treatment, including palm and granulated sugar balances the sour flavor of pineapple peel with a sweet flavor. However, the duration of fermentation reduced the panelists' organoleptic quality. This is because the fermentation process generates lactic acid and reduces the minimal pH value, enhancing the sour flavor (Rahayu et al., 2021).

3.2.4. Acceptability

Acceptability is the ability to determine whether the community acknowledges a product. The G2F1 treatment (100 g of granulated sugar with a 3-days fermentation duration) produced the pineapple peel tepache probiotic beverage the panelists preferred the most. It had an average value of 2.8 and a light-yellow color, tepache aroma, and acidic flavor. The public favors G1F1 and G2F2 treatment with acceptability scores of 2.53 and 2.67. The treatment that they did not like much by the panelists was G1F2 (100 g of palm sugar with a 5-days fermentation duration). which had an average score of 2.20 with aspect a brownish-yellow color, an original tepache aroma, and a sour flavor. This is because palm sugar is the less preferred form of sugar in the G1F2 treatment. Palm sugar lends tepache a brownish color, a sour flavor, and an aroma that panelists don’t like much (Iskandar et al., 2015). The panel of panelists do not like much the 5-days fermentation duration much because it gave the tepache sourer flavor and sharper aroma.

4. CONCLUSION

Based on the results and discussion of the research, it can be concluded that the G1F1 treatment (100 g of palm with a 3-days fermentation duration) produced the highest glucose level of 12.22 % and the G2F1 treatment (100 g of granulated with a 3-days fermentation duration) produced the highest organoleptic quality with a light-yellow color, tepache-specific aroma, and sour flavor.

5. ACKNOWLEDGMENTS

The authors thank the Biology Education Program at Muhammadiyah Surakarta University for providing financial support INCOBEST article, as well as Mrs. Titik Suryani for guiding the research.

6. REFERENCES

Aprilia, A. W. A., & Suryana, A. L. (2022). Perbedaan Pemberian Larutan Gula Pasir Dan Gula Aren Terhadap Kadar Trigliserida Pada Tikus Wistar Jantan (Rattus norvegicus). *Jurnal Gizi*, *2*(3), 125–132.

Astuti, F. P., Datu, O. S., & Tallei, T. E. (2020). Pengaruh Penambahan Asam Benzoat Terhadap Pertumbuhan Ragi dan Kadar Alkohol pada Fermentasi Kulit Nanas (Ananas comusus L.). *Jurnal Pharmacon*, *9*, 432–442.

Diniyah, N., Subagio, A., & Fauzi, M. (2013). Produksi Minuman Fungsional Sirsak (Anona muricata Linn) Dengan Fermentasi Bakteri Asam Laktat. *Jurnal Teknotan*, *7*(2), 1007–1012.

Dipu, Y. V., Hastuti, U. S., & Gofur, A. (2016). Pengaruh Macam Gula Terhadap Kualitas Yoghurt Kacang Buncis (Phaseolus Vulgaris) Varietas Jimas Berdasarkan Hasil Uji Organoleptik. *Proceeding Biology Education Conference*, *13*(1), 857–862.

Hendry, F., Yudho, P., Suryakancana, U., & Kunci, K. (2021). Peningkatan mutu dan pemasaran gula aren. *Journal of Empowerment*, *2*(1), 150–161.

Hujjatusnaini, N., Amin, A. M., Perditson, H. F. A., Robiyansyah, M., Guri, W. A., Husna, N., Annisa, N., & Chairunnisa, R. (2022). Inovasi Minuman Tepache Berbahan Baku Kulit Nanas (Ananas comosus (L .) Merr .) TERSUPLEMENTASI PROBIOTIK Lactobacillus casei. *Teknologi Pangan Dan Gizi*, *21*(1), 47–54.

Iskandar, A., Yuliasih, I., Machfud, & Haryanto, B. (2015). Karakteristik sifat fisiko kimia, struktur dan morfologi gula aren cetak. *Jurnal Teknologi Industri Pertanian*, *25*(2), 107–115.

Kusuma, A. P., Chuzaemi, S., & Mashudi. (2019). Pengaruh Lama Waktu Fermentasi Limbah Buah Nanas Kandungan Nutrien Menggunakan Aspergillus niger. *Jurnal Nutrisi Ternak Tropis*, *2*(1), 1–9.

Lalisang, I. (2018). Pemberdayaan petani aren melalui diversivikasi produk olahan air nira. *JPengabdian Kepada Masyarakat*, *23*(4), 415–418. https://doi.org/https://doi.org/10.24114/jpkm.v23i4.8938

Masengi, K. I., Siampa, J. P., & Tallei, T. E. (2020). Penyalutan Bakteri Asam Laktat Hasil dari Fermentasi Kulit Buah Nanas (Ananas comosus) dengan Pewarna Bunga Telang (Clitoria ternatea). *Jurnal Bios Logos*, *10*(28), 86–92.

Milaniyah, I., Chrisnandari, R. D., & Setyawan, K. D. (2022). Pengaruh Penambahan Susu Kapur Terhadap Nilai Turbidity Nira Tebu Dalam Pembuatan Gula Pasir. *Distilat Jurnal Tekonologi Separasi*, *8*(2), 402–409.

Ojeda-linares, C., Gonzalo, D. Á., Figueredo-urbina, C. J., Islas, L. A., Lappe-oliveras, P., Nabhan, G. P., Torres-garc, I., Vallejo, M., & Casas, A. (2021). Traditional Fermented Beverages of Mexico : A Biocultural Unseen Foodscape. *Foods*, *10*(10), 1–31. https://doi.org/https://doi.org/10.3390/foods10102390

Puspitasari, Y., Palupi, R., & Nurikasari, M. (2017). Analisis Kandungan Vitamin C Teh Kombucha Berdasarkan Lama Fermentasi sebagai Alternatif Minuman untuk Antioksidan. *Journal Golab HEalth Science*, *2*(3), 245–253.

Putri, R. M. A., Yuanita, T., & Roelianto, M. (2016). Daya anti bakteri ekstrak kulit nanas (Ananas comosus) terhadap pertumbuhan bakteri Enterococcus faecalis Antibacterial potency of pineapple peel extract (Ananas comosus) on Enterococcus faecalis growth. *Conservative Dentistry Journal*, *6*(2), 61–65.

Rahayu, W., Albaar, N., & Saleh, E. R. M. (2021). Pembuatan Minuman Probiotik Berbasis Kulit Nanas Bogor Menggunakan Lactobacillus casei dengan Lama Fermentasi yang Berbeda. *Agribisnis Perikanan*, *14*(1), 172–183. https://doi.org/10.29239/j.agrikan.14.1.172-183

Refita, K. (2021). *Ketersediaan Produk Pangan Mengandung Kultur Di Situs Belanja Daring dan Pengetahuan Serta Persepsi tentang Probiotik pada Mahasiswa Di Jabodetabek*. IPB Press.

Rizal, S., & Nurdin, S. U. (2020). Kajian Potensi Sari Kulit Buah Nanas Yang Difermentasi Dengan Lactobacillus casei Sebagai Minuman Probiotik Secara In Vivo Research On Potentials Of Pineapple Skin Extract Fermented With Lactobacillus casei As A Probiotic Beverage By In Vivo.*AgroIndustri*, *10*(1), 12–20. https://doi.org/10.31186/j.agroind.10.1.12-20

Romero-luna, H. E., Hernández-sánchez, H., & Dávila-ortiz, G. (2017). Traditional fermented beverages from Mexico as a potential probiotic source. *Annals of Microbiology*, *67*(9), 577–586. https://doi.org/10.1007/s13213-017-1290-2

Setyawati, H., & Rahman, N. A. (2017). Bioethanol From Pineapple Peel With Saccharomyces Cereviceae Mass And Fermentation Time Variation. *UPN Veteran*, *1991*, 1–4.

Simanjuntak, M., Karo-karo, T., & Ginting, S. (2017). Pengaruh Penambahan Gula Pasir Dan Lama Fermentasi Terhadap Mutu Minuman Ferbeet (Fermented Beetroot). *Rekayasa Pangan Dan Pertanian*, *5*(1), 96–101.

Sukriadi, E. H., Rustomo, W. T., & Astiana, R. (2022). Tepache Kulit Nanas sebagai Bahan Campuran Minuman. *Pariwisata Indonesia*, *18*(1), 28–37. https://doi.org/10.53691/jpi.v18i1.267

Sultan, R. A. (2022). Karakteristik Minuman Probiotik Kombinasi Sari Buah Nenas (Ananas comosus L.) dan Pepaya (carica papaya L.). *Jurnal Pendidikan Teknologi Pertanian*, *8*, 37–46.

Utami, C. R. (2018). Karakteristik Minuman Probiotik Fermentasi. *Teknologi Pangan*, *9*(1), 1–9. https://doi.org/https://doi.org/10.35891/tp.v9i1.932

Widyantara, I. W. A., Nocianitri, K. A., & A, N. M. I. H. (2020). Pengaruh Lama Fermentasi Terhadap Karakteristik Minuman Probiotik Sari Buah Sirsak (Annona muricata Linn). *Itepa*, *9*(2), 151–160.

Wilberta, N., Sonya, N. T., & Lydia, S. H. R. (2021). Analisis Kandungan Gula Reduksi pada Gula Semut dari Nira Aren yang Dipengaruhi Ph dan Kadar Air. *Bioedukasi*, *12*(1), 101–108.

International Conference on Biology Education, Natural Science, and Technology

Vol. 1 No. 1 (2023)

Empowerment of Animalia Classification Material: A Review of Literature

Tunjung Nala Puti*, Puguh Karyanto, Umi Fatmawati

Magister of Biology Education Department, Faculty of Teacher Training and Education, Universitas Sebelas Maret Surakarta. Jl. Ir. Sutami 36 Kentingan, Jebres, Surakarta 57126, Jawa Tengah, Indonesia

*Corresponding Author. E-mail address: tunjung.nala23@student.uns.ac.id

KEYWORDS:

Animalia,
Klasifikasi,
Project-based learning,
Media pembelajaran,
Peningkatan

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

This article is a literature review that discusses the characteristics of animal classification as biology learning material. Animalia classification material is one of the materials that are difficult for students to understand. So the purpose of this literature review is to analyze the characteristics of Animalia classification material to determine and find the right way of empowerment so that students can receive the material well. The method used is a systematic literature review (SLR) with PRISMA guideline, reviewed from 2013-2023 with certain criteria. The literature obtained based on these criteria obtained as many as 150 articles from Google Schoolar, Scopus, and Web of Science, but after analysis based on abstracts, keywords, research methods, and discussion, 21 articles were finally selected. The results of the literature review show that Animalia classification material can be empowered with a learning model that is collaborative learning combined with online visual media. One of the learning innovations that can be used is project-based learning in online media.

1. INTRODUCTION

Biological material that is quite difficult to understand, one of which is taxonomic (Arifin et al. 2019). The material requires a specific description so that students can understand the classification clearly (Istiani and Retnoningsih 2015). Students consider taxonomy material to have a wide scope so it requires clear examples or depictions so that it can be understood well and easily (Aziz et al. 2021).

Taxonomy is a branch of learning in biology that is systematic (Mayr 2015). Systematics in classification is concerned with learning about the identification, naming (nomenclature), and classification of a living thing. The classification of an organism can be grouped based on physical or nonphysical characteristics. The classification system of living things was first introduced by Linnaeus in 1735, which divided the grouping of living things into two groups called the two-kingdom classification system (Verma and Prakash 2020). The classification system of the two

kingdoms distinguishes living things into kingdoms Plantae (plants) and Animalia (animals). From 2015 to date, the classification system has developed into seven kingdoms consisting of Bacteria, Archaebacteria, Protozoa, Chromista, Fungi, Plantae, and Animalia (Rudyshyn and Samilyk 2015).

The purpose of classifying living things is to simplify the grouping of abundant biodiversity (Swift et al. 2004). To date, more than 1.6 million species have been identified. One of the kingdoms with the most varied members is the animal kingdom. Kingdom Animalia is grouped into two major groups, namely invertebrates and vertebrates (Verma and Prakash 2020). Furthermore, the two groups are further divided into several taxon orders after kingdom, namely phylum, class, order, family, genus, and species (Mohammed et al. 2011). Each taxon sequence has specific features that characterize the group of a species (Segata et al. 2012). The concept of animalia classification should not be rote but needs to be understood so that when students are confronted with real circumstances they will easily group the individual into the taxa sought (Hamidah et al. 2019).

The concepts of Animalia classification are often not easily accepted, not only because of their characteristics but can occur for other reasons, affecting students' understanding of animal classification. One of the causes that often complicates the acceptance of concepts is the lack of explanation from sources (Simpson 1961). In addition, learning media can affect the acceptance of the concept of animal classification (Widodo and Utomo 2021). The need for learning media that can accommodate the characteristics of Animalia classification material can be sought or further developed (Putri, 2016).

This article examine more deeply the characteristics of Animalia classification material and determine the right learning to deliver Animalia classification material so that students can understand the classification system, not just memorize it. So the purpose of this literature review is to analyze the characteristics of animalia classification material to determine and find the right way of empowerment so that students are able to receive the material well.

2. MATERIALS AND METHODS

The method used is Systematic Literature Review (SLR). The guideline used in this research literature review is PRISMA. PRISMA provides a methodological standard for selecting usable literature (Rethlefsen et al. 2021). SLR is performed to identify, analyze, and interpret all available information. The SLR stage begins with determining the formulation of the research problem. The formulation of the research problem is 1) What are the characteristics of Animalia classification material in biology learning?; 2) How to empower Animalia classification material in biology learning?; and 3) How to choose the right learning to meet the characteristics of Animalia classification material in biology learning?

The literature search is carried out by determining criteria related to Animalia classification material. The initial literature obtained was selected based on predetermined criteria, namely: 1) reputable Indonesian and English articles; 2) Articles are collected from electronic databases (Google Scholar, Scopus, and Web of Science) using the following keywords: animal kingdom material in biology, animal taxonomy in biology, animal kingdom material, Animalia classification, and animal taxonomy learning; 3) The search is limited to articles published from 2013 to 2023; and 4) The article contains a clear identity such as title, author, and year.

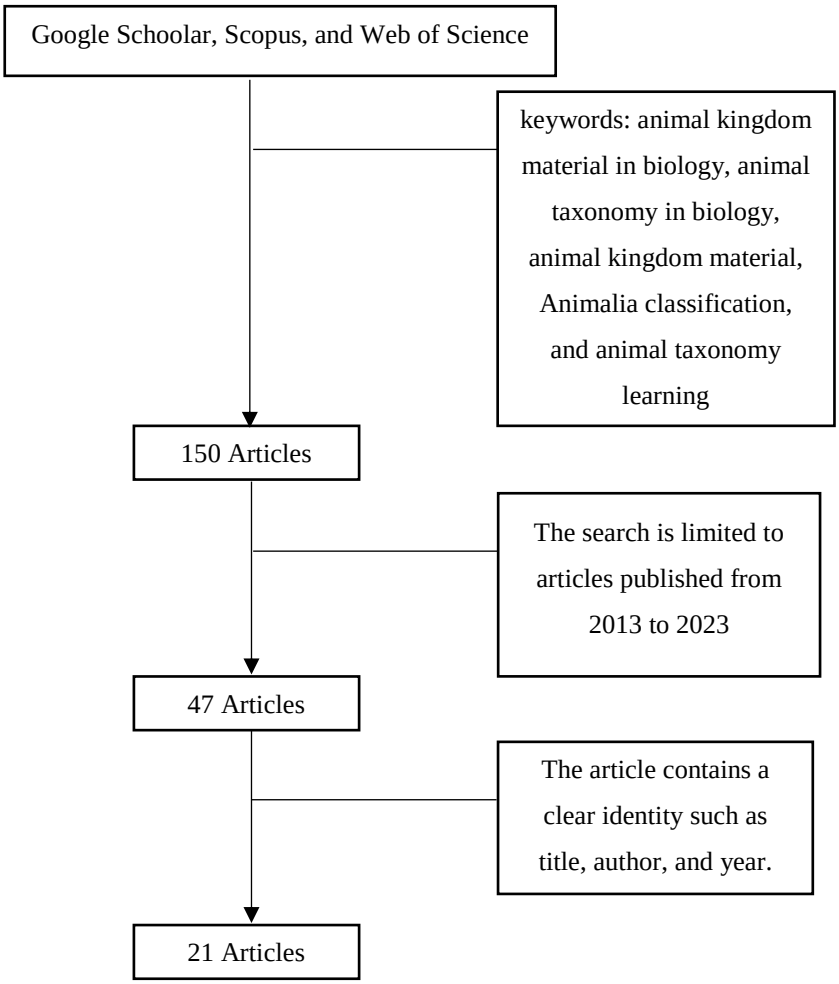


Figure 1. Flow Chart of Literature Search

The selection of articles that match the criteria is done by filtering titles, abstracts, and keywords. The results of the literature based on the requirements amounted to 150 articles from Google Schoolar, Scopus, and Web of Science. However, after being analyzed based on the discussion, finally 21 articles were selected that could be used as study material for the research objectives (see Fig. 1). This article discusses the characteristics of Animalia classification material, how to empower learning animal classification material, and how to learn about Animalia classification material.

3. RESULTS AND DISCUSSION

3.1. Literature Review Result

This study discusses the characteristics of animal classification material, how to empower learning animal classification material, and how to learn about animal classification material. The list of review articles used as a study can be seen in the table below (**Table 1**).

Table 1. Article Reviews

No	Author	Title	Year	Review
1	Emilia Fägerstam and Jonas Blom	Learning biology and mathematics outdoors: effects and attitudes in a Swedish high school context	2014	It is better to give questions regarding the taxonomy of animal classification in essay form to practice analytical skills.
2	Michael Allen	Preschool children's taxonomic knowledge of animal species	2015	How to learn the classification of Animalia by describing and comparing the structure of animals
3	Noah Wafula Wekesa and RaphaelOdhiambo Ongunya	Project Based Learning on Students' Performance in the Concept of Classification of Organisms among Secondary Schools in Kenya	2016	Project based learning is a model that can be used for Animalia classification material.
4	Didem Kılıç	Pre-service Teachers ‟ Conceptual Structures and Reasoning Patterns on Animal Classification. Universal Journal of Educational	2016	Discussion activities or peer learning can occur and the use of animal classification materials and models allowing concrete experiences can be suggested to facilitate the creation of connections about animal characteristics.
5	Alex R. Hardisty, et al.	BioVeL: a virtual laboratory for data analysis and modeling in biodiversity science and ecology	2016	The concept of taxonomy is a branch of biology related to the naming, identification, and classification of organisms to facilitate scientific communication towards biological objects.

No	Author	Title	Year	Review
6	Putri Agustina	Senior High School Biology Teacher Perception about Learning Media for the Subject of Animals Kingdom	2017	Learning about kingdom classification requires simple animal identification and determination activities.
7	Ben G. Weinstein	A computer vision for animal ecology	2017	Animalia classification material can be presented with computer-based media
8	Valleta, Torney, Kings, Thornton, and Madden	Applications of machine learning in animal behaviour studies	2017	Classification of animals can be grouped with the help of videos
9	Alexander Weiss	Personality Traits: A View From the Animal Kingdom	2018	Kingdom Animalia has many theories in its classification
10	Willi, Pitman, Cardoso, Locke, Swanson, Boyer, Veldthuis, and Fortson	Identifying animal species in camera trap images using deep learning and citizen science	2018	Animalia classification material needs to be visualized to be able to identify animal characteristics
11	Jana Wäldchen and Patrick Mäder	Machine learning for image based species identification	2018	One simple way to identify species to determine their classification is through pictures.
12	Zofia Anna Chyleńska and Eliza Rybska	Understanding Students Ideas about Animal Classification	2018	In learning animal classification students must understand the basic concepts to achieve the classification of species that are rarely found
13	Fahad Alharbi, Abrar Alharbi, and Eiji Kamioka	Animal species classification using machine learning techniques	2018	Unique characteristics of animals such as ears and eyes can observe by image
14	Zayyana Fatati Azizah, Puguh Karyanto, and Yudi Rinanto	Challenges and opportunities of using virtual laboratory in teaching biodiversity and classification	2019	Project-based learning is one of the constructive strategies for enhancing the meaningfulness in

No	Author	Title	Year	Review
15	Andro Satria, Afreni Hamidah, and Upik Yelianti	Development of Magic Disc on Animal Taxonomy Material for Student of Senior High School	2019	Animal classification material is not memorized but needs to be understood.
16	Intan Delia Tivania Putri, et al.	Learning Kingdom Animalia Material Using AnimalPedia	2020	Material about the kingdom Animalia is better conveyed in visual form.
17	Kombe Musonda and David Chituta	Impact of Problem Based Learning on Learner Achievement and attitude in Animal Taxonomy: A case at Kasama College of Education	2020	Classification of animals can be grouped by looking at traits such as morphology, physiology, behavior, and distribution.
18	Yulyani Arifin, Hendra, Rosyid Prasetio Wibowo, and Ozsa Praditiya	Taxondroid: Design Interactive Application for Animal Taxonomy Learning Using Teen-Computer Interaction Approach	2020	Classification of animals can be understood by looking at the anatomy and structure of the body, so it requires learning media that can visualize it
19	Diamanto Filippatou and Stavroula Kaldi	The Effectiveness of Project-Based Learning on Pupils with Mild Learning Difficulties: A Preliminary Study	2020	Project based learning is effectively used as a learning model in marine animal classification material.
20	Yigal Rosen, Iris Wolf, and Kristin Stoeffler	Fostering collaborative problem solving skills in science: The Animalia project	2020	Collaborative learning is the best approach for identifying and classifying Animalia.
21	Astried Pascafitri Harenda, Puguh Karyanto, and Muzzazinah	Online Learning Design for Animalia Classification Materials With Discovery Learning-Based Learning Videos and Vee. Diagrams	2021	Video can be used as a semi-contextual learning medium for classifying animals when it is unable to present real animals

The table show 43% of literature reviews stated that empowerment of learning methods is needed in order to improve students' ability to describe, analyze, and group animals into an appropriate classification. This method of empowerment based on the results of the literature of

43% stated that it can be done by developing the right learning media, the learning media studied in the literature of 10% stated that project-based learning in online media.

3.2. Characteristics of Animalia Classification Material in Biology Learning

Animalia classification material has characteristics that biology teachers must know to conduct appropriate learning. The characteristics of Animalia classification materials include::

a. Taxonomy is the study of theoretical, basic, principles, procedures, and classification rules (Simpson 1961).
b. Selection and use of words that are difficult for ordinary people to understand (Simpson 1961).
c. The material is difficult to present in a systematic and interesting form (Mallik and Ramani 2015).
d. Requires the definition of terms so that the material can be conveyed properly (Simpson 1945).
e. Experience the novelty of science continuously (Elshahed et al. 2008).
f. Has many theoretical approaches (Weiss 2018).
g. Wide material coverage due to the potential for interbreeding (Simpson 1961).
h. Many animals do not yet have a clear classification (Simpson 1961).
i. Homology is the basis of classification and phylogeny (Hall 2012).
j. Need references to study taxonomic material (Simpson 1961).
k. Many subspecies of species are distinguished by geographical location (Simpson 1961).
l. In modern taxonomy, it has more to do with populations rather than individuals (Simpson 1961).

The classification material of Animalia is described as broad because of the many variations within each species. So it requires the right approach in the learning process. The learning process in animal classification material requires the unity of appropriate models, media, and learning techniques to be conveyed properly. Thus, the concept of learning Animalia classification must find an ideal foundation to organize various tools and practices in the best way.

3.3. How to Empower Animalia Classification Material in Biology Learning

How to empower Animalia classification material can be done by applying learning that is constructivism and collaborative learning. Constructivism is carried out to achieve meaningfulness in learning Animalia classification, strengthening students' ability to recognize animal traits to be classified in taxon (Azizah et al. 2019). Collaborative learning is used as a means of student discussion in groups because in animal classification material a lot of information needs to be explored so that collaboration between students in sorting and determining information can be done more quickly and precisely if done together (Rosen et al. 2020).

Project based learning (PjBL) is one of the learning models in which there are constructivism and collaborative learning strategies. PjBL has proven effective as a learning model in Animalia classification material (Azizah et al. 2019; Filippatou and Kaldi 2016; Wafula and Ongunya Raphael Odhiambo 2016). PjBL is a project-based learning model that has five stages, the five stages in PjBL can empower students' ability to analyze and group animals into their classification system.

The first stage is planning an investigation process according to driving questions: students can identify various types of animals, determine specific markers on these animals, and formulate problems to be solved (Turgut 2008). This stage will accommodate a person to raise initial questions as the initial process of achieving higher-order thinking skills and analytical thinking.

The second stage is searching for the theoretical background of the driving questions: students collect and analyze theories that can answer problem formulations (Turgut 2008). At this stage, a thesis or statement can be raised as an answer to the problem formulation.

The third stage is presenting that theoretical background to class and discussion about issue: students present the results of exploring the information that has been obtained and discuss it in groups (Turgut 2008). Discussion in groups is intended so that students obtain more evidence that can be used to answer problem formulations.

The fourth stage is deciding the study group the way of collecting data and data analysis: students and group mates make a decision to start the project (Turgut 2008). At this stage, students must be able to collaborate to connect answers to problem formulations and information that has been obtained to be able to compile projects well.

The last stage is evaluating data, arriving a conclusion, presenting the project in class as preferred and discussion (Turgut 2008). At this stage, students can evaluate information data to compile a logically reasoned conclusion based on the project that has been produced. The final stage is to present the results in class discussion.

3.4. Proper Learning for Animalia Classification Material

Based on the characteristics of the material, Animalia classification can be given to students in several ways that utilize learning innovations. Learning activities that can meet the characteristics of Animalia classification material are by multiplying activities or activities describing and comparing the characteristics of various animal species because Animalia classification material is a grouping of animals by looking at traits such as morphology, physiology, behavior, distribution, and genetic inheritance (Agustina 2017; Wäldchen and Mäder 2018; Willi et al. 2019). Activities that are trained students will provide an experience so that students can constructivistically build their knowledge (Azizah et al. 2019). So that Animalia classification material is accepted by students as understanding, not rote memorization (Weiss 2018). An

understanding of classification material can make it easier for students to analyze and determine the taxon of a species.

The selection of teaching materials and the way of delivering the material affect students' understanding of Animalia classification material. The teaching materials used must be able to meet the characteristics of Animalia classification materials. The characteristic of Animalia classification material that needs to be considered in the preparation of teaching materials is the existence of animal visualizations that can be accessed at any time by students to be able to describe and analyze the characteristics of these animals without time limits (Arifin et al. 2019; Putri et al. 2020; Willi et al. 2019). The teaching materials needed can be embedded in online learning media. Online learning media can be accessed by students anywhere and anytime. In addition, this learning media has other advantages, namely being able to display video and sound (Valletta et al. 2017). The pictures presented through online learning media can make it easier for students to practice grouping activities in animal classification (Alharbi et al. 2019). Online learning media also makes it easier for students to access other learning resources, in animal classification materials, other internet-based sources are needed to assist students in analyzing animal characteristics so that students can group these animals (Pascafitri and Karyanto 2021).

Learning media can be arranged in such a way that it can meet learning objectives (Williamson et al. 2020), That is, students can analyze animal characteristics to group them to find the right classification. The learning media developed must be able to increase students' understanding of animal classification material. Based on a learning model that can empower students' ability to classify animals, it is necessary to develop project-based learning in online media.

4. CONCLUSIONS

Based on a review of literature related to the classification of animals as learning materials with various characteristics, 43% of literature reviews stated that empowerment of learning methods is needed in order to improve students' ability to describe, analyze, and group animals into an appropriate classification. This method of empowerment based on the results of the literature of 43% stated that it can be done by developing the right learning media, the learning media studied in the literature of 10% stated that project-based learning in online media.

5. ACKNOWLEDGEMENT

Thank you to previous researchers who have written articles on animal classification, how to empower animal classification material, and learning for animal classification material, so that the author can use it in reviewing and writing this literature review article.

6. REFERENCES

Agustina, P. 2017. Persepsi guru biologi SMA tentang media pembelajaran materi kingdom animalia. in: *Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning* 318–321.

Alharbi, F., Alharbi, A., and Kamioka, E. 2019. Animal species classification using machine learning techniques. *MATEC Web of Conferences* (W. Anggono, ed.) 277: 02033. DOI: 10.1051/matecconf/201927702033

Arifin, Y., Hendra, Wibowo, R. P., and Praditiya, O. 2019. Taxondroid: Design Interactive Application for Animal Taxonomy Learning Using Teen-Computer Interaction Approach. in: *2019 IEEE International Conference on Engineering, Technology and Education (TALE)* IEEE 1–7. DOI: 10.1109/TALE48000.2019.9225967

Aziz, A., Zhafari, R. R., and Santoni, M. M. 2021. Klasifikasi 10 Spesies Monyet Berdasarkan Citra Menggunakan Convolutional Neural Network. *Senamika* 2(2): 138–145.

Azizah, Z. F., Karyanto, P., and Rinanto, Y. 2019. Challenges and opportunities of using virtual laboratory in teaching biodiversity and classification. in: *AIP Conference Proceedings* 1–7. DOI: 10.1063/1.5139742

Elshahed, M. S., Youssef, N. H., Spain, A. M., Sheik, C., Najar, F. Z., Sukharnikov, L. O., Roe, B. A., Davis, J. P., Schloss, P. D., Bailey, V. L., and Krumholz, L. R. 2008. Novelty and Uniqueness Patterns of Rare Members of the Soil Biosphere. *Applied and Environmental Microbiology* Am Soc Microbiol 74(17): 5422–5428. DOI: 10.1128/AEM.00410-08

Filippatou, D., and Kaldi, S. 2016. The Effectiveness of Project-Based. *International Journal of Special Education* 308–316(January 2016).

Hall, B. K. 2012. *Homology: The hierarchial basis of comparative biology*. Academic Press.

Hamidah, A., Satria, A., and Yelianti, U. 2019. Development of Magic Disc on animal taxonomy material for student of Senior High School. *Biodik* Pendidikan Biologi FKIP UNJA 5(3): 239–249.

Istiani, R. M., and Retnoningsih, A. 2015. Pemanfaatan lingkungan sekolah sebagai sumber belajar menggunakan metode post to post pada materi klasifikasi makhluk hidup. *Journal of Biology Education* 4(1). DOI: https://doi.org/10.15294/jbe.v4i1.5237

Mallik, B., and Ramani, S. 2015. Teaching taxonomy. *Current Science* Current Science Association 109(6): 1009.

Mayr, E. 2015. *Principles of systematic zoology*. Scientific Publishers.

Mohammed, M. H., Ghosh, T. S., Singh, N. K., and Mande, S. S. 2011. SPHINX—an algorithm for taxonomic binning of metagenomic sequences. *Bioinformatics* Oxford University Press 27(1): 22–30. DOI: 10.1093/bioinformatics/btq608

Pascafitri, A., and Karyanto, P. 2021. Online Learning Design for Animalia Classification Materials With Discovery Learning-Based Learning Videos and Vee . Diagrams. 14(1): 43–53. DOI: http://dx.doi.org/10.20961/bioedukasi

Putri, I. D. T., Savitri, S. D., Puspitasari, I. D., Aisyah, R. N., Firmansyah, F. E., and Ambarwati, R. 2020. Pembelajaran Materi Kingdom Animalia Menggunakan Animalpedia. *Jurnal Inovasi Pembelajaran Biologi* 1(1): 1–9. DOI: 10.26740/jipb.v1n1.p1-9

Putri, L. O. L. 2016. Card of Identification Phylum as an Inovative Media to Study Animal Classifications. *JPBI (Jurnal Pendidikan Biologi Indonesia)* 2(1): 31–38.

Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., Koffel, J. B., Blunt, H., Brigham, T., Chang, S., Clark, J., Conway, A., Couban, R., de Kock, S., Farrah, K., Fehrmann, P., Foster, M., Fowler, S. A., Glanville, J., Harris, E., Hoffecker, L., Isojarvi, J., Kaunelis, D., Ket, H., Levay, P., Lyon, J., McGowan, J., Murad, M. H., Nicholson, J., Pannabecker, V., Paynter, R., Pinotti, R., Ross-White, A., Sampson, M., Shields, T., Stevens, A., Sutton, A., Weinfurter, E., Wright, K., Young, S., and Group, P.-S. 2021. PRISMA-S: an extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews. *Systematic Reviews* 10(1): 39. DOI: 10.1186/s13643-020-01542-z

Rosen, Y., Wolf, I., and Stoeffler, K. 2020. Fostering collaborative problem solving skills in science: The Animalia project. *Computers in Human Behavior* 104: 105922. DOI: https://doi.org/10.1016/j.chb.2019.02.018

Rudyshyn, S., and Samilyk, V. 2015. Development of Knowledge of the Taxonomy and Phylogeny of Living Organisms for Future Biology Teachers. *The Advanced Science Journal* Citeseer 2015(1): 75–82. DOI: 10.15550/ASJ.2015.01.075

Segata, N., Waldron, L., Ballarini, A., Narasimhan, V., Jousson, O., and Huttenhower, C. 2012. Metagenomic microbial community profiling using unique clade-specific marker genes. *Nature Methods* 9(8): 811–814. DOI: 10.1038/nmeth.2066

Simpson, G. G. 1945. *The principles of classification and a classification of mammals*. New York: American Museum of Natural History.

Simpson, G. G. 1961. Principles of animal taxonomy. in: *Principles of Animal Taxonomy*. New York*:* Columbia University Press.

Swift, M. J., Izac, A.-M., and van Noordwijk, M. 2004. Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? *Agriculture, Ecosystems & Environment* Elsevier 104(1): 113–134. DOI: 10.1016/j.agee.2004.01.013

Turgut, H. 2008. Prospective Science Teachers ' Conceptualizations About Project Based. *International Journal of Instruction* 1(1): 62–79.

Valletta, J. J., Torney, C., Kings, M., Thornton, A., and Madden, J. 2017. Applications of machine learning in animal behaviour studies. *Animal Behaviour* Elsevier Ltd 124: 203–220. DOI: 10.1016/j.anbehav.2016.12.005

Verma, A. K., and Prakash, S. 2020. Status of animal phyla in different kingdom systems of biological classification. *International Journal of Biological Innovations* 2(2): 149–154.

Wafula, W. N., and Ongunya Raphael Odhiambo. 2016. Project Based Learning on Students' Performance in the Concept of Classification of Organisms among Secondary Schools in Kenya. *Journal of Education and Practice* 7(16): 25–31.

Wäldchen, J., and Mäder, P. 2018. Machine learning for image based species identification. *Methods in Ecology and Evolution* (N. Cooper, ed.) 9(11): 2216–2225. DOI: 10.1111/2041-210X.13075

Weiss, A. 2018. Personality Traits: A View From the Animal Kingdom. *Journal of Personality* Wiley Online Library 86(1): 12–22. DOI: 10.1111/jopy.12310

Widodo, A., and Utomo, A. B. 2021. Media Pembelajaran Taksonomi Hewan Berbasis Augmented Reality dengan Fitur Multi Target. *Edu Komputika Journal* 8(1): 1–8. DOI: 10.15294/edukomputika.v8i1.40611

Willi, M., Pitman, R. T., Cardoso, A. W., Locke, C., Swanson, A., Boyer, A., Veldthuis, M., and Fortson, L. 2019. Identifying animal species in camera trap images using deep learning and citizen science. *Methods in Ecology and Evolution* (O. Gaggiotti, ed.) 10(1): 80–91. DOI: 10.1111/2041-210X.13099

Williamson, B., Eynon, R., and Potter, J. 2020. Pandemic politics, pedagogies and practices: digital technologies and distance education during the coronavirus emergency. *Learning, Media and Technology* Taylor & Francis.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Quality of Herbal Tea Combination Between Corn Silk and Mint Leaf in a Variation of Temperature and Drying Duration

Imroatul Husna, Titik Suryani*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: ts169@ums.ac.id

KEYWORDS:
Antioxidant activity
Corn silk
Herbal Tea
Mint leaf
Organoleptic qualities

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Corn silk has high antioxidant activity so that with a combination of mint leaf it can be made into herbal tea which is beneficial for health. This research aims to determine the antioxidant activity and organoleptic quality of herbal tea combination between corn silk and mint leaf in a variations of temperature and drying duration. The method in this research used a completely randomized design (CRD) with 2 factors, factor 1 were drying temperature (J) (45 °C, 50 °C, and 55 °C) and factor 2 were drying time (K) (2 hours and 4 hours). The results of this study showed that the highest antioxidant activity of the herbal tea combination between corn silk and mint leaf on J_1K_2 treatment (temperature 45 °C and drying time 4 hours) of 85.375 %, while the best organoleptic quality of herbal tea between corn silk and mint leaf was in the J_1K_1 treatment (temperature of 45 °C and drying duration of 2 hours) with a fresh taste, mint tea aroma, and yellowish color.

1. INTRODUCTION

Herbal tea has numerous health benefits and is one of the most popular beverages. Herbal tea constituents can be derived from spices, fruits, or other medicinal plants (Dusun, 2017). Herbal tea is included in the category of functional beverages because it contains healthful polyphenol compounds. Functional beverages are one form of functional consumables that provide nutritional value and sensory loading, such as a pleasant flavor and texture (Herawati et al., 2012). Both functions can be obtained from herbal tea drinks based on corn silk with a combination of mint leaf.

The hair of corn is the head and roof of the fruit of Zea mays L. (Syawal & Laeliocattleya, 2020). Compounds in corn silk can be used as herbal tea such as alkaloids, flavonoids, phenolics, beta-cytosterols, and glycosides. Fresh corn silk contains 23.58 Ggae/G of phenolics and 50–83.54 percent antioxidant activity (Salsabila et al., 2021). Antioxidants are substances capable of preventing lipid oxidation (Nabila & Hendriani, 2018). Therefore, with the abundance of compounds, especially antioxidant in corn silk, it can be used as the main ingredients for making of herbal tea. The content of these compounds is not much known to society so they only regard it as waste. However, corn silk tea has an unpleasant acidic taste, making it less acceptable in society (Rohmadianto, 2019). For that, it is necessary to add other alternative ingredients such as mint leaf to produce a delicious taste and smell.

Mint leaf contain essential oils (0,5 – 4 %), menthol (14 – 32 %), and menthol (30 – 55 %) (Rizqa, 2019)**.** Menthol is a chemical that has many benefits for the intestinal tract such as relaxing smooth muscles in the digestive tract, and also as an anti-inflammatory that can inhibit the

metabolism of arachidonic acid into leukotrien B4 and prostaglandin E2 (Selina et al., 2019). According to Anggraini's (2014) study, if more peppermint leaf is added to the herbal beverage, the better of aroma, taste, color of the steeping, and antioxidant activity will increase.

In the process of making herbal tea, it is necessary to pay attention to the determination of the drying temperature which will affect the antioxidant activity. The temperature and drying duration of production of tortured leaf tea *(Coleus amboinicus)* using temperatures of 45 °C, 50 °C, and 55 °C with long variations of 2 hours, 3 hours, and 4 hours. At a temperature of 50 °C with a drying time of 3 hours is the best treatment because in addition to being the most preferred treatment of panels, at that temperature it also has an antioxidant activity of 18,033% (Saragih, 2014). In order to manufacture herbal tea of high quality, drying techniques must also be considered. One of the finest techniques for drying is using the oven since it quickly lowers the water content (Winangsih et al., 2013). The oven-drying technique produces a higher total phenol concentration than the sun-drying method. This is because the enzyme becomes inactive when the dehydration process is accelerated (Bernard et al., 2014).

The purpose of this research is to determine the antioxidant activity and organoleptic qualities of herbal tea combination between corn silk and mint leaf in a variations of temperature and drying duration.

2. MATERIALS AND METHODS

2.1. Place and Time

The research was conducted at the Biological Laboratory of UMS, Jl. Ahmad Yani Tromol Pos 1, Pabelan, Kartasura, as a place to make herbal tea. While to test of antioxidant activity was carried out in the Laboratory of the Faculty of Food Technology, University of Slamet Riyadi, and testing of organoleptic quality was conducted in the area of the campus Muhammadiyah University of Surakarta. The research has been carried out since the issuance of the permit in less than two months, namely from February to March 2023.

2.2. Materials

The equipment used in the making of an herbal tea combination between corn silk and mint leaf are pans, oven, analytical scales, tea bags, gloves, beaker glasses, 360 ml plastic glass, aluminum foil, UV-Vis spectroscopic photometer, reaction tube, reacting tube shelf, micropipette, vortex, and observation sheet. The ingredients used were fresh eight-week-old sweet corn hair (*Zea mays saccharta*), mint leaf (*Mentha piperita*), aquades, DPPH test solution, and ethanol.

2.3. Research Procedure

This research procedure consists of the following steps: 1. Preparation: preparing apparatus and ingredients, sorting corn silk and mint leaves to remove damaged pieces, and then washing them clean. 2.) Implementation stage: squeeze corn silk and mint leaves at room temperature (27 °C) in conditions not exposed to sunlight, then dry with a measurement of 1: 1 (50g: 50g) in the oven on each treatment, the corn silk and mint leaves that have been dried are cut into a powder then weighs a weight of 2 grams on each treatment, packaging of corn silk and mint leaves that have been mixed is 5.5 x 7 cm tea bags, then brew herbal tea combination between corn silk and mint.

2.4. Research Design

The research was conducted using the experimental method and Completely Randomized Design (CRD) with two factors. Factor 1 variation of the drying temperature (J1 = 45 ˚C, J2 = 50 ^{o}C, J3 = 55 ^{o}C) and factor 2 drying duration (2 hours and 4 hours), so that with 6 treatments (J_1K_1 = temperature 45 ˚C and drying duration 2 hours, J_1K_2 = temperature 45˚C and drying duration 4 hours, J_2K_1 = temperature 50 ˚C and drying duration 2 hours, J_2K_2 = temperature 50˚C and drying duration 4 hours, J_3K_1 = temperature 55 ˚C and drying duration 2 hours, J_3K_2 = temperature 55 ˚C and drying duration 4 hours), each treatment was repeated 2 times. The antioxidant activity test used by DPPH method with the final percentage result, while the organoleptic quality test (taste, aroma, color, and receptivity) involved the filling out the questionnaire sheet by 15 panelists.

2.5. Data Analysis

The research used qualitative descriptive analysis techniques for organoleptic testing, while for the testing of antioxidant activity used quantitative descriptive methods. Quantitative data testing analysis using the Kruskal-Wallis test and qualitative data testing analysis using Excel. Data collection is carried out using experimental methods, the observation method, the library method, documentation of the duration of research, measurement of antioxidant activity, and organoleptic quality testing.

3. RESULTS AND DISCUSSION

Herbal tea is one of the highest quality drinks (Zainuddinnur et al., 2017). Consuming herbal tea regularly can improve health and even be an alternative to preventing various diseases (Santi et al., 2022). In order to get a good tea product, it is necessary to pay attention to the process of managing the heat supply in the dryer. Tea will become excessively dry and damaged if the heating process is overheated, and it will take longer to dry if the heat source is insufficient, so the resulting tea does not meet the standard of tea drying. Therefore, in this research used 3 temperature variations (45 °C, 50 °C, 55 °C) and 2 drying duration (2 hours and 4 hours) to know the best treatment for the making of herbal tea combination between corn silk and mint leaf.

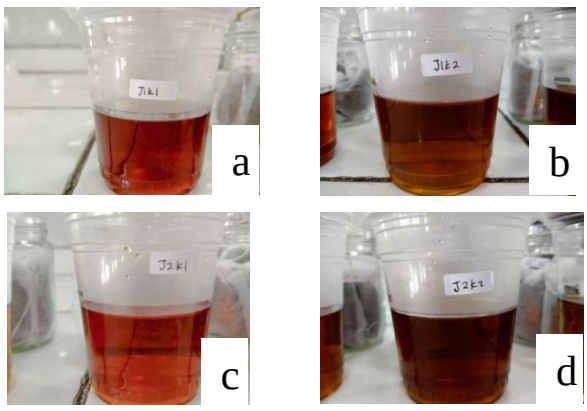
Table 1. Results of Antioxidant Activity and Organoleptic Quality of Herbal Tea Combination Between Corn Silk and Mint Leaf

Drying Treatment	Antioxidant Activity (%)	Kualitas Organoleptik			
		Color	Aroma	Taste	Receptivity
J_1K_1 (Temperature 45 ˚C + 2 hours)	85.021	Yellowish	Mint tea	Fresh	Like
J_1K_2 (Temperature 45 ˚C + 4 hours)	85.375	Brown-yellow	Rather mint tea	Fresh	Rather like
J_2K_1 (Temperature 50 ˚C + 2 hours)	83.597	Yellowish	Rather mint tea	Fresh	Unlike
J_2K_2 (Temperature 50 ˚C + 4 hours)	82.955	Brown-yellow	tidak Khas teh daun mint	Unfresh	Unlike
J_3K_1 (Temperature 55 ˚C + 2 hours)	81.688	Brown-yellow	Untypical mint tea	Unfresh	Unlike
J_3K_2 (Temperature 55 ˚C + 4 hours)	80.725	Brown-yellow	Untypical mint tea	Unfresh	Unlike

The results of the research on herbal tea combination between corn silk and mint leaf in a variation of temperature drying duration using the DPPH method showed quite high antioxidant activity ranging from 80.725 % to 85.375 %. Based on table 1. shows that he highest antioxidant activity was found in the treatment of J_1K_2 (temperature 45 ˚C and drying duration 4 hours) and the lowest was found in the J_3K_2 treatment (temperature 55 ˚C and drying duration 4 hours). An analysis of the antioxidant activity of herbal tea combination between corn silk and mint leaf showed that duration factors, temperature, and the interaction between duration and drying temperature affect antioxidant activity. It can be seen in Table 1. that the value of antioxidant activity in 6 different treatments is accurate, and with each increase in the temperature of the drying treatment obtained the result of its antioxidant activity is lower. This is consistent with the research (Sayekti, 2016), one of the causes of low antioxidant activity is that the high drying temperature used can even cause damage to the activity of those antioxidants. According to Dewi's (2017) study, the antioxidant activity in grapefruit leaf herb tea will decrease when the drying temperature is too high. This happens because the secondary metabolite compounds that act as antioxidants become broken if the heating temperature increases.

The drying duration can affect the content of food. This is in line with the study of Yulianti (2019), which found that the drying duration of corn barley flour has a natural effect on the chemical, phytochemical, and organoleptic properties. In addition, the drying method used on a food ingredient has a different effect. According to the results of research Saragih (2014), stated that the longer of drying duration used the more antioxidant activity will decrease, this is due to the antioxidant properties that are not resistant to the heating process. That aligns with this research that found that two-hour drying results in higher antioxidant activity than four-hours drying. There are numerous error-causing factors in antioxidant activity testing. For instance, DPPH compounds are extremely light-sensitive, which will result in their degradation. In addition, DPPH compounds are susceptible to injury from excessive temperatures. When extract/sample weighing does not match the evaluation, which can compromise the accuracy of the results, is an additional factor that is not less essential (Nahat, 2017).

Based on the statistical test results on factor 1 (drying temperature) obtained the Asymp value. Sig is 0,180 > 0,05, so it can be stated that the drying temperature has no real effect on antioxidant activity. In the statistical test factor 2 (drying duration) results asymp values. Sig is 0.513 > 0.05, so it can be stated that the drying duration has no natural effect on antioxidant activity. Then the interaction between factor 1 and factor 2 has an Asymp result. Sig is 0.416 > 0.05, which means that the temperature and drying duration have no natural effect on antioxidant activity.



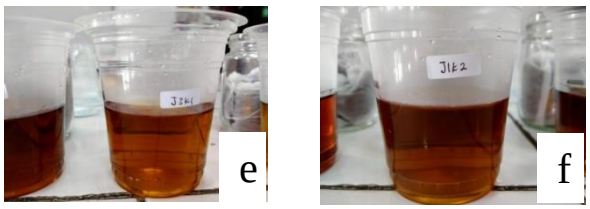


Figure 1. J_1K_1 (a), J_1K_2 (b), J_2K_1 (c), J_2K_2 (d), J_3K_1 (e), J_3K_2 (f)

Based on the Figure 1, organoleptic quality results of the herbal tea combination between corn silk and mint leaf which has been brewed showed a yellowish color in the J_1K_1 and J_2K_1 treatments, and the brown-yellow color in J_1K_2, J_2K_2 and J_3K_1. From the above results can be assured that the temperature and drying duration influence the color of herbal tea combination between corn silk and mint leaf. Herbal tea that uses a drying duration 4 hours has a seductive color result that tends to be brown-yellow compared to herbal tea with a drying duration of 2 hours. In addition, if the drying temperature is higher, the color produced by herbal tea will be more concentrated. That statement is consistent with the study of Fitrayana (2014), which found that using a higher drying temperature might result in a reduction in the herbal tea's natural color. This is because drying can harm the color pigments like chlorophyll on the leaves. Strengthened by the Wadi (2021) study, based on the results of the drying of herbal tea leaves of buni, the higher temperature of drying than the degradation of the color of the tea will occur.

The aroma in the treatment of J_1K_1 is typical herbal tea mint leaf, the treatment of J_1K_2 and J_2K_2 has a rather typical aroma of herbal tea mint leaf, and the treatment of J_2K_2, J_3K_1, J_3K_2 there is an untypical fragrance of mint tea leaves**.** The results showed that the higher of drying temperature will get lessen the smell of herbal tea leaf of mint produced. Meilgard (2000) stated that the smell in food will appear because there are components of volatile compounds that have easily evaporative properties, but the compound will disappear during the heating process. Strengthened by Patin et al., study (2018) that increasing drying temperatures result in volatile compounds in vaporizing food being carried by a flow of hot gases.

The taste of the herbal tea combination between corn silk and mint leaf in the treatments of J_1K_1, J_1K_2, and J_2K_1 has a fresh taste, while in the treatments of J_2K_2, J_3K_1, and J_3K_2 has an unfresh taste. Based on the results, it can be identified that the higher drying temperature used will make the resulting taste more unfresh or the characteristic taste of the tea will decrease. The statement is consistent with the Wijaya's study (2015), which found that the higher of drying temperature, the taste of herb tea mint leaf increasingly decreases, this is due to the reduced oil content during the drying process. Essential oils can evaporate at high drying temperatures. According to SNI 01-3836-2013, the seductive taste of good tea is characteristic of the product itself.

According to a study by Taufik et al. (2016), the distinctive flavor and aroma of tea can be created through the proper dehydrating method. The dehydrating procedure increases the concentration of the phenolic compounds that give tea its flavor, aroma, and hue. In addition to the dehydrating procedure, the quantity of tea used on the sample has an effect on the organoleptic qualities of herbal tea. The drying process and presentation of dried tea can substantially alter the flavor parameters of the presented sample (Adhamatika & Murtini, 2021).

The reception of this herbal tea combination between corn silk and mint leaf involves 15 panelis. From the results of the research carried out, if the higher of temperature and the longer of drying duration, resulted in the receptive capacity of society decreased. In the treatment J_1K_1 shows the receptivity is like. In the case of the J_1K2 treatment, the effect of receiving power is less

favorable. Then, the treatment of J_2K_1, J_2K_2, J_3K_1, and J_3K_2 had unlikely results. This is because the drying process causes the taste of fresh mint leaf to decrease more and more, so that the reception capacity at temperature treatments of 50 °C and 55 °C will decline further. According to the recognition of several panelists, treatments that have high temperatures have a slightly smooth taste and the smell of mint leaf is reduced. This is in line with the Mardiana et al. study (2022), which states that the use of temperature during drying can cause the natural ingredients in herbal tea to undergo biochemical changes, thereby reducing the quality of the product. Panelists most preferred herbal tea is on treatment J_1K_1 (temperature 45 ˚C and drying duration 2 hours) with the result of fresh sweetness, a yellowish color, and a typical smell of mint tea.

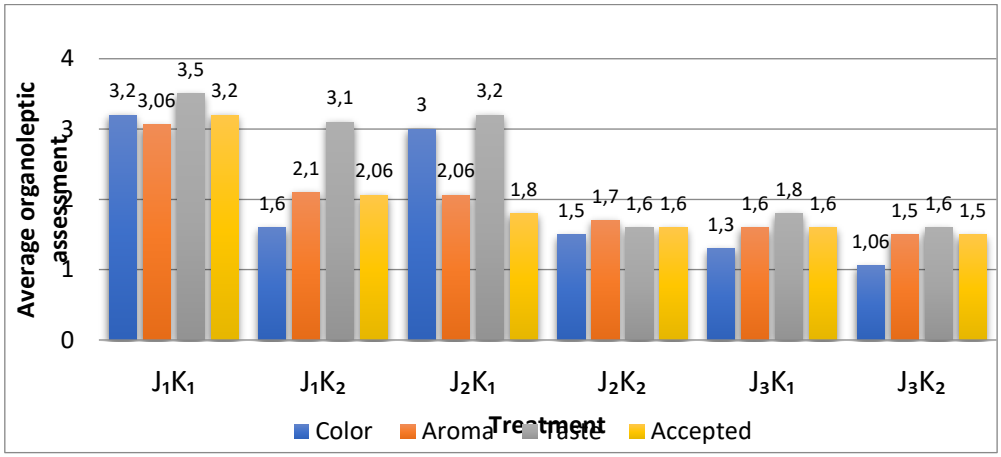


Figure 2. Histogram of organoleptic quality tests

The results of organoleptic testing of color, aroma, taste, and receptivity of a herbal tea combination between corn silk and mint leaf in a variation of temperature and drying duration can be seen in Figure 2. Increasing temperature diminishes a substance's organoleptic qualities. Panelis prefers herbal tea blended with maize hair and mint leaves dried at low temperatures because the flavor and aroma of the mint remains robust. According to Sucianti's study (2021), the scent of menthol on the herbal tea mint leaves diminishes as the dehydrating temperature rises, thereby making the panelis more offensive.

4. CONCLUSION

The results of this research showed that the highest antioxidant activity of the herbal tea combination between corn silk and mint leaf on J_1K_2 treatment (temperature 45 ^oC and drying duration 4 hours) of 85,375 %, while the organoleptic quality of the herbal tea combination between corn silk and mint leaf was the best on J_1K_1 treatment (temperature 45 °C and drying duration 2 hours) with a fresh taste, mint tea aroma, and light yellow color. Temperature variations and drying duration have no significant effect on the antioxidant activity of the herbal tea combination between corn silk and mint leaf. Further test is needed regarding the glucose content in herbal tea of corn silk and mint leaf.

5. REFERENCES

Adhamatika, A., & Murtini, E. S. (2021). Pengaruh Metode Pengeringan Dan Persentase Teh Kering Terhadap Kakarteristik Seduhan Teh Daun Bidara (Ziziphus mauritiana L.). *Jurnal Pangan Dan Agroindustri*, *9*(4), 196–207.

Anggraini, T. et al. (2014). Pengaruh Penambahan Peppermint (Menta piperita L.) Terhadap Kualitas Teh Daun Pegagan (Centella asiatica L. Urban). *Jurnal Litbang Industri*, *4*(2), 79–88.

Bernard, D., Kwabena, A., Osei, O., Daniel, G., Elom, S., & Sandra, A. (2014). The Effect of Different Drying Methods on the Phytochemicals and Radical Scavenging Activity of Ceylon Cinnamon (Cinnamomum zeylanicum) Plant Parts. *European Journal of Medicinal Plants*, *4*(11), 1324–1335.

Dewi, W. K. (2017). Pemanfaatan Daun Katuk (Sauropus adrogynus) dalam Pembuatan Teh Herbal dengan Variasi Suhu Pengeringan. *Jom Faperta*, *4*(2).

Dusun, C. (2017). Kandungan Polifenol dan Aktivitas Antioksidan Teh Daun Jambu Biji (Psidium guajava L.). *Jurnal Teknologi Pertanian*.

Fitrayana, C. (2014). *Pengaruh Lama dan Suhu Pengeringan Terhadap Karakteristik Teh Herbal Pare (Momordica charantia L.)*. Universitas Pasundan.

Herawati, N., Windrati, W. S., Jember, U., & Jember, U. (2012). Pembuatan Minuman Fungsional Berbasis Ekstrak Kulit Buah Naga Merah (Hylocereus polyrhizus) , Roseka (Hibiscus sabdariffa L.) Dan Buah Salam (Syzygium polyanthum wigh walp). *Agrotek*, *6*(1), 40–50.

Mardiana, N., Agustina, R., & Khathir, R. (2022). *Pengaruh Suhu Pengeringan Terhadap Mutu Teh Herbal Daun Sirsak (Annona muricata Linn .) Effect of Drying Temperature on Soursop Leaf Herbal Tea Quality (Annona muricata Linn .) Program Studi Teknik Pertanian , Fakultas Pertanian , Universitas Syiah Kual*. *7*(November), 799–808.

Meilgard, M. (2000). *Sensory Evaluation Techniques*. CRC Press.

Nabila, U., & Hendriani, R. (2018). Review: suhu penyimpanan bahan baku dan produk farmasi di gudang industri farmasi. *Farmaka*, *16*(2), 316–321.

Nahat, P. M. et al. (2017). Kandungan Asam Sianida dan Aktivitas Antioksidan pada Kluwak (Pangium edule Reinw.) Setelah Proses Perebusan. *Analisis Kesehatan Sains*, *6*(2), 495–500.

Patin, E. W., Zaini, M. A., & Sulastri, Y. (2018). Pengaruh Variasi Suhu Pengeringan Terhadap Sifat Fisiko Kimia Teh Daun Sambiloto (Andrographis paniculata) [Influence of Dried Temperature Variation to Chemical Physical Properties Tea Leaf (Andrographis paniculata)]. *Pro Food (Jurnal Ilmu Dan Teknologi Pangan)*, *4*(1), 251–258.

Rizqa, I. M. (2019). Pemanfaatan minyak atsiri daun mint (Mentha piperita L) dengan kulit jeruk purut (Cytrus hystrix DC) sebagai sediaan aroma terapi. *Farmasi Politeknik*, *2*(1), 1–25.

Salsabila, S., Sri Palupi, N., & Astawan, M. (2021). Potensi Rambut Jagung sebagai Minuman Fungsional. *Jurnal Pangan*, *30*(2), 137–146.

Santi, I., Amirah, S., & Andriani, I. (2022). Sosialisasi Pembuatan Teh Herbal Dalam Kemasan Teh Celup Pada Kelompok Pkk Kalabbirang, Kabupaten Takalar. *Dharmakarya*, *11*(1), 22.

Saragih, R. (2014). Uji Kesukaan Panelis pada Teh Daun Torbangun (Coleus Amboinicus). *Journal WIDYA Kesehatan Dan Lingkungan*, *1*(1), 46–52.

Sayekti, E. D. . (2016). *Aktivitas Antioksidan Teh Kombinasi Daun Katuk dan Daun Kelor dengan Variasi Suhu Pengeringan Doctoral Dissertation*. Universitas Muhammadiyah Surakarta.

Selina, C., Darwis, I., & Graharti, Rr. (2019). Peppermint (Mentha piperita) sebagai Pengobatan Alternatif pada Irritable Bowel Syndrome (IBS). *Majority Medical Journal Of Lampung University*, *8*(1), 211–219.

Sucianti, A., Yusa, N. M., & Sughita, I. M. (2021). Pengaruh Suhu Pengeringan Terhadap Aktivitas Antioksidan Dan Karakteristik Teh Celup Herbal Daun Mint (Mentha piperita L.). *Jurnal Ilmu Dan Teknologi Pangan (ITEPA)*, *10*(3).

Syawal, A. N., & Laeliocattleya, R. A. (2020). Potensi Teh Herbal Rambut Jagung (Zea mays L.) Sebagai Sumber Antioksidan: Kajian Pustaka. *Jurnal Ilmu Pangan Dan Hasil Pertanian*, *4*(1), 1–6.

Taufik, Y., Widiantara, T., & Garnida, Y. (2016). The effect of drying temperature on the antioxidant activity of black mulberry leaf tea (Morus nigra). *Rasayan Journal of Chemistry*, *9*(4), 889–895.

Wadi, Y. R. (2021). *Pengaruh Suhu Pengeringan Terhadap Mutu Teh Herbal Daun Buni (Antidesma bunius L.)*. Universitas Muhammadiyah Mataram.

Wijaya, C., Jayuska, A., & Alimuddin, A. H. (2015). Peningkatan Rendemen Minyak Atsiri Daun Cengkeh (syzygium Aromatic) Dengan Metode Delignifikasi Dan Fermentasi. *Jkk*, *4*(4), 15–20.

Winangsih, Prihastanti, E., & Parman, S. (2013). Pengaruh Metode Pengeringan Terhadap Kualitas Simplisia. *Buletin Anatomi Dan Fisiologi*, *21*(1), 19–25.

Yannie Asrie Widanti, Dobby Rohmadianto, N. S. &. (2019). Aktivitas Antioksidan Teh Rambut Jagung (Zea mays L. sacharata) Dengan Penambahan Rosela (Hibiscus sabdariffa L) Dan Variasi Lama Pengeringan. *Jurnal Teknologi Dan Industri Pangan*, *3*(2), 3–10.

Yulianti, L. et al. (2019). *Pengaruh Lama Waktu Pengeringan Terhadap Sifat Kimia, Fitokimia dan Organoleptik Tepung Tongkol Jagung (Zea mays L.)*. Universitas Semarang.

Zainuddinnur, M., Meldayanoor, M., & Nuryati, N. (2017). Proses Pembuatan Teh Herbal Daun Sukun Dengan Optimasi Proses Pengeringan Dan Penambahan Bubuk Kayu Manis Dan Cengkeh. *Jurnal Teknologi Agro-Industri*, *3*(1), 14–21.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Number of Erythrocytes of White Rats (*Rattus norvegicus*) Sonded with a Combination of Porang Tuber and Moringa Leaf Extract

Alya Anggitasari, Endang Setyaningsih*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: es211@ums.ac.id

KEYWORDS:
Glucomannan
Moringa leaves
Number of erythrocytes
Obest rat
Porang tubers

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Overcoming obesity which is increasing in the pandemic era. Obesity or overweight is an abnormality in the amount of body weight that results in excessive accumulation of body fat and can pose a risk of other diseases. This also affects the supply of the number of erythrocytes that enter the body. This study aims to determine the number of erythrocytes of obese white rats (*Rattus norvegicus*) that were sounded with a combination of pouring tuber glucomannan (*Amorphophallus mulleri* Blume) and moringa leaf extract. This research method used a true experimental which was prepared using a Completely Randomized Design (CRD) in the form of a Posttest Only Control Design. The data obtained were analyzed using One Way ANOVA SPSS version 20 followed by the DMRT test. The results of this study indicated that the combination of pouring tuber glucomannan and moringa leaf extract affected increasing the number of erythrocytes in obese white rats. Administration of pouring tuber glucomannan and moringa leaf extract increased the number of erythrocytes, with the order of increasing P7 (60:40), P5 (80:120), and P3 (100:100). With these results, it can be concluded that the combination of pouring tuber with moringa leaf extract is effective in increasing the number of erythrocytes in obese people.

1. INTRODUCTION

Since the COVID-19 pandemic era, the government has issued a Work From Home (WFH) policy that requires all activities to be done from home or online. With this policy, it changes the way of life and also the environmental conditions of the community, thus bringing some emerging problems. One of them is an increasing number of cases of obesity in the community. This is due to the presence of restrictions on leaving the house, which indirectly causes the time to play gadgets as well as the habit of snacking snacks to increase. According to (Mutia et al., 2022), based on the results of the analysis of the relationship between dietary patterns and the incidence of adolescent obesity during the covid-19 pandemic, 11 (23.9%) obese students with frequent diets were obtained, while non-obesity students with regular diets was 35 (76.1%) students. There is a link between dietary patterns and the incidence of adolescent obesity during the Covid-19 pandemic. A diet where a person consumes foods that tend to contain high energy, carbohydrates and fat and low fiber can lead to obesity.

Obesity is an abnormal amount of body weight caused by excess body fat. Obesity is also associated with increased inflammation and abnormal body metabolism, thereby increasing the risk of insulin resistance, type 2 diabetes, stroke, and cardiovascular disease (Septiyanti & Seniwati, 2020). Based on the national data of obesity in Indonesia, the number of centrally obese

people aged >15 years of age increased in 2018, which is 31.0% compared to 2013. In contrast, the national prevalence of obesity in the proportion of adults aged >18 in 2018 ranged from 21.8% to 14.8% in 2013 (Depkes, 2018). There is a need for a solution to the growing problem of obesity. The prevalence of central obesity among the population in Indonesia was 31%. The prevalence of central obesity in adolescents continues to increase every year. There was an increase in cases of 2.9% from 2007-2010. Then, 2010-2013 increased by 4.9%, and 2013-2018 by 4.4%. DKI Jakarta province ranks second in the province with 42% of the population aged ≥15 years suffering from central obesity.5 The prevalence of obesities tends to be higher in teenage girls compared to teenage boys, which is 1.5% in teenaged girls and 1.3% in teenager boys (Zaki et al., 2022).

Obesity is influenced by several factors, such as excessive food intake, a lack of physical activity, technological advances, and genetic factors (Praditasari & Sumarmik, 2018). There are also treatments for obesity. Obesity is usually dealt with through diet. Some people have done this way to lose their weight. Diet is part of the key to weight loss success because it affects how many calories enter the body. A high-fiber diet that recommends the consumption of foods high in fiber becomes one of the diets recommended for obese people. Through the implementation of this high-fiber diet, one is expected to be able to modify the arrangement and portion of daily foods by increasing the high-fiber content more than usual or exceeding the recommended daily intake of fiber. This diet aims to provide food intake according to the nutritional needs of the body and is high in fiber so that it can trigger the intestinal peristaltic movement so that the process of urination becomes normal. A high-fiber diet includes a diet that is good for health, easy to do and affordable. This is because foods that are high in fiber are safer for the human body, and most have a purchase price that is not too high. Therefore, high-fiber diets can be applied by all groups of society (Zaki et al., 2022).

There is also an alternative, natural way to deal with obesity is by using natural ingredients such as leaf extracts and grain plants. Glucomannan is a polysaccharide compound of 67% D-manose and 33% D-glucose, with properties between cellulose and galactomanan, which crystallize forming fine fibrous structures. The main content of the porridge plant is glucomannan, that is found in the part of the bulbs. Glucomannan is a hydrocoloid that has the ability to thicken and form a gel so it is widely used in various industries such as food, chemistry, biotechnology and pharmaceuticals (Wardani et al., 2021). In the field of health, glucomannan lowers cholesterol and is used to prevent disease by lowering the blood sugar response. Glucomannan can be used as a functional nutrient-provider food ingredient that gives a sense of satiety because it contains one of the active ingredients contained in the foam and can also be used by dissolving it in water. Glucomannan also plays a role in decreasing and inhibiting blood lipids, preventing cancer, dealing with constipation, and reducing obesity. (Alamsyah, 2019).

Amorphophallus muelleri Blume is one of the most promising export commodities for Japan, China, Vietnam, Australia, and other countries (Pertanian Kementerian, 2020). Indonesia still exports pork in the raw form of chipped pork or crude pork flour. Grapefruit is widely used as a cosmetic, glue, and supplement. Proper processing of light can be profitable in its sale and use because light cannot be consumed directly. The use of pork as a food material in Indonesia is controlled by the high content of calcium oxalate, which is 0.19% (Wahyuni et al., 2020). This is due to the content of oxalate crystals, which can cause an allergic reaction or irritation in the mouth and damage the organs in the body. Based on research (Saputro et al., 2014) the level of

glucomannan obtained after the purification process to remove larger oxalate crystals ranged from 36.69% to 64.22% compared to the pre-purification flour of 28.76%.

In this study, not only is glucomannan important in dealing with obesity, but there is also a role for leafy vegetables. Kelor is a type of multiguna plant, and almost all parts of the kelor plant can be used as antimicrobial material. The parts of the clay plant that have been proven to be antimicrobial substances include leaves, seeds, oils, flowers, roots, and skins (Luluk Sutji Marhaeni, 2021). The leaves are known to contain alkaloids, saponins, phitosterols, tanins, polyphenols, phenols, and flavonoids that act as antioxidants (Saputra et al., 2020). The leaves are also known to contain 120mg of vitamin C per 100g. The role of flavonoids and alkaloids as hypoglycemic agents works through intra- and extra-pancreatic mechanisms, playing a role in the repair and regeneration of pancreatic cells and stimulating the release of the hormone insulin. Arkanoid stimulates the sympathetic nerve and increases insulin secretion. Giving decoctions of leaves can lower blood sugar levels in diabetics. (Lakshita, 2017).

Overweight and obesity also increase the risk of anemia due to the occurrence of fat storage. Fat accumulation in overweight or obese people causes inflammatory reactions and increased cytokines (IL-6), thus stimulating increased hepsidine and decreasing iron absorption in the intestines. In addition, the accumulation of fat in the liver can trigger the formation of lipid peroxide, which damages the membranes of red blood cells and disrupts the synthesis of hemoglobin. The accumulation of fat in the liver can trigger the formation of lipid peroxide,e which will ultimately affect the iron metabolism process so that free radicals occur. This causes the synthesis of Hb tob noto run perfectly. In the final stage, hemoglobin decreases in number and erythrocytes decrease,e sot anemia can occur. The accumulation of fat in the liver can trigger the formation of lipid peroxide,e which will ultimately affect the iron metabolism process so that free radicals occur. This causes the synthesis of Hb tob noto run perfectly. In the final stage, hemoglobin decreases in number and erythrocytes decrease,e sot anemia can occur (Pasalina et al., 2019). A person is called anemic when their red blood cells are lower than the reference value. The reference value in this study for men is 4.50–6.50 x106µl and for women is 3.80–4.80 x 106µl. The results of the erythrocyte examination are important to know. If a person has an abnormality in the number of erythrocytes, then the results of the erythrocyte examination should be reliable. (Haiti et al., 2021).

White rats (*Rattus norvegicus*) are a trial animal that is often used in obesity reduction research because they have more agility compared to other trial animals, are easy to handle, can be obtained in large quantities without being too expensive, and have valid repeat results. (Wistar et al., 2019). White rats (*Rattus norvegicus*) are often used as food tests and food deficiency tests on all types of animals, including humans (Rejeki et al., 2018).

Based on reference searches, research on the number of white rats' erythrocytes fed a combination of porang tuber glucomannan and moringa leaf extract, researchers saw the effect of high protein and fat on the process of erythropoiesis which affected the number of erythrocytes. In addition, researchers also looked at the effect of porang glucomannan and porang leaf extract on reducing obesity. The purpose of this study was to determine the effect of the glucomannan content of porang tubers and moringa leaf extract on the increase in the number of erythrocytes in obese rats.

2. MATERIALS AND METHODS

2.1. The Location of The Study

The research was conducted from September 2022 to May 2023, from the selection of titles to the drawing of conclusions. The study was conducted at the university's Eleven March Animal Experiment Laboratory as a place of maintenance, treatment, and blood sampling. The research was also conducted in the Biology Education Laboratory of the Keguruan Faculty and Education Sciences of the Muhammadiyah Surakarta University as a place of examination and analysis of the number of esritrocytes under a microscope.

2.2. The Materials and Tools Used

The tools used in this research include: (1) A set of hemositometers consists of two boxes that include a leucocyte pipette and an erythrocyte pipette, a counting chamber, and a sucker. (2) 1 cup of petri (3) Glass and deck glass for 4 sets (4) Olympus CX 23 binocular microscope (5) Counter-count to two. (6) 1 tissue, and (7) The blood tubes contain the anticoagulant EDTA.

The materials used include: (1) blood samples of white Wistar rats (Rattus norvegicus) with obesity from 4 treatment samples; (2) Reagen Hayem, and (3) The Aquades.

2.3.Determination of The Sample

The sample is taken at the UNS Animal Test Laboratory by preparing the microhematocrit and divided into two, while the mice are held properly, then the microhematocrit is scratched on the medial canthus of the eye under the eyeball towards the foramen opticus. The blood is stored in the blood tubes that already contain the anticoagulant EDTA. Before taking blood, the mice are first fasted overnight and then blood is taken from the retro-orbitalis sinus. Blood sampling is carried out slowly so that it does not hurt the animal and is guarded so that no clots occur. In the microtube, add a 0.1% heparin anticoagulant solution and warm it slowly to prevent licking and clotting. Given that hematological measurements are cellular measures, the presence of clots can affect the outcome, as well as cause collapse in the measuring machine (Rosidah, 2020).

2.4. Measurement Methods

The method used in this study is (1). Experimental method with a post-only control design. (2). Documentation method: this method helps in taking pictures of research used in documenting tools, materials, research processes, and research results. (3). The library method, the technique of collecting data by library, is carried out by searching for references in books, national and international journals, existing scientific works, and scripts and studying the same scope. This method is used to support the creation of library reviews and speeches.

2.5.Experimental Design

The study used a true experimental method composed of a complete random plan (RAL) of a posttest-only control design using 4 groups of treatments and each treatment having 2 repetitions. The details are as follows:

1). Treatment 1 (Control): Control group with normal feeding (P1).

2). Treatment 3: high-fat dietary feed treatment group + glucomannan and moringa leaf extract 100 mg/kg BBB (P3)

3). Treatment 5: high-fat dietary feed treatment group + glucomannan and moringa leaf extract, 80 mg/kg BBB: 120 mg/kg BBB (P5)

4). Treatment 7: high-fat dietary feed treatment group + glucomannan and kelor moringa extract (60 mg/kg BBB): 40 mg/kg BBB (P7)

2.6.Stages of Research Activities

The stages of activity in this study include: (1) level of maintenance; (2) level of treatment; and (3) Stage Examination of the number of erythrocytes by installing the aspirator pipette on the thoma pipette, preparing the hayem reagent to avoid contamination, pouring the hayem reactor on the glass beaker, and before pressing the blood, first homogenize the blood. Blood in the pipette to the limit of 0.5 ml. Clean the pipette with tissue. The pipette uses the same pipette, trimming the hemoglobin reagent to the limit of 101, removing the aspirator from the pipet, and homogenizing the pipette by stretching for about 1 minute. Execute a blood test using a binocular microscope by placing a blood sample on the deck glass and the counting chamber. Test and calculate the number of erythrocytes.

2.7. Data Calculation and Analysis

The result of the next examination of the number of erythrocytes will be calculated using the following formula:

Jumlah Eritrosit : $\frac{n}{v}\ x\ p$

Where (n) is the total cell counted, (v) is volume (p x l x t) x number of boxes, and (p) is a dilution of the sample on the thoma haemositometer pipette.

Then the results of the study were analyzed statistically using the one-way analysis of variance (ANOVA) in SPSS version 20, followed by Duncan's multiple range test (DMRT) to find out the rates between the treatment groups.

3. RESULTS AND DISCUSSION

The results of the analysis of the number of erythrocytes of fat white rats dissected with a combination of porang tubers and moringa leaf extract showed that there was a difference in the dose of the treatment group with the number of normal white rats, namely the first treatment group was positive in the control group (P1) with normal feeding and showed the number of erythrocytes 7.16 million /l. In the P3 treatment group, the dose of a mixture of porang tuber glucomannan and moringa leaf extract with a ratio of 100:100 mg/kgBB showed an erythrocyte count of 6.20 million/L. Then in the P5 treatment group with a combined dose of porang tuber glucomannan and moringa leaf extract 80:120 mg/kgBB, the red blood cell count was 5.05 million/L. And in the P7 treatment group with a dose of 60:40 mg/kg BB, the number of erythrocytes was 4.55 million/L.

In the number of erythrocytes, based on the statistical tests in the treatment group, there was a distinct and significant increase that can be seen in the following table:

Table 1: Results of statistical tests on measuring the number of erythrocytes

ANOVA

Jumlah Eritrosit

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.269	3	2.756	220502.333	.000
Within Groups	.000	4	.000		
Total	8.269	7			

Description: There were significant differences in the number of erythrocytes between the doses of the treatment groups (P 0.05).

Based on the results of the Anova test, it can be seen that the significance value of 0.000 is less than 0.05 (P 0.05), so the different treatment is real or has a significant influence on the blood erythrocyte number. Because the treatment is different, further tests are carried out using the Duncan test, with the following results:

Table 2. Results of the Uji DMRT (*Duncan Multiple Range Test*)

Jumlah Eritrosit
Duncan

Kelompok Perlakuan	N	Subset for alpha = 0.05			
		1	2	3	4
P7	2	4.5500			
P5	2		5.0500		
P3	2			6.2000	
P1	2				7.1650
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

The Duncan test results above can be concluded as follows:
1. P1 treatment is different from P7, P5, and P3 treatment, and vice versa.
2. P7 treatment is different from P1, P5, and P3 treatment, and vice versa.
3. P5 treatment is different from P1, P7, and P3 treatment, and vice versa.
4. P3 treatment is different from P1, P7, and P5 treatment, and vice versa.

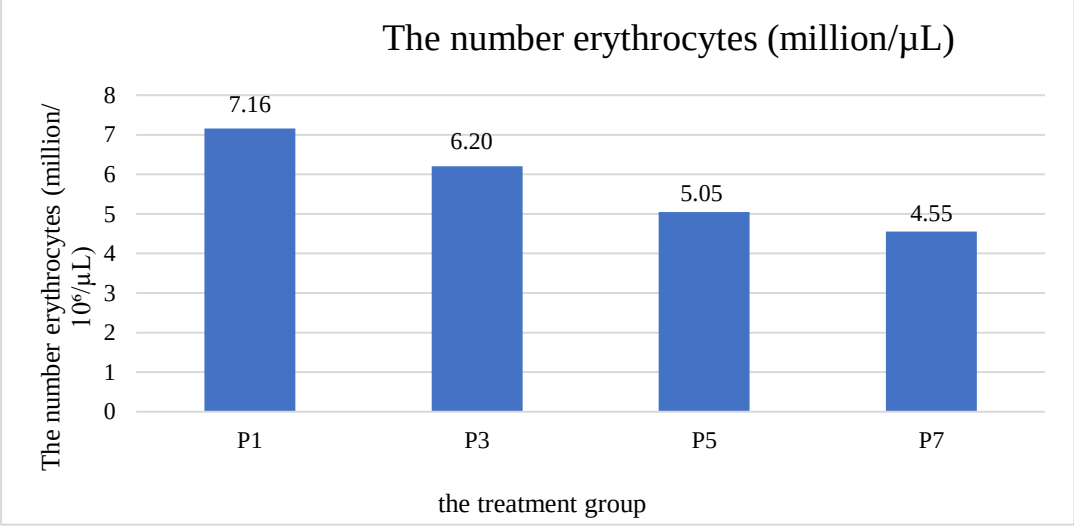
Table 3. The Duncan test results above can be made in the form of a notation, which is as follows:

Treatment	Average	Noted
P7	4.55	a
P5	5.05	b
P3	6.20	c
P1	7.16	d

Letters (a) indicate the lowest to (d) the highest.

Treatment with the same notation is not really different; on the contrary, treatment with different notations is really different. Based on the above table, it can be concluded that treatments

are really different from each other because they have different notations. The normal total number of erythrocytes in white rats ranges between 7 While the total erythrocytes in this study were in treatment group 1, a positive control group (P1) with normal feeding showed a number of erythrocyts of 7.16 million/L, which correlated with the letter "a," which indicates having the highest result among all treatment groups. While the treatment group P3 doses of a mixture of glucomannan porang tuber and moringa leaf extract with a ratio of 100:100 mg/kgBB showed a number of erythrocytes of 6.20 million/L, the letter "b" was connoted, indicating that the result was a moderate number. Then, in the P5 treatment group, a combination dose of glucomannan porang tuber and moringa leaf extract of 80:120 mg/kgBB showed a number of red blood cells of 5.05 million/L with the connotation "c," which showed results with small amounts. And in the treatment group P7 with a dose of 60:40 mg/kgBB, the number of erythrocytes was 4.55 million/L, associated with the letter "d," referring to the lowest outcome among the other treatment groups.



Description: P1 (control), P3 (100:100), P5 (80:120), and P7 (60:40)

Figure 1: A graph of the average number of erythrocytes in obese white mice that have been treated with a combination of glucomannan and leaf extract.

The average total range of erythrocytes resulting from this study is (3.16–5.10) x 10^6/µL. At P1 (normal), that is, 7.16 x 10^6/µL, erythrocytes are within the normal range of the number of white rats erythrocyts based on the (Dewi et al., 2022) the normal number of erythrocytes in white rats ranges around between (7-11)x10^6/µL. This is due to the treatment one, given normal feeding and does not contain high fat, so the number of erythrocytes is still within the normal range. At P3 (100:100) 6.20x10^6/µL, this number decreases from the normal range of white-mouse erythrocytes ranging from (7-11) x10^6 /µL. This is due to the dose (100:100) of glucomannan porang tuber and moringa leaf is not high enough to make the normal number of red blood cells in obese rats. However, in these three treatments, the number of erythrocytes is higher than in the treatments P5 (80:120) 5.05x10^6/µL and P7 (60:40) 4.55x10^6/µL. According to (Sundayani et al., 2016),the number of erythrocytes is influenced by gender, age, body condition, daily variation, and stress conditions. The number of erythrocytes is also due to the size of the blood cell itself. An abnormal number of erythrocytes in mice was caused by mice who had not reached the age of 3 months, weighed below the standard weight (250 g), and were at the time of blood collection.

The results of statistical tests showed that the administration of a combination glucomannan porang tuber and (*Amorphophallus muelleri* Blume) and moringa leaf extract (*Moringa oleifera*) with different dosage levels had a real effect (P 0.05) on the decrease and increase in the number of white rats erythrocytes. The lack of precursors such as iron and amino acids that help the erythrocyte formation process causes a decrease in the number of erythrocytes. This condition can be caused by a disruption in the absorption of decreased nutritional values in the feed given, which will affect the organs that play a role in the production of blood cells. Other factors that affect the difference in the number of erythrocytes are age, nutrition, blood volume, species, height, location, season, time of sampling, and type of anticoagulant (Zuraidawati et al., 2019).

The effect of the administration of the combination glucomannan porang tuber and (*Amorphophallus muelleri* Blume) and moringa leaf extract (*Moringa oleifera*) on the total number of erythrocytes through the Duncan trial can be known that the treatment of P1, P3, P5, and P7 had a significant difference in the number of the erythrocyte, but when seen a decrease in the amount of obese mice erytrocyte from the normal number of mice, the most observed in the treatment group P7 (60 mg/kgBB: 40 mg / kgBB) with the erytrocyte number of $4.55x10^{6}/\mu L$. Glucomannan porang tuber helps in increasing the number of red blood cells against obese people as found in the study (Alamsyah, 2019), which states that the fiber of the gallbladder will inhibit the process of recycling and bile salts will be secreted through the feces, so that only a small amount of bile salt is returned to the liver. This will stimulate the liver to form new bile salts and will take cholesterol from the blood as a bile salt-forming material. The more bile salts are formed, the less cholesterol circulating in the blood.

The average obese person has a low iron intake. When a good-quality diet is not balanced, such as with high-energy foods, low iron intake, and absorption enhancers, it can support the onset of anemia. 20% of obese subjects had a low iron status, and 94% had an average low-quality diet score of 52.04 5.2 (Nurramadhani et al., 2019). In the research conducted by (Suzana et al., 2017), Moringa extract contains 27.33% protein by Kjeldahl's method. The total iron content in moringa extract is an average of 14.67 mg/100g. The extract containing vitamin C is 759.05 mg/100 g with HPLC (*High Performance Liquid Chromatography*). The analysis of the nutrient levels in the capsules used in the study was based on the amount of iron in 100 g of the extract. If one capsule containing 700 mg of iron extract contains 0.103 mg of iron per capsule, vitamin C is 5.313 mg/cappule and the protein content is 39.043 mg in one capsule.

Therefore, the administration of glucomannan porang tuber and the moringa leaf extract is expected to increase the number of erythrocytes in patients with hypercholesterolemia, so that it can be concluded through Table 1 that the use of the combination of glucomannan porang tuber and the moringa leaf extract can increase the amount of the erythrocyte, with an increased sequence of P7 (60:40), P5 (80:120), and P3 (100:100).

4. CONCLUSIONS

The addition of a combination of porang tuber glucomannan (Amorphophallus muelleri Blume) and moringa leaf extract (Moringa oleifera) had an effect on increasing the number of erythrocytes in white rats suffering from obesity but did not affect the decrease in the number of erythrocytes. The combination of porang tuber glucomannan and Moringa leaf extract with a dose of P3 (100 mg/kgBW : 100 mg/kgBW) was able to increase the number of erythrocytes in obese

white rats. This research can be continued to calculate the differential erythrocytes and see the effect of giving a combination of porang tuber glucomannan and Moringa leaf extract on antibodies.

5. ACKNOWLEDGMENTS

The author thanks the Biology Education Study Program for providing funding for the incobest article.

6. REFERENCES

Alamsyah, M. A. B. O. (2019). Pengaruh Glukomanan Terhadap Penurunan Risiko Penyakit Stroke Iskemik. *Jurnal Ilmiah Kesehatan Sandi Husada*, *10*(2), 292–298. https://doi.org/10.35816/jiskh.v10i2.171

Gusti Ayu Mirah Afsari Dewi, I., Agung Ayu Mirah Adi, A., Luh Eka Setiasih, N., Sarjana Pendidikan Dokter Hewan, M., Patologi Veteriner, L., & Histologi Veteriner, L. (2022). Fluktuasi Profil Hematologi Tikus Putih Hewan Model Fibrosarkoma yang Diinduksi Benzo(a)piren. *Indonesia Medicus Veterinus Maret*, *11*(2), 2477–6637. https://doi.org/10.19087/imv.2022.11.2.267

Haiti, M., Sinaga, H., & Ramadani, U. R. (2021). Jumlah Eritrosit Dengan Teknik Homogenisasi Sekunder Inversi 5 Kali Dan 8 Kali. *Jurnal Masker Medika*, *9*(2), 499–503.

Indonesia, B. (2020). Profil Hematologi Tikus (*Rattus norvegicus*) Galur Sprague-Dawley Jantan Umur 7 Dan 10 Minggu. *7*(August), 136–145.

Lakshita, N. (2017). *Anak Aktif Bebas Diabetes*. *8*(Dm), 11.

Luluk Sutji Marhaeni. (2021). Daun Kelor (Moringa oleifera) Sebagai Sumber Pangan Fungsional Dan Antioksidan. *Agrisia*, *13*(2), 40–53.

Mutia, A., Jumiyati, J., & Kusdalinah, K. (2022). Pola Makan Dan Aktivitas Fisik Terhadap Kejadian Obesitas Remaja Pada Masa Pandemi Covid-19. *Journal of Nutrition College*, *11*(1), 26–34. https://doi.org/10.14710/jnc.v11i1.32070

Pasalina, P. E., Jurnalis, Y. D., & Ariadi, A. (2019). Hubungan Indeks Massa Tubuh Dengan Kejadian Anemia Pada Wanita Usia Subur Pranikah. *Jurnal Ilmu Keperawatan Dan Kebidanan*, *10*(1), 12. https://doi.org/10.26751/jikk.v10i1.584

Praditasari, J. A., & Sumarmik, S. (2018). Asupan Lemak, Aktivitas Fisik Dan Kegemukan Pada Remaja Putri Di Smp Bina Insani Surabaya. *Media Gizi Indonesia*, *13*(2), 117. https://doi.org/10.20473/mgi.v13i2.117-122

Rejeki, P. S., Putri, E. A. C., & Prasetya, R. E. (2018). Ovariektomi Pada Tikus Dan Mencit. In *Airlangga University Press*.

Saputra, A., Arfi, F., & Yulian, M. (2020). Literature Review: Analisis Fitokimia Dan Manfaat Ekstrak Daun Kelor (Moringa oleifera). *Amina*, *2*(3), 114–119. https://journal.ar-raniry.ac.id/index.php/amina/article/view/1220

Sekar Ratry Nurramadhani, Fillah Fithra Dieny, Etisa Adi Murbawani, A Fahmy Arif Tsani, Deny Yudi Fitranti, N. W. (2019). Status Besi dan Kualitas Diet berdasarkan Status Obesitas pada Wanita Usia Subur di Kota Semarang. *Amerta Nutrition*, *3*(4), 247–256. https://doi.org/10.20473/amnt.v3i4.2019.247-256

Septiyanti, S., & Seniwati, S. (2020). Obesity and Central Obesity in Indonesian Urban Communities. *Jurnal Ilmiah Kesehatan (JIKA)*, *2*(3), 118–127. https://doi.org/10.36590/jika.v2i3.74

Sundayani, L., Maswan, M., Satmiko, F. S., & Hanafi, F. (2016). Analisis jumlah eritrosit pada darah hewan coba tikus putih jantan (rattus novergicus) strain wistar sebelum dan setelah pemberian filtrat tanaman pakis sayur (Diplazium esculentum) Lina Sundayani*, Moch. Maswan**, Fajar Sigit Satmiko***, Fachrudi Han. *Jurnal Kedokteran*, *1*(2), 203–213.

Suzana, D., Suyatna, F. D., Azizahwati, Andrajati, R., Sari, S. P., & Mun'im, A. (2017). Effect of moringa oleifera leaves extract against hematology and blood biochemical value of patients with iron deficiency anemia. *Journal of Young Pharmacists*, *9*(1), S79–S84. https://doi.org/10.5530/jyp.2017.1s.20

Wahyuni, K., Rohmah, M., Ambari, Y., & Romadhon, B. (2020). Pemanfaatan Umbi Porang (. *Jurnal Karinov*, *3*(1), 3–6.

Wardani, N. E., Subaidah, W. A., & Muliasari, H. (2021). Ekstraksi dan Penetapan Kadar Glukomanan dari Umbi Porang (Amorphophallus muelleri Blume) Menggunakan Metode DNS. *Jurnal Sains Dan Kesehatan*, *3*(3), 383–391. https://doi.org/10.25026/jsk.v3i3.574

Wistar, G., Lahamendu, B., Bodhi, W., & Siampa, J. P. (2019). *Uji efek analgetik ekstrak etanol rimpang jahe putih (zingiber officinale rosc . Var . Amarum) pada tikus putih jantan Program Studi Farmasi FMIPA UNSRAT Manado , 95115 PENDAHULUAN Nyeri adalah pengalaman sensorik dan emosional yang tidak menyenangkan a*. *8*(November), 928–935.

Zaki, I., Wati, T. W., Kurniawati, T. F., Putri, W. P., & Khansa, I. (2022). Diet Tinggi Serat Menurunkan Berat Badan pada Obesitas. *Jurnal Gizi Dan Kuliner (Journal of Nutrition and Culinary)*, *2*(2), 1. https://doi.org/10.24114/jnc.v2i2.36756

Zuraidawati, Darmawi, & Sugito. (2019). Jumlah Leukosit dan Eritrosit Tikus Putih (Rattus norvegicus) yang di beri Ekstrak Etanol Bunga Sirsak (Annona muricata L.). *Prosiding Seminar Nasional Biotik*, 588–593.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Pakcoy *(Brassica chinensis L.)* Growth Using Moringa Leaf Extract with the Addition of Red Onion Skin

Dwi Putri Widjaya*, Suparti
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: dwiputriiwidjaya@gmail.com

KEYWORDS:
Pakcoy,
Growth
Fertilizer
Moringa leaves,
Shallot Skin

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Pakcoy is a vegetable that contains carbohydrates, fat, Fe, P, Ca, vitamins A, B, C, E, and K. moringa leaves and shallot skin are one of the organic wastes that can be used as additional media for plants. The purpose of the research is to identify the effect of moringa leaf extract and shallot skin on the growth of pakcoy plants. This research used a CRD (completely randomized design) with 1 factor 4 repetitions. The factors used were extract of moringa leaved and shallot skin which included P0=0% concentration, P1=20% extract concentration, P2=40% extract concentration, P3=60% extrac concentration. Parameters observed wre plant height and number of leaves. Data were examined with the non-parametric Statistical test, namely the Kruskal Wallis and continued with Duncan's Multiple Range Test to determine the best growth and yield in that treadment. The results of data analysis showed that the best treatment. The results of data analysis showed that the best treatment for pakcoy growth was in treatment P1 with an average plant height of 7.725 cm and average number of leaves of 2.5 leaves. The lowest treatment of pakcoy growth was in treatment P3 with an average plant height of 4.875cm and average number of leaves of 0.25.

1. INTRODUCTION

Pakcoy is a horticultural plant whose leaves are used as vegetables. Cultivation of pakcoy plants is not only easy to carry out, but also produces fast results due to the short life span from planting to harvesting. Pakcoy plants have a very fast growth and harvest period of 30-45 days. The planting process is easy after the seeds of 3-4 leafy plants or 15 days old, the seeds are moved insidepoly bag (Putri et al. 2022). Plant growth and development certainly requires soil nutrients as nutrients. The availability of macronutrients and micronutrients has a significant impact on the growth of pakcoy plants; if soil nutrient availability is not maximum, fertilization is required. According to research results (Erawan and Bahrun 2013).

People of all ages, from children to the elderly, are very interested in eating pakcoy because it contains a lot of nutrients which are beneficial for your health, including protein, fat, carbs, calcium, iron, and vitamins A, B, C, and E. The nutritional content in pakcoy is very good, especially for pregnant women because it can prevent anemia. In addition, pakcoy can ward off hypertension, heart disease, and reduce the risk of various types of cancer (Pracaya 2016).

Fertilizers are nutrients that are added to growing plants to get the nutrient needs needed by plants so they can produce well. Fertilizers can be categorized as either organic or inorganic depending on where the raw materials came from (rice novita 2015). Vegetable farmers generally use inorganic fertilizers. The use of inorganic fertilizers can increase the content of macronutrients

in the soil, but their continuous use can cause adverse side effects. For example, the effectiveness of using urea fertilizer does not last long, because urea fertilizer that is used continuously and used in excessive doses can cause soil nitrate contamination (Triyono et al. 2013).

Organic fertilizer can be classified into two categories based on the form: liquid fertilizer and solid fertilizer. A liquid fertilizer is a soluble solution that contains one or more carrier elements required by plants. The benefits of liquid organic fertilizers are overcoming the shortage of organic matter in the soil, improving the physical, chemical and biological properties of the soil and being able to reduce the use of inorganic fertilizers. cause wilting and death symptoms in plants (Waluyo, 2020) Liquid fertilizer is generally made from a mixture of plant waste and organic matter containing plant growth support substances, such as Moringa leaves as a mixture for making liquid fertilizer.

The time and dose or concentration of liquid fertilizer application to plants must also be considered to avoid excess or deficiency of nutrients in plants. Research result (Suhastyo and Raditya 2019) showed that MOL of Moringa leaves on pagoda mustard (*Brassica narinosa*) was significantly different in the mustard plant's height, namely in the treatment of the frequency of giving 70 ml MOL of Moringa leaves once every 6 days. In the administration of 50 ml and 70 ml Moringa leaf MOL, there was no discernible variation in the number of leaves of the pagoda mustard plant.

Moringa Plant (*Moringa oleifera*) is a vegetable plant that has good nutritional content, including vitamin C and chlorophyll, and can grow in the lowlands and highlands up to ± 1000 meters over sea level (Fajri, Rahmatu, Rostiati 2018). Moringa plants are widely known in Indonesia, but have not been used optimally. Moringa is a plant that has almost complete macro elements and amino acids. Moringa leaf extract is an effective way to organically speed up plant growth. This is because Moringa leaves are rich in zeatin, cytokinins, ascorbate, phenolics, and minerals that can stimulate plant development including Ca, K, and Fe. Cytokinins are plant hormones that induce cell division, growth, and promote new cell growth and delay cell aging (Suhastyo and Raditya 2021). The amount of moringa leaf extract added to liquid organic fertilizer, up to 40%, impacts the growth of pakchoy plants, including the number of leaves, plant length, wet weight, and dry weight (Kartika 2014).

Shallot waste extract can be used as one of the nutrients that can be applied to plants. Onion skin contains growth hormones in the form of auxin and gibberellin hormones which can stimulate plant growth.

Onion skin contains protein, minerals, sulfur, anthocyanins, kaempferol, carbohydrates, and fiber. These elements are nutrients needed for plant growth. One of the substances contained in shallot skin is sulfur. Sulfur is one of the compounds needed by plants, it is absorbed as sulfate ion and undergoes reduction in plants to become a sulfhydryl group (Hanum et al. 2021).

According to the context, the purpose of the research is to identify the effect of moringa leaf extract and shallot skin on the growth of pakcoy plants.

2. MATERIALS AND METHODS

2.1. Location and Time

Research on the manufacture of liquid organic fertilizer and testing on plants was conducted at the Green House Laboratory of the Teaching and Education Faculty, Muhammadiyah University, Surakarta. This research was conducted in March – April 2023.

2.1.1. Tools and Materials

This study's instruments included poly bag, rockwoll, toothpicks, shovels, filters, stirrers, containers for holding solutions, lids, scissors, measuring cups, buckets/basins, trays, knives, stationery, rulers, paper labels, documentation tools, TDS meters, pH sticks. The materials used are soil, moringa leaves, shallot skin, pakcoy seeds, brown sugar, distilled water.

2.1.1.1. Research Prosedure

Making POC of Moringa leaves and shallot skin.

Shallot skins were taken from the production house "Brambang Goreng Jawa SW" in Colomadu District, Karanganyar Regency, Central Java. Moringa leaves were taken from a garden in Siwal village, Baki, Sukoharjo Regency.

Prepare other ingredients, namely brown sugar and distilled water. The next step is to make extracts of Moringa leaves and shallots by means of 1000g of shallot skin and 1000g of Moringa leaves, each of which is mashed with 1 liter of water. Then add 3 crushed brown sugar seeds and stir until all the ingredients are mixed. The mixture of shallot skin extract and Moringa leaves was placed in a tightly closed bucket and allowed to stand for 15 days, once every 2 days the Moringa leaf extract and onion skin were homogenized. After being left for 15 days, the solution was filtered using a funnel to obtain a filtrate. This solution is used as a stock solution with a concentration of 100%. For the treatment of the concentration of organic liquid fertilizer for Moringa leaves and shallots, it is sufficient to dilute the stock solution according to the required treatment.

Seeding

Nursery preparation begins with preparing nursery tools such as trays,cutter, and a toothpick. Materials used for nursery craterockwoll, and pakcoy seeds. Then choose the seeds to be sown and soak them in water for ± 12 hours, then cut themrockwoll 5×5 cm. Put it downrockwoll on a tray that has been filled with water as much as half a tray, make a holerockwoll with a toothpick to place the soaked pakcoy seeds. Sow the pakcoy seeds on rockwool for 15 days.

Planting

After 15 days or if the leaves have 4 strands, the pakcoy can be transferred to the planting medium.

Fertilizer Application

The treatment of giving liquid organic fertilizer by pouring 70 ml on the plants with a predetermined concentration. Provision of liquid organic fertilizer after the seedlings are 2 weeks old after planting with fertilization intervals every 6 days.

This research is quantitative experimental study. The design adopted in this research was a CRD (completely randomized design), with one experimental factor, especially the concentration of organic liquid fertilizer for moringa leaves and shallot skins, with four repetitions. The concentrations given are as follows; Concentration of 0% (P0) with no application of organic liquid fertilizer, concentration of 20% (P1) by means of dilution, take 200 ml of organic liquid fertilizer for moringa leaves and shallots plus 800 ml of distilled water, 40% concentration (P2) by means of dilution, take organic fertilizer 400 ml liquid moringa leaves and shallots plus 600 ml of distilled

water, a concentration of 60% (P3) by dilution method, 600 ml of organic liquid fertilizer for moringa leaves and shallots plus 400 ml of distilled water is taken.

The data of this study is the result of observing the height of the pakcoy plants which were observed at 14, 21 and 28 days after planting. The data obtained was processed using the Non-parametric Statistical data analysis technique, namely the Kruskal Wallis test and continued with Duncan's Multiple Range Test to find out the best growth and results in the treatment and then presented in graphical form.

3. RESULTS AND DISCUSSION

3.1.Result

Pakcoy plant growth was observed by measuring the height and calculating how many leaves there are once a week on the 14th, 21st, and 28th days after planting. Pakcoy plant height measurement starts from the base of the plant to the tallest leaf. This is in accordance with research **(Ningsi 2019)** which states that the measurement of plant height starts from the base of the plant to the highest point that can be reached by plant leaves by closing the plant leaves, measurements are made using a meter. While the observation of the number of leaves is completed by calculating how many leaves are on the plant. This is in accordance with research **(Jayanti 2018)** which states that the measurement of the number of leaves is done by calculating how many leaves that have opened perfectly.

Tabel 1. *Tes Statistics* (Kruskal Wallis Test)

	Plant height	**Number of leaves**
Asymp. Sig.	.015	.021

Based on the comparison of probability values (Asymp. Sig)

- If probability (Asymp. Sig) > 0.05, maha H0 is accepted
- If probability (Asymp. Sig) < 0.05, maha H0 is rejected

From the Statistics Test table above, the probability values (asymp. Sig) = 0.015 (plant height) and 0.021 (number of leaves). Result result :

From the output it can be seen that the probability values (Asymp. Sig.) are 0.015 < 0.05 and 0.021 < 0.05, so H0 is rejected, meaning there is a difference in the average plant height and number of leaves.

According to the analysis of variability findings, Table 2 displays that there was no discernible difference in fertilizer content according to plant height.

Tabel 2. Duncan's multiple range test results on growth of Pakcoy plant height

Pakcoy plant height Duncan				
extract concentration of moringa leaved and shallot skin	**N**	**Subset for alpha = 0.05**		
		1	**2**	**3**
P0 = extract concentration of moringa leaved and shallot skin 0%	4	2.800		
P3 = extract concentration of moringa leaved and shallot skin 60%	4	4.875	4.875	

Pakcoy plant height Duncan				
P2 = extract concentration of moringa leaved and shallot skin 40%	4		6.350	6.350
P1 = extract concentration of moringa leaved and shallot skin 20%	4			7.725
Sig.		.076	.192	.222

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 4.000.

The average values of P1 and P2 were not significantly different because they were in the same subset, namely subset 3, while there were significant differences in P0 and P1.

The analysis of variance data revealed a significant difference between fertilizer concentration and leaf count, as shown in Table 3.

Table 3. Duncan's multiple range test results Number of leaves of Pakcoy plant

Number of leaves of Pakcoy plant Duncan			
extract concentration of moringa leaved and shallot skin	**N**	**Subset for alpha = 0.05**	
		1	**2**
P0 = extract concentration of moringa leaved and shallot skin 0%	4	.25	
P3 = extract concentration of moringa leaved and shallot skin h 60%	4	.25	
P2 = extract concentration of moringa leaved and shallot skin 40%	4	1.00	
P1 = extract concentration of moringa leaved and shallot skin 20%	4		2.50
Sig.		.195	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 4.000.

The mean values of P0, P3, and P2 were not significantly different because they were in the same subset, namely subset 1, while the mean values of P2 were significantly different from P1 because they were in different subsets.

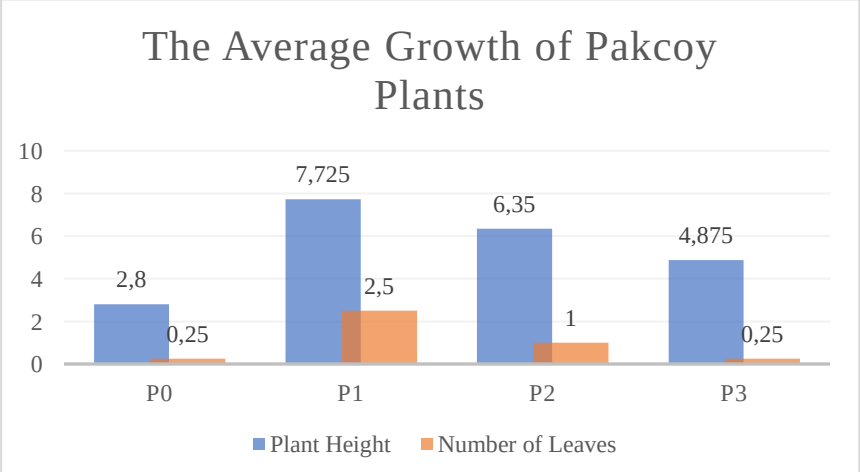


Figure 1. Histogram of the average growth of Pakcoy Plants

3.2.Discussion

The impact of the concentration of organic liquid fertilizer on Moringa leaves and shallot skin on plant height is presented in table 2, and Figure 1. It appears that the organic liquid fertilizer of Moringa leaves and shallot skin had no significant effect on the height of pakchoy plants in all treatments. The treatment that produced the best plant height was in treatment P1 with a dose of liquid organic fertilizer for Moringa leaves and shallots 20%, getting the highest average of 7,725 cm. These results indicate that applying liquid organic fertilizer to Moringa leaves and shallots with a concentration of 20% to the planting medium can increase the height of the pakcoy plants. This is because Moringa leaf extract contains cytokinin which is a hormone that accelerates plant growth, this is in accordance with research (Suhastyo and Raditya 2021) which states that moringa leaf extract can be applied to speed up plant growth naturally. This is because Moringa leaves are rich in cytokinins. In addition, shallot skin also contains auxin which is a hormone that has an impact in encouraging cell elongation, cell division, differentiation of xylem and phloem tissues. This is consistent with the findings (Hanum et al. 2021) which states that one of the aspect that can impact the increase in plant height is the hormone auxin which has a function to stimulate the elongation of stem cells.

The lowest plant height was found in treatment P3 with a dose of organic liquid fertilizer for Moringa leaves and 60% shallot skin, obtaining an average pakcoy plant height of 4.875 cm. This shows that the use of organic matter as liquid fertilizer will be effective in increasing plant growth if it is at the right dosage or concentration. Excessive dosage or concentration of fertilizer will be toxic to plants. Fertilizer application with low concentrations will not meet the needs of nutrients for plants, causing inhibition of plant growth. This is consistent with the findings (Hidayah et al. 2022) which states that at a higher concentration of shallot skin liquid organic fertilizer, the availability of nutrients and minerals for plants exceeds the adequacy limit, so it is not effective in supporting better growth, but on the contrary inhibits plant growth.

(a) (b)

Figure 2. The best plant height (a) and the lowest plant height (b)

Based on table 3 and figure 1, it can be seen that liquid organic fertilizer for moringa leaves and shallots had no discernible impact on the number of leaves of the pakcoy plant in all treatments. The treatment that produced the best number of leaves was in treatment P1 (20% organic liquid fertilizer for moringa leaves and shallot skin) with an average number of leaves of 2.5 strands. This is as a result of growth regulators in shallot skin extract, one of which is the hormone gibberellin. This is supported by research (Firdausi 2019) the presence of growth regulators such as gibberellins which are sufficient to encourage plant growth, especially in the formation of leaves.

In the therapy treatment P3, the fewest leaves were discovered (60% organic liquid fertilizer for moringa leaves and shallot skin) with an average number of leaves of 0.25 leaves. Fertilizer concentrations that are too high make plant growth less than optimal, so the growth of the number of leaves is also slow, which means the number of leaves will be less. In addition, plant height will also affect the number of leaves. The P3 treatment obtained the lowest average on the plant height parameter, so that the number of leaves parameter also obtained the lowest results. This is supported by research (Siregar 2018) which states that the increase in plant height indirectly affects the rise in leaf count, the higher the plant, the number of leaves will increase because the number of segments and the appearance of new shoots always produce new leaves.

One of the factors that influence leaf formation is the availability of nitrogen and phosphorus nutrients. Based on research (Banu 2020) Shallot skin extract contains nutrients contained in the shallot skin for example K, Mg, P, and Fe which can be used as organic liquid fertilizer that fertilizes plants. Whereas as a Growth Regulatory Substance (ZPT) in shallot skin there are hormones auxin and gibberellin which are growth hormones so that shallot skin might be utilized as a growth controller.

Figure 3. Treatment P1 (highest number of leaves) and P3 (least number of leaves)

One of the aspect that influence the growth and development of plants is the preparation of planting media, in this case the provision of nutrients in the form of fertilizers (nutrients) that are appropriate to the media. Provision of moringa leaf extract and shallot skin can meet the nutritional needs of the pakcoy plant (*Brassica chinensis* L.) because it contains flavonoids which can

stimulate the growth of pakcoy plants. This is in accordance with research (Prabowo and Noer 2020) which stated that shallot skins tested positive for containing alkaloid compounds, saponins, flavonoids and tannins. The function of flavonoids in plants in general is as a growth regulator, photosynthetic regulator, anti-microbial and anti-viral work. In addition, according to research (Tri Akbar et al. 2019) Moringa leaf mixture in fertilizer can be used by spraying it on the leaves to accelerate plant growth because it contains chemical compounds such as calcium, magnesium, phosphorus, iron and sulfur so that Moringa leaves can be used to make organic fertilizer ca.

Utilization of shallot skin as liquid organic fertilizer can reduce planting costs. Shallot waste extract contains nutritional elements needed for plant growth such as protein, minerals, sulfur, anthocyanin, kaempferol, carbohydrates, and fiber. These elements are nutrients needed for plant growth. Based on research (Yikwa and Banu 2020) states that shallot skin extract contains calcium (Ca) which is a nutrient needed by plants in addition to nitrogen, phosphorus, potassium, magnesium and sulfur.

4. CONCLUSIONS

Liquid organic fertilizers for Moringa leaves and shallot skins can be used as alternative hormones for plant growth. The implementation of organic liquid fertilizer for Moringa leaves and shallot skins affects the height and number of leaves of the pakcoy plant.

Applying organic liquid fertilizer for Moringa leaves and shallot skins with a concentration of 20% gives the best growth of pakcoy plants. Meanwhile, the implementation of organic liquid fertilizer for Moringa leaves and shallots with a concentration of 60% gave the lowest growth of pakcoy plants.

The concentration of organic liquid fertilizer for Moringa leaves and shallot skins 200 ml/l water is the best concentration, but this result is not an optimal concentration, because the concentration of 20% is the concentration at the lowest level in this experiment. So that further study is needed to identify the concentration of organic liquid fertilizer with a lower or higher concentration level which will produce a truly optimum concentration for growth and number of leaves. Researchers hope that further research can add other parameters so that the effect given by liquid organic fertilizer of Moringa leaves and shallot peels is more maximal on plant growth.

5. REFERENCES

Banu, L. S. 2020. Review: Pemanfaatan Limbah Kulit Bawang Merah dan Ampas Kelapa sebagai Pupuk Organik terhadap Pertumbuhan Beberapa Tanaman Sayuran. *Jurnal Ilmiah Respati* 11(2): 148–155. DOI: 10.52643/jir.v11i2.1125

Erawan, D., and Bahrun, A. 2013. Pertumbuhan dan Hasil Tanaman Sawi (Brassica juncea L.) pada Berbagai Dosis Pupuk Urea. *Jurnal Agroteknos* 3(1): 19–25.

Fajri, Rahmatu, Rostiati, N. A. 2018. Kadar Klorofil Dan Vitamin C Daun Kelor (Moringa oleifera Lam) dari Berbagai Ketinggian Tempat Tumbuh Chlorophyll and Vitamin C Levels of Moringa Leaf (Moringa Oleifera Lam) Growingon Various Altitudes. *J. Agrotekbis* 6(2): 152–158.

Firdausi, a. A. (2019). *Pengaruh Pemberian Ekstrak Umbi Bawang Merah (Allium cepa L) Terhadap Pertumbuhan Tanaman Baby Kailan (Brassica oleracea L)*. Lampung: Universitas Lampung.

Hanum, U. F., Rahayu, Y. S., and Ratnasari, E. 2021. Pengaruh Atonik dan Filtrat Kulit Bawang Merah Terhadap Pertumbuhan dan Produktivitas Tanaman Bunga Matahari (Helianthus annuus). *LenteraBio : Berkala Ilmiah Biologi* 9(1): 17–22. DOI: 10.26740/lenterabio.v9n1.p17-22

Hidayah, N. U. R., Corina, T., Ode, L. A., Agroteknologi, J., Pertanian, F., and Halu, U. 2022. Bawang Merah Terhadap Pertumbuhan Tanaman Kembang Kol (Brassica oleracea var . botrytis) The Effect of Concentration of Liquid Organic Fertilizer (POC) Shallot Skin on Growth Cauliflower (Brassica oleracea var . botrytis). *Jurnal Agroteknos* 12(2).

Jayanti, K. D. (2018). Perbandingan Pertumbuhan dan Hasil Ketimun Melalui Cara Aplikasi Pupuk Organik Cair yang Berbeda. *Jurnal AgroPet*, 20-25.

Kartika, Rahma Dewi. 2014. "Pengaruh Pupuk Organik Cair Daun Kelor (Moringa Oleifera, Lamk) Terhadap Pertumbuhan Tanaman Pakchoy (*Brassica Rapa, L*.) yang ditanam Secara Hidroponik dan Sumbangannya Pada Pembelajaran Biologi di SMA". *Naskah Publikasi. Universitas Sumatera Utara.*

Ningsi, B. P. dan S. 2019. Peranan Pupuk Kotoran Kambing Terhadap Tinggi Tanaman, Jumlah Daun, Lebar dan Luas daun Total Pennisitum purpureum cv. Mott. *STOCK Peternakan* 2(2): 11–24.

Prabowo, A., and Noer, S. 2020. Uji kualitatif fitokimia kulit bawang merah (Allium ascalonicum). *Prosiding Seminar Naisonal Sains* 1(1): 250–253.

Pracaya., dan Juang Gema Kartika. (2016). Bertanan 8 Sayuran Organik. Jakarta : Penebar Swadaya.

Putri, Y. D. A., Kurniasih, S., and Munarti, . 2022. Efektivitas Kulit Bawang Merah (*Allium ascalonicum*) Terhadap Pertumbuhan Pakcoy (*Brassica rapa*). *Ekologia* 21(2): 44–53. DOI: 10.33751/ekologia.v21i2.3635

rice novita, novita sari. 2015. Analisis Dan Perancangan Berorientasi Obyek. *Teknoif* 3(2): 1–6.

Siregar, D. A. 2018. Pemanfaatan Ekstrak Bawang Merah (Allium cepa L.) Terhadap Viabilitas Benih Kakao (Theobroma kakao L.). *Jurnal Education and Development* 3(2): 23.

Suhastyo, A. A., and Raditya, F. T. 2019. Respon Pertumbuhan dan Hasil Sawi Pagoda (Brassica Narinosa) terhadap Pemberian Mol Daun Kelor. *Agrotechnology Research Journal* 3(1): 56–60. DOI: 10.20961/agrotechresj.v3i1.29064

Suhastyo, A. A., and Raditya, F. T. 2021. Pengaruh Pemberian Pupuk Cair Daun Kelor Dan Cangkang Telur Terhadap Pertumbuhan Sawi Samhong (Brassica juncea L.). *Jurnal AGROSAINS dan TEKNOLOGI* 6(1): 1. DOI: 10.24853/jat.6.1.1-6

Tri Akbar, C., Suketi, K., and Gema Kartika, J. 2019. Panen dan Pascapanen Kelor (Moringa oleifera Lam.) Organik di Kebun Organik Kelorina, Blora, Jawa Tengah. *Buletin Agrohorti* 7(3): 247–254. DOI: 10.29244/agrob.v7i3.30171

Triyono, A., Purwanto, and Budiyono. 2013. Efisiensi Penggunaan Pupuk – N untuk Pengurangan Kehilangan Nitrat pada Lahan Pertanian. *Prosiding Seminar Nasional Pengelolaan Sumber Daya Alam dan Lingkungan* (1): 526–531.

Tri Waluyo. (2020). "Analisis Finansial Aplikasi Dosis Dan Jenis Pupuk Organik Cair Terhadap Produksi Tanaman Tomat (Lycopersicum Esculentum Mill)". *Jurnal Ilmu Budaya.* 8357-8370.

Yikwa, P., and Banu, L. S. 2020. Respon Polikultur Cabai Rawit Dan Sawi Terhadap Waktu Pengomposan Dan Dosis Kompos Kulit Bawang Merah. *Jurnal Ilmiah Respati* 11(1): 46–61. DOI: 10.52643/jir.v11i1.850.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Mustard (*Brassica Juncea* L.) Growth Hydroponically Using AB-Mix and Liquid Organic Fertilizer Tea Pulp

Dinda Putri Trisnawati*, Suparti
Biology Education Department, Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Central Java, Indonesia
*Corresponding Author. E-mail address: dindaputry496@gmail.com

KEYWORDS:
AB Mix
Hydroponic
Liquid organic fertilizer
Mustard
Tea pulp

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Mustard greens are vegetables that have a high potential to be cultivated and contain nutrients. Hydroponics is an alternative to the cultivation of mustard plants. AB Mix and liquid organic fertilizer are nutrients to increase plant productivity. In addition, the content of tea pulp can help plant growth. This study was conducted to determine the effect of AB Mix concentration and tea pulp liquid organic fertilizer on mustard growth hydroponically. The study used a Complete Randomized Design in an experimental setting with four different AB Mix nutrient combinations treatments and tea pulp liquid organic fertilizer in the form of V0 (control), V1, V2, and V3. Each treatment is repeated four times. The results showed that the concentration of AB Mix and liquid organic fertilizer tea pulp affected the growth of mustard plant height, number of leaves, and wet weight of mustard plants. The greatest treatment on V2 has a plant height of 14 cm, lots of leaves 7 strands, and a wet weight of 5.8 g.

1. INTRODUCTION

Mustard plants are vegetables that the people of Indonesia favor. Mustard greens have a high nutritional content, so the community uses them as a side dish. Mustard greens are vegetables that have a high potential to be cultivated, besides that mustard greens are also vegetables that are easy to grow in the lowlands or highlands according to research (Lestari, 2017). The contents contained in mustard greens have many uses for the health of the body. According to research (Alifah, 2019), mustard greens contain lots of vitamins A, B, C, E, and K, besides that the content in mustard greens there are carbohydrates, proteins, fats, and other contents in the form of calcium, potassium, manganese, folate, iron, phosphorus, magnesium are also found in mustard vegetables which are helpful as a balance to the health of the body.

Using data analysis from the Central Statistics Agency as a basis (2022), the total value of mustard crop production in Indonesia in 2018 reached 635,982 tons. In 2019 it reached 652,723 tons. In 2020, the total harvest reached 667,473 tons. In 2021, the total production reached 727,467 tons. To meet consumer needs in a sustainable manner, mustard cultivation can be carried out that has good quality and quantity in the crops. According to (Siregar, 2017), cultivation with hydroponic techniques can be an alternative to produce high-quality mustard vegetable products continuously.

One effort to balance the process of growth and development of plants grown hydroponically requires providing proper nutrition, with the provision of little nutrition can cause delays, and the growth and development of mustard plants might be negatively impacted by an excessive nitrogen supply, which will lower yields. However, according to (Fauziah, 2022), mustard greens can grow

and develop optimally with the fulfillment of essential nutrients according to the needs of mustard plants.

AB Mix nutrition is a standard nutrient usually used in addition to nutrients in hydroponics. The use of nutrient solution AB mix requires relatively expensive costs. So alternative technology is needed to develop hydroponic technology to make it easier for people to cultivate planting hydroponically. According to research (Marginingsih, 2018), one way to produce optimal crops for plant growth is to use liquid organic fertilizer as a substitute for AB Mix nutrients. In addition to using AB Mix, liquid organic fertilizer is also very necessary for hydroponic vegetable cultivation to reduce the use of inorganic fertilizers. AB Mix nutrients can be combined with liquid organic fertilizer with the main component of tea pulp to reduce production costs.

Organic fertilizer is fertilizer derived from organic matter such as animal manure, household waste, plants, and sawdust. Making this organic fertilizer by utilizing organic waste can produce environmentally friendly organic fertilizer. Solid organic fertilizers and liquid organic fertilizers are the two categories of organic fertilizers. Organic fertilizers that are liquid rather than solid are more efficient to employ. This type of organic fertilizer known as liquid organic fertilizer has a liquid form and is easily soluble in the soil. According to (Pantang, 2021), liquid organic fertilizer has the advantages that it is easy to make and does not require a long time, can improve the structure of soil particles, and is easy to apply. According to research (Marginingsih, 2018), the usage of liquid organic fertilizer in hydroponics is best combined with AB Mix nutrients so that nutrients complement one another since it can have a perfect influence on plant development and productivity. Therefore, liquid organic fertilizer is used as a substitute in AB Mix nutrition with a liquid organic fertilizer in order to fulfill the nutritional requirements of plants.

Based on research (Ulfa, 2021), In agriculture, organic fertilizer from tea pulp can be used because there are various kinds of minerals and nitrogen that are easily absorbed by plants. In addition, tea pulp is also useful as a provider of nutrients during the decomposition process. In addition to nitrogen (N), it also includes the minerals zinc (Zn), selenium (Se), molybdenum (Mo), germanium (Ge), and magnesium (Mg). Minerals included in tea are a crucial component that plants require, thus if they aren't present, growth would be impeded or inadequate (Gultom, 2013).

There are several contents in tea pulp that can help plant growth, namely Organic Carbon, Copper (Cu) 20%, Magnesium (Mg) 10%, and Calcium (Ca) 13%. Tea grounds also contain antioxidant elements to help prevent free radicals in plant cells (Widyantika, 2018). Tea pulp also has a fairly high protein content of 27.42%, the content of other substances in tea pulp, including caffeine 2.5 - 5.5%, theobromine 0.07 - 0.17%, and theophylline of 0.002 - 0.013%, tannin 1.35%, and crude fiber content of 23.01%. All of these ingredients are needed by plants to grow more optimally (Rinaldi, 2021). Tea pulp as a manufacturer of liquid organic fertilizer, can utilize waste from daily household consumption. The benefits of tea pulp for plants include boosting root, stem, and leaf growth, as well as improving soil fertility.

According to this description, research was conducted on employing liquid organic fertilizer made from tea pulp and ab mix to study the growth of mustard (Brassica juncea L.) hydroponically.

2. MATERIALS AND METHODS

This research was carried out at the Green House, Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta. The study runs from February 2023 to May 2023. The tools used are buckets, rockwool, flannel cloth, basins, knives, scales, trays, blenders, sieves, bars, scissors, jars, stirrers, net pots, plastic containers, and stationery. The materials used are mustard plant seeds brand red arrow stamp, tea dregs, AB Mix, water, EM4, brown sugar, and labels.

The study method employed is an experimental research approach with a Completely Randomized Design, consisting of 4 treatments and 4 repeats. This research design uses one factorial with a combination of AB Mix nutrients and tea pulp liquid organic fertilizer, namely V0 = AB Mix 20 ml + liquid organic fertilizer 0 ml, V1 = AB Mix 15 ml + liquid organic fertilizer 35 ml, V2 = AB Mix 10 ml + liquid organic fertilizer 40 ml, V3 = AB Mix 5 ml + liquid organic fertilizer 45 ml.

The research procedure is to seed mustard seeds that have been soaked into rockwool; make liquid organic fertilizer from tea grounds; transfer seeds after 14 days of age into the Wick system hydroponic installation; prepare a solution of liquid organic fertilizer and AB Mix according to treatment as hydroponic nutrients; changing the nutrient solution once a week; measure height growth, and the number of leaves on mustard plants once a week; took data at the end of the observation (28 HST) and weighed the wet weight of the mustard plant. Observational measures, such as plant height, the number of leaves, and wet weight, are used as data on mustard growth characteristics.

Plant height parameters can be measured using the bar as a measuring tool. Plant height is measured using units (cm). The measured part starts from the base of the plant stem that appears on the surface of the medium to the plant's very tip. The parameter of the number of leaves is calculated manually for strands on each plant. Counted leaves are all leaves that have opened perfectly. Wet weight parameters how to take the results by weighing plants using digital scales after harvesting.

3. RESULTS AND DISCUSSION

3.1. Results

Increased plant height, leaf count, and wet weight are indicators of growth in mustard plants. In research that has been conducted on mustard plants using a mixture of liquid organic fertilizer tea pulp and AB Mix as the treatment given to the plant, it was found that the results observed in the study were in the form of plant growth parameters which included plant height, many leaves, and weight of wet mustard plants. Table 1 shows the average of each parameter.

Table 1. Ror average plant height, many leaves, wet weight of mustard plants

Treatment	Average Parameters		
	Plant Height (cm)	Many Leaf (strand)	Wet Weight (g)
V0	13.9	4.0	5.5
V1	12.4*	3.7*	4.8*
V2	14.0**	7.0**	5.8**
V3	13.4	4.2	5.0

Note: * : lowest
**: best

According to Table 1's average mustard plant findings, the best mustard plant height was discovered in the V2 treatment, where it was 14 cm on average, while the worst treatment was V1, where it was 12.4 cm on average. The best treatment in the parameters of many leaves is V2, which has an average of 7 strands of leaves, while the worst treatment is V1, which has an average of 3.7 strands of leaves. The wet weight parameter shows that V2 has the best treatment with an average wet weight of 5.8 g, and V1 has the worst treatment with an average wet weight of 4.8 g.

Plant height (cm)

According to the analysis showed that the combination of liquid organic fertilizer tea pulp and AB Mix nutrients may increase the height of mustard plants. Figure 1 shows the yield of the average height growth of mustard plants (4 MST- 1 MST).

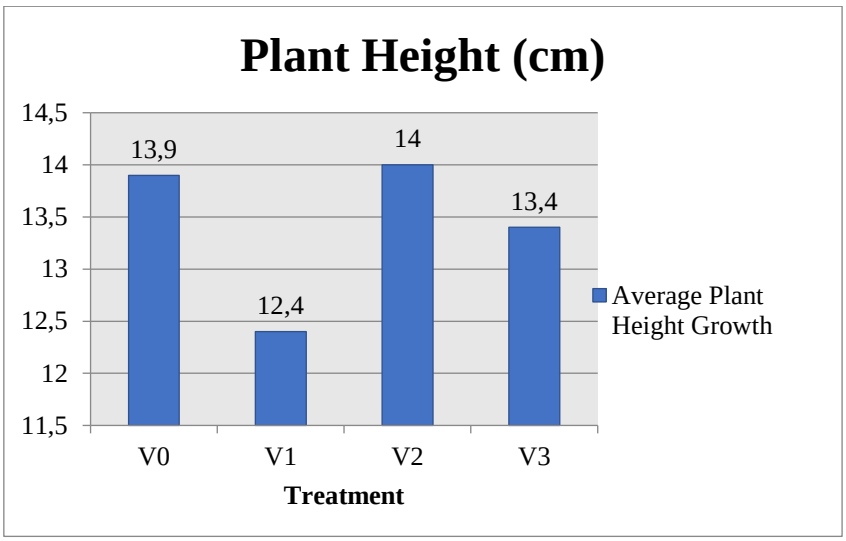


Figure 1. Average Plant Height Growth (cm)

The highest average growth of mustard plants is found in V2 treatment with an average plant height of 14 cm. In the V2 treatment using a combination of nutrients AB Mix 10 ml coupled with liquid organic fertilizer tea pulp 40 ml and produce the best plant height, it shows that the AB Mix and liquid organic fertilizer tea pulp combination's nutrition may satisfy the nutrient requirements of mustard plants. In accordance with the statement (Marginingsih, 2018) that the substitution of liquid organic fertilizer in the nutrients in AB Mix can result in this good growth because the nutrients in AB Mix contain enough macro- and micronutrients to support plant growth during physiological and metabolic processes.

In increasing height, plants need nutrients contained in them such as nitrogen. Nitrogen serves to stimulate budding and increase plant height. In addition, nitrogen accelerates the growth of the entire plant, particularly the stems and leaves, when it is present in appropriate amounts. Research (Alsyah, 2018) states that fertilization is needed to increase plant height and to meet the needs of plant nitrogen nutrients, besides that there are also microelements that function to increase plant height. According to (Adikasari, 2012), tea pulp contains nitrogen minerals that play a role in spurring stem growth and helping root growth.

(a) (b)

Figure 2. Mustard plant height (a) highest, (b) lowest

The lowest average mustard plant growth was found in the V1 treatment, with an average plant height of 12.4 cm. In this V1 treatment using a combination of AB Mix 15 ml with liquid organic fertilizer tea pulp 35 ml. The V1 treatment produces less than optimal plant height growth. This

can be because the V1 treatment has a nutrient content that is not able to meet the needs of mustard plants. This fits the definition of the statement (Marginingsih, 2018) that nutrient concentrations that are unable to meet the needs of plants in carrying out physiological processes cause slow growth and development processes. And also, according to a statement (Hidayanti, 2019) which states that the provision of nutrients can increase plant growth if the amount is given according to plant needs. If it is too excessive, it will cause growth to be stunted.

Amount of Leaves

According to the analysis showed that the combination of liquid organic fertilizer tea pulp and AB Mix nutrients may increase the number of mustard plant leaves. Figure 3 shows the average outcome of the mustard plant's number of leaves (4 MST minus 1 MST).

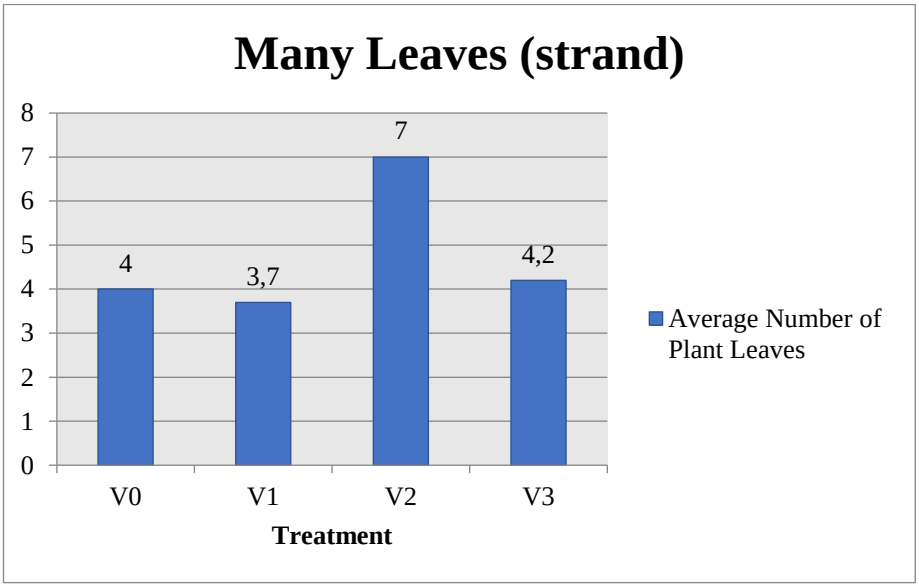


Figure 3. Average Number of Plant Leaves

Based on Figure 3, the conclusions of the study of the average number of leaves on mustard plants indicate that V2 has the best average, with an average of 7 strands of leaves. Considering what has been discovered as a result, it can be seen that the provision of appropriate nutrition will provide optimal results for plant growth and development. Since there are more leaves because of nitrogen, photosynthesis can proceed more quickly, hastening the development of leaf organs. According to (Munifatul, 2014), the amount of nitrogen and phosphorus that is present in the medium and is accessible to plants has a significant impact on how quickly plants can develop leaves. One of the factors in increasing the number of leaves is the absorption of nutrients, especially N. Nitrogen is a macronutrient that of its functions as a constituent of chlorophyll. If the leaves lack chlorophyll, it will slow down the growth of the leaves. Based (Nuryanti, 2022) explained that the use of macro N nutrients is to function as a constituent of chlorophyll, besides that macro N nutrients are also needed by plants in large quantities.

(a) (b)

Figure 4. Many leaves of mustard plants (a) highest, (b) lowest

The average number of leaves in V1 has 3.7 strands, which is the lowest growth output of many leaves. The number of leaves was counted, and the results demonstrate that as the plant grows taller, the number of leaves also grows. In accordance with the statement (Marginingsih, 2018), According to the average number of leaves produced by mustard greens in relation to their average height, it can be concluded that the higher the plant, the more leaves that will be produced. The increasing number of leaves will cause a lot of light absorption as well so that the photosynthesis process can take place properly. As the amount of photosynthesis produced increases, the leaf width is greater, and the wet weight is high.

Wet Weight

According to the analysis showed that the AB Mix nutrients and liquid organic fertilizer tea pulp could have an impact on the wet weight of mustard plants. The results of the average wet weight of mustard plants (4 MST- 1 MST) are shown in (Figure 5)

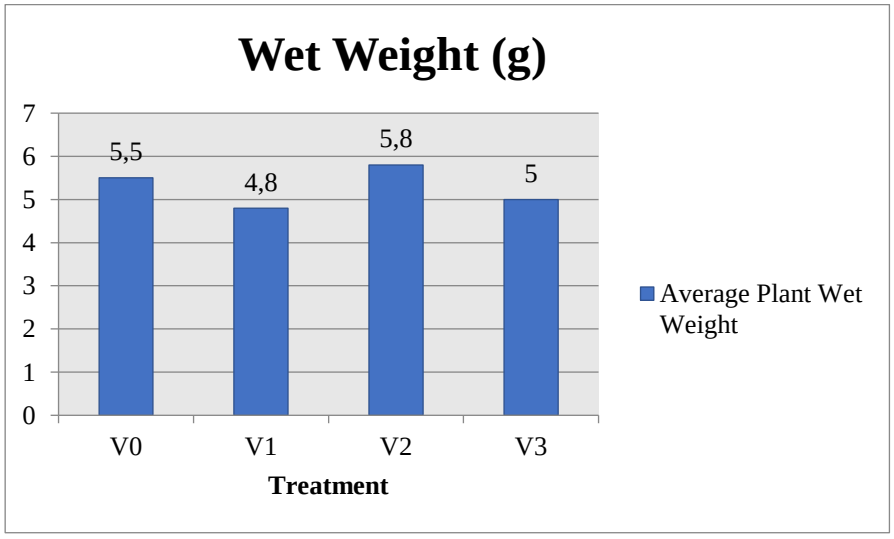


Figure 5. Average Plant Wet Weight (g)

(a) (b)

Figure 6. The wet weight of mustard plants (a) highest, (b) lowest

Wet weight in mustard plants is obtained by weighing mustard plants when the plants are harvested and the roots have been cleaned. Wet weight is used as a clue that characterizes plant growth. Based on Figure 5, the analysis's conclusions of the average number of leaves of mustard plants that have the best average are found in V2, have an average wet weight of plants of 5.8 g. Wet weight in plants can be influenced by the level of effectiveness of plants in absorbing nutrients and water. The number of leaves owned can affect the plant's wet weight, the more the number of leaves, the greater the plant's wet weight. This is in accordance with (Triadiawarman, 2019), the plant's fresh weight will rise in direct proportion to the plant's height and leaf count. In contrast, when a plant's growth is restricted, its fresh weight will be low. In comparison, the lowest plant wet weight is found at V1 because it has an average wet weight of 4.8 g. The variation in mustard plant wet weight in each treatment is caused by the ability of plants to absorb water. If a plant can take water as much as it needs to, its moist weight will rise.

Based on the results of this study, implications can be put forward that can provide information to the community, especially mustard plant cultivators, that AB Mix and tea pulp used as liquid organic fertilizer can be helpful as a combination of nutrients for mustard plants. In addition, it is expected to provide benefits in terms of using cultivation techniques and solution nutrition to increase crop production. In education, this research can be used as input for teachers and prospective teachers as input in the teaching and learning process in grade 12 Biology subjects in Biotechnology.

4. CONCLUSIONS

According to the result and discussion, AB Mix combined with liquid organic fertilizer tea pulp has a significant impact on mustard plant growth in terms of plant height, number of leaves, and wet weight. The V2 treatment uses 10 ml of AB Mix and 40 ml of liquid organic fertilizer, which is the optimum combination of AB Mix and liquid organic fertilizer, while the V1 treatment uses 15 ml of AB Mix and 35 ml of liquid organic fertilizer, which is the lowest combination. The provision of AB Mix nutrition and appropriate liquid organic fertilizer can boost the growth of mustard plants by providing the nutrients that plants need. In this study using liquid organic fertilizer tea pulp, it is necessary to test the content of further fertilizer, including NPK test to see if this fertilizer is by the Indonesian National Standard (SNI).

5. ACKNOWLEDGMENTS

Author respectfully expresses his sincere gratitude to the Biology Education Study Program Universitas Muhammadiyah Surakarta and all parties who have helped in this research.

6. REFERENCES

Abstinence, L. S., &; Ardan, A. S. (2021). *Effectiveness of Household Waste Liquid Organic Fertilizer in Increasing Growth and Production of Tomato Plants (Lycopersicum esculentum Mill .)* . *1*(2), 85–90.

Adikasari, R. 2012. Utilization of Tea Grounds and Coffee Grounds as a Nutrient Enhancer in the Growth of Tomato Plants (*Solanum lycopersicum*) with Hydroponic Media. [Thesis]. Surakarta: University of Muhammadiyah Surakarta.

Alifah, S., Nurfida, A., &; Hermawan, A. (2019). Processing of mustard greens into green noodles that have high economic value in Sukamanis Village, Kadudampit District, Sukabumi Regency. *Journal of Empowerment Community (JEC*), 1(2), 52–58. https://doi.org/10.36423/jec.v1i2.364

Alsyah, Anang Dani; Darmawati, Adriani, and Sumarsono. (2018) . "Growth and production response of Pakchoy (*Brassica chinensis* L.) plants due to the application of various organic waste fertilizers." *Journal of Agro Complex*. 2(1), 59-67.

Fauziah, S., Kameswari, D., &; Setia Asih, D. A. (2022). The Effect of Liquid Organic Fertilizer of Bamboo Shoots on the Growth of Mustard Plants (*Brassica juncea* L.) Hydroponically. *EduBiologia: Biological Science and Education Journal*, *2*(1), 26. https://doi.org/10.30998/edubiologia.v2i1.10424

Gultom, Atri Gustiana. (2013). The effect of tea pulp on the growth and yield of string bean plants (Vigna sinensis L.) . *Unimed biosciences*. 1(2). 43-55.

Hendriyani, I. S., & Setiari, N. (2009). KANDUNGAN KLOROFIL DAN PERTUMBUHAN KACANG PANJANG (Vigna sinensis) PADA TINGKAT PENYEDIAAN AIR YANG BERBEDA. *Artikel Penelitian*, *17*(3), 145–150. http://eprints.undip.ac.id/2335/1/artikel_jsm_nintya.pdf

Hidayanti, L., & Kartika, T. (2019). Pengaruh Nutrisi AB Mix Terhadap Pertumbuhan Tanaman Bayam Merah (Amaranthus tricolor L.) secara Hidroponik. *Sainmatika: Jurnal Ilmiah Matematika Dan Ilmu Pengetahuan Alam*, *16*(2), 166. https://doi.org/10.31851/sainmatika.v16i2.3214

Lestari, S. U., Susi, N., &; Mutryarny, E. (2017). Testing of Local Microorganisms Vegetable Waste on The Growth and Production of Mustard Plants (*Brassica juncea* L). *Agricultural Scientific Journal*, *14*(1), 50–60.

Manullang, I. F., Hasibuan, S., &; CH, R. M. (2019). The effect of different nutrient mix and planting media on the growth and production of lettuce plants (*Lactuca sativa*) hydroponically with the wick system. *BERNAS Agricultural Research Journal*, *15*(1), 82–90.

Marginingsih, R. S., Nugroho, A. S., &; Dzakiy, M. A. (2018). Effect of Substitution of Liquid Organic Fertilizer on AB mix Nutrition on the Growth of Caisim (*Brassica juncea* L.) in the Hydroponic Drip Irrigation System. *Journal of Biology and its Learning*, *5*(1), 44–51.

Munifatul, I. A. Rahmah, & P. Sarjana. (2014). Pengaruh Pupuk Organik Cair Berbahan Dasar Limbah Sawi Putih (*Brassica chinensis* L.) Terhadap Pertumbuhan Tanaman Jagung Manis (*Zea mays* L. Var. Saccharata). *Jurnal Anatomi dan Fisiologi*, 22(1), 65-71.

Nuryanti, Ika; Muslimin2; Yusran; Wahyuni, Goddess. (2022). Effect of various types of organic fertilizers on the growth of sea sengon seedlings (*Paraserianthes falcataria* (L.) Nielsen) on ultisol soil in polybags. J. ForestScience. 19(2):(63 – 71).

Rinaldi, A., Ridwan, &; M.Tang. (2021). Analysis of Bokashi fertilizer content from tea dregs waste and cow dung. *Scientist*, *2*(1), 5–13.

Siregar, M. (2017). The response of AB mix nutrition in hydroponic planting systems to the growth and production of mustard plants (*Brassica juncea*). *Journal of Animal Science and Agronomy Panca Budi*, 2(2), pp. 18-24.

Supardi, A. (2011). Aplikasi Pupuk Cair Hasil Fermentasi Kotoran Padat Kambing Terhadap Pertumbuhan Tanaman Sawi (Brassica Juncea) Sebagai Pengembangan Materi Mata Kuliah Fisiologi Tumbuhan. *Skripsi.* Surakarta : Program Studi Pendidikan Biologi FKIP Universitas Muhammadiyah Surakarta.

Triadiawarman, D., & Rudi, R. (2019). Pengaruh Dosis dan Interval Waktu Pemberian Pupuk Organik Cair Daun Gamal Terhadap Pertumbuhan dan Hasil Tanaman Sawi (Brassica Juncea L.). *Jurnal Pertanian Terpadu*, *7*(2), 166–172. https://doi.org/10.36084/jpt..v7i2.196

Ulfa, M., Pranoto, H., &; Sulylowati. (2021). Growth Response and Yield of Celery Harvest (*Apium graveolens* L.) Against the growing media and different nutrient solution concentrations in the wick system. *46*(2), 232–240.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Effect of Cassava Peel Powder on the Productivity of the Brown Oyster Mushroom (*Pleurotus cystidiosus*)

Emmalia Rahmawati* and Suparti
Biology Education Department, Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Central Java, Indonesia
* Corresponding Author. E -mail address : a420190090@ student.ums.ac.id

KEYWORDS:
Brown Oyster Mushroom
Cassava Peel Powder
Productivity
Sengon Wood Powder

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The oyster mushroom cultivation medium is generally sengon sawdust. As time goes by, there is a buildup of agricultural waste, one of which is cassava skin. Cassava peel contains nutrients that are in accordance with the nutrients needed as a medium for oyster mushroom cultivation. The purpose of this study was to determine the effect of a mixture of sengon sawdust and cassava peels with different weight ratios on the productivity of the brown oyster mushroom (*Pleurotus cytidiosus*). The research design used was a completely randomized design with 7 treatments, including M0, M1, M2, M3, M4, M5, and M6. Then the data were analyzed with One Way Anova using SPSS 20. The results showed that the M2 treatment (90% sengon sawdust + 10% cassava peel powder) had the highest average wet weight, namely 84.9 g, and the fastest *pinhead* appearance time, which was 40.2 days after inoculation. Then in the M5 treatment (75% sengon sawdust + 25% cassava peel powder), the highest average number of fruit caps was 22.8 fruit caps. And the One Way Anova test shows that all three parameters have F count > F table. Thus, there is an effect of adding media mixed with sengon sawdust and cassava peels with different weight ratios on the productivity of brown oyster mushrooms.

1. INTRODUCTION

Mushroom cultivation in Indonesia has been widely developed and has become a lucrative business opportunity for farmers. Some of the advantages of producing mushrooms include being easy to cultivate, not requiring large areas of land, a relatively fast production period, and relatively stable market selling prices (Wahyuningtyas and Damanhuri 2019) . The majority of mushrooms that are widely cultivated by farmers in Indonesia include oyster mushrooms, straw mushrooms, ear mushrooms, and button mushrooms. According to Jakiyah et al. (2017), there are several types of oyster mushrooms, including white oyster mushrooms, brown oyster mushrooms, white oyster mushrooms of the *Gray oster variety* , yellow oyster mushrooms, ash oyster mushrooms, and pink oyster mushrooms.

In the cultivation of oyster mushrooms, farmers generally use the media in the form of sawdust (Tolera and Abera 2017). The types of sawwood commonly used by mushroom farmers are sengon wood, teak wood, mahogany, candlenut wood, and rambutan wood (Nasution 2016) which are then added with bran, lime, and gypsum with a certain composition to support the growth of these mushrooms (Elfandari et al. al. 2021) .

The sawdust that is generally used by mushroom farmers is the sawdust from sengon wood because of its light characteristics, not gummy, and the texture are not too coarse. Suryani & Carolina 's research (2017) also states that sengon sawdust contains high cellulose, low lignin, is not gummy, easily absorbs and stores water, and has a fast drying and composting process. The chemical content in sengon sawdust is 49.40% cellulose, 24.10% hemicellulose, 23.55% lignin,

and 4.67% extractive substances. These ingredients can support the productivity of oyster mushrooms. Cellulose and hemicellulose are substrates that fungi will break down into simpler components so that they are easily absorbed by fungi for growth (Adawiyah et al. 2017) .

As the industry develops, Elfandari et al. (2021) stated that sengon sawdust is increasingly difficult to obtain due to the reduced use of wood, which causes the price of sawdust to increase and results in increased mushroom production costs. Massive logging of forests and the conversion of forests into settlements have also been a factor in the reduced production of wooden crafts in Indonesia. In addition, sengon sawdust is also used for the manufacture of activated charcoal, charcoal briquettes, mixtures for making bricks, and others (Suparti and Marfuah 2015) . Thus, an alternative is needed to overcome this problem by utilizing waste in the form of cassava peels which can be used as a mixture of planting media in producing mushrooms.

Cassava skin waste can be found in *the home industry* for making cassava chips, cassava cheese, cassava tape, and many more. According to the Central Bureau of Statistics, cassava production in Indonesia in 2020 will reach 18.3 million tons. While the percentage of cassava skin is approximately 20% of the tuber. So that in 1 kg of cassava, 0.2 kg of cassava skin is produced, which is simply ignored (Ntelok, 2017) . According to Widyastuti (2019), in one year, the use of cassava reaches 18.9 million tons. This means that the white inner skin or cortex waste can reach 1.5-2.8 million tons while the brown outer skin waste or epidermis reaches 0.04-0.09 million tons. Therefore, the use of cassava peel waste needs to be increased, namely as an addition to the manufacture of oyster mushroom media.

The cellulose content in cassava peel is quite high, which ranges from 80-85% by weight of cassava peel (Santoso et al. 2012) . According to research by Sastri and Putra (2015) also states that cassava peel waste contains 43.63% cellulose, 36.58% starch, 10.38% hemicellulose, 7.65% lignin, and 1.76% other components. So that this cassava peel waste is considered capable of being an alternative in the addition of oyster mushroom growth media in the form of sengon wood powder, which is now increasingly difficult to find.

Based on Pratama's research (2017) which created an innovation in the form of using a mixture of cassava peel and sawdust of sengon wood as an alternative growth medium for white oyster mushrooms, the result is that white oyster mushrooms can grow optimally with a certain composition ratio. The parameters measured were total body weight, number of fruiting bodies, cap diameter, biological efficiency, and harvesting speed. The results of this study stated that white oyster mushrooms can grow optimally at a percentage ratio of 75% sengon wood powder and 25% cassava peel powder. This percentage produces the best white oyster mushroom production among other percentages. In addition, research by Wabali & Favor (2021) also states that mushroom cultivation can be increased by adding agricultural waste such as cassava peels. The addition of 10% cassava peel to the sawdust formulation increased the height, weight, *pileus diameter* and number of mushroom fruiting bodies. Then in this study, using an object in the form of brown oyster mushrooms and combined the two previous studies, which were arranged in a Completely Randomized Design (CRD) with an interval of 5%, including the addition of cassava skin by 5%; 10%; 15%; 20%; 25%; and 30% to determine the best percentage of addition of cassava skin to the productivity of brown oyster mushrooms.

In this study, the brown oyster mushroom is interesting for further research because it has various advantages compared to other types of oyster mushrooms. The brown oyster mushroom has a longer shelf life, a thick or chewy body texture, and a low water content, so it doesn't wilt easily after being harvested (Okere et al. 2021). The selling price at the farm level of brown oyster mushrooms is relatively more expensive than white oyster mushrooms (Ramadhan 2019). And

according to Seswati et al. (2013), brown oyster mushrooms have a better taste than other types of oyster mushrooms. The results of this study, it is expected to be able to determine the effect of using a mixture of sengon sawdust and cassava peel media with different weight ratios on brown oyster mushrooms. In order to reduce the production of cassava skin waste in Indonesia.

2. MATERIALS AND METHODS

2.1 Place and time of research

research was conducted at the Mushroom Cultivation Laboratory for Biology Education FKIP Muhammadiyah University Surakarta from December 2022 to May 2023.

2.2 Tools and materials

The tools used include press machines, matches, tarpaulins, spirit burners, storage racks / lemurs, spatulas, digital scales, soil testers, Thermo hygrometers, sterilization cabinets, shovels, hoses, calculators, cameras, and stationery. As well as the materials used include sawdust of sengon wood, cassava peel powder, lime, 70% alcohol, water, polypropylene (PP) plastic measuring 30 cm x 18 cm, baglog rings, rubber bands, F2 white oyster mushroom seeds, F2 mushroom seeds, chocolate oyster.

2.3 Research methods

This study used a one-factor, Completely Randomized Design (CRD) method where the difference in the composition of the cassava peel mixed media was the main factor. The repetition treatment was carried out 3 times in 2 harvest periods. Observations were analyzed using descriptive quantitative data analysis. The parameters studied were the wet weight of the mushrooms, the number of mushroom caps, and the time of appearance of the first *pinhead* .

2.4 Experimental design

The experimental design of this study can be seen in Table 1.

Table 1. Experimental design

Test	M0	M1	M2	M3	M4	M5	M6
1	$M0_1$	$M1_1$	$M2_1$	$M3_1$	$M4_1$	$M5_1$	$M6_1$
2	$M0_2$	$M1_2$	$M2_2$	$M3_2$	$M4_2$	$M5_2$	$M6_2$
3	$M0_3$	$M1_3$	$M2_3$	$M3_3$	$M4_3$	$M5_3$	$M6_3$

Information:

M0 : Brown oyster mushroom with 100% sengon sawdust media
M1 : Brown oyster mushroom mixed with 95% sengon powder and 5% cassava peel
M2 : Brown oyster mushroom mixed with 90% sengon powder and 10% cassava peel
M3 Brown oyster mushroom mixed with 85% sengon powder and 15% cassava peel
M4 : Brown oyster mushroom mixed with 80% sengon powder and 20% cassava peel
M5 : Brown oyster mushroom mixed with 75% sengon powder and 25% cassava peel
M6 : Brown oyster mushroom mixed with 70% sengon powder and 30% cassava peel

2.5 Data collection technique

Data collection techniques used included measuring the wet weight of the mushrooms using digital scales, counting the number of oyster mushroom caps, and calculating the time the pinhead first appeared after inoculation. Then the data were analyzed with One Way Anova using SPSS 20 to determine the effect of the F test treatment at a significance level of 5% (0.05). The results of the observations were then analyzed using descriptive quantitative data analysis .

2.6 Stages of Research Implementation

In the preparatory stage, starting to carry out permits at the Mushroom Cultivation Laboratory for Biology Education, FKIP, Muhammadiyah University, Surakarta, then preparing tools and materials as well as lemur mushrooms to be used in the process of growing oyster mushroom media.

The stage of making the media begins with sorting and washing the cassava skins, then soaking them for 5 minutes to remove any dirt that sticks to the cassava skins. Then, dry the cassava skin for 4 days until completely dry. After drying, the cassava skin is mashed using a grinding machine so that the cassava skin becomes powder which can be mixed with sengon wood powder.

The next step is to compost the sengon sawdust media, which has been given additional ingredients such as lime, rice bran, and water overnight. After composting, mix the media with cassava peel powder according to a predetermined concentration. Then pack the media into *polypropylene plastic* and compact it using a press machine. Then attach the *baglog ring* and close it with the *baglog ring cover* .

The next stage is sterilization by placing and arranging *baglogs* into the sterilization cupboard. The working principle of sterilization is to utilize the heat of water vapor up to 100 ° C for 6-8 hours. This sterilization aims to suppress the growth of other microbes that can inhibit the growth of oyster mushrooms.

Inoculation is done by inserting the brown oyster mushroom F2 seeds into *the baglog* . Inoculation is done by opening the *baglog ring cover, unraveling the seeds, then inserting and spreading the seeds* evenly on the top of *the baglog* . Then close *the baglog* again. After that, arrange the baglog in an incubation room with minimal light. Aim for the mycelium to quickly spread.

Oyster mushroom maintenance after the incubation period until harvest is placed in the kampung. At this maintenance stage, the room temperature is always checked from 10 ° -27 ° C. If the temperature is lower or more, then the mushrooms will not grow optimally. Then, harvesting is done when *the pinheads*, mushroom stalks, and mushroom bodies begin to appear, with the cap widening in the shape of an umbrella.

3. RESULT AND DISCUSSION

3.1. Research result

The research began in December 2022, starting with the manufacture of cassava peel powder media, making brown oyster mushroom baglogs, and treating the kumbung until May 2023. Observations made included calculating the wet weight of the mushrooms, the number of mushroom caps, and the time the first pinheads appeared. The research results are presented in the form of tables and graphs as follows.

Table 2. Average Productivity of Brown Oyster Mushroom

Treatment	Wet Weight (g)		Average Wet Weight (g)	Number of Hoods (hood)		Average Number of Hoods (hood)	Emerging Pinheads (HSI)		Pinhead Appearance Rate (HSI)
Harvest	1	2		1	2		1	2	
M0	86.6	45.0	65.8	2.6	5.0	3.8*	40.0	79.0	59.5
M1	87.0	51.3	69.2	12.0	7.6	9.8	43.0	76.0	59.5
M2	101.6	68.3	84.9**	8.6	5.3	6.9	36.0	44.3	40.2**
M3	87.0	55.3	71.2	11.0	5.6	8.3	66.3	79.0	72.6*
M4	70.0	64.3	67.2	12.3	10.0	11.2	66.6	78.3	72.5
M5	72.5	58.5	65.5	31.0	14.5	22.8**	44.0	64.5	54.3
M6	62.5	65.5	64.0*	8.0	7.5	7.8	51.0	76.5	63.8

Description: (**) Best, (*) Worst

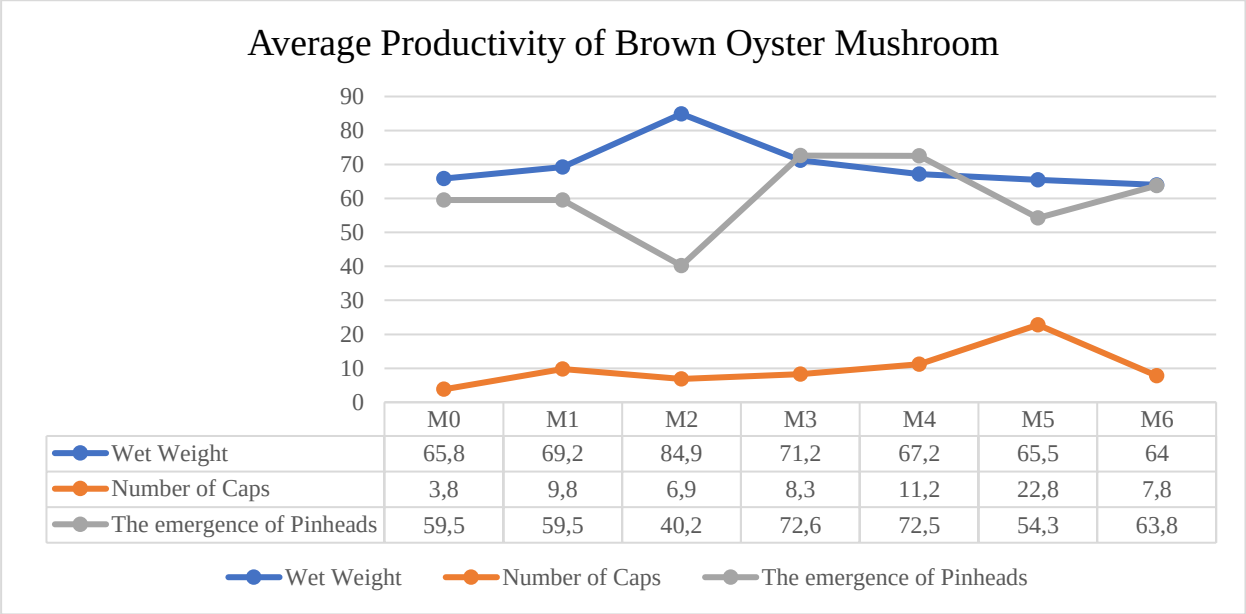


Figure 1. Brown Oyster Mushroom Productivity Graph

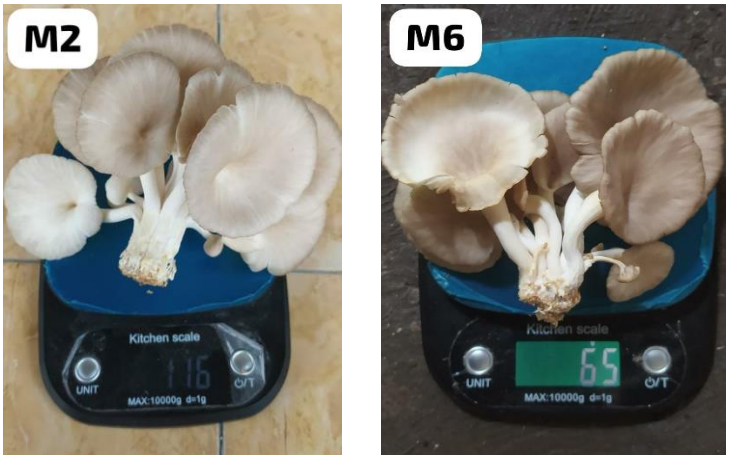
Table 3. F test results with SPSS 20

Parameter	F	Sig.	Information
Mushroom Wet Weight	2.553	.037	H_0 is rejected
Number of Mushroom Caps	2.591	.035	H_0 is rejected
The emergence of Pinheads	3.224	.013	H_0 is rejected

3.2. Discussion

The wet weight of the brown oyster mushroom in the M2 treatment (90% sengon sawdust + 10% cassava peel) was superior, with an average weight of 84.9 g compared to the other treatments, and the M6 treatment (70% sengon sawdust + 30% cassava peel) obtained the lowest wet weight with an average weight of 64.0 g. Adawiyah et al (2017) stated that the productivity of the total fresh weight of the fruit bodies of oyster mushrooms decreased because there were not many fruiting bodies that grew, and the ideal conditions needed by the mushrooms were not met. The ideal conditions are influenced by temperature and humidity. The range of temperature and humidity in week 1 to week 6 is 27.5 ° C - 29.6 ° C with humidity 84%-86%. While the 7th to 11th

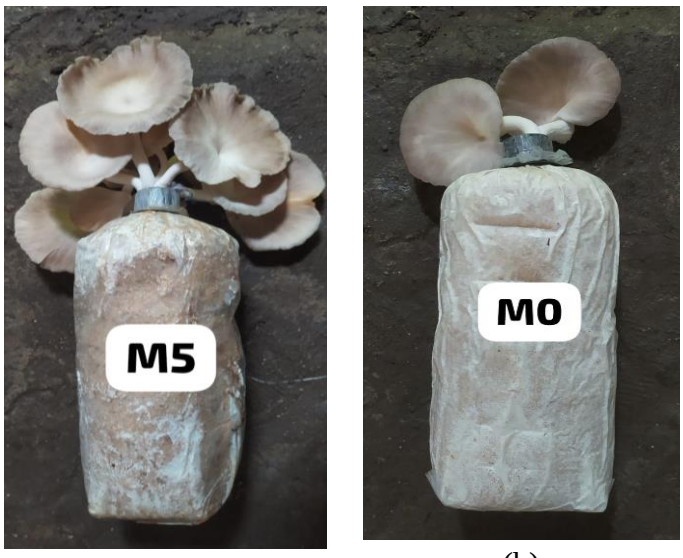
week is 32.9 ° C - 34.2 ° C with 69% -76% humidity. This temperature causes the formation of fruit bodies to be not optimal. In the formation of fruiting bodies, oyster mushrooms require lower temperatures, ranging from 22-28°C. This causes the wet weight of the brown oyster mushroom harvested in the first week to be superior to that of the mushrooms harvested in the last week. The pH level also affects the acidity of the media because fungi can only grow in places with an acidity level close to neutral (Erlinda et al. 2022). The pH level from week 1 to week 11 was relatively the same, ranging from 6-7. Then the One Way Anova analysis test was carried out with SPSS 20, showing that F count > F table, namely 2,553 > 2,372, so there was an effect of adding cassava peel powder with a different composition on the productivity of the brown oyster mushroom, namely on the wet weight parameter of the mushroom.



(a) (b)

Figure 2. Comparison of Highest (a) and Lowest (b) Wet Weight of Brown Oyster Mushroom

The number of mushroom caps in the M5 treatment (75% sengon sawdust + 25% cassava peel) was superior to the other treatments, with an average number of caps in one *baglog* of 22.8 caps. While the M0 treatment (100% sengon sawdust) with an average number of caps was 3.8 caps. According to research by Istiqomah & Fatimah (2014), The fruit bodies that are formed usually depend on the number of growing primordia. If there are many primordia, the number of fruiting bodies formed will also be large because the nutrients contained in the planting medium are spread over each primordia that forms. With a small number of caps, the growth of the caps can grow optimally and not crowd each other, while in the large number of caps, the growth of the caps will jostle each other, causing the mushroom caps to grow less than optimally. In addition, at a small number of caps, the distribution of food will be optimal because the nutrients in the growing media can be maximally absorbed by the mushrooms, but for a large number of caps, the nutrients in the growing media are not evenly distributed because there is competition between the mushroom caps in absorbing nutrients (Apriyani et al(Apriyani et al. 2020). Thus, the number of caps will affect the wet weight produced by the oyster mushrooms because the nutrients are distributed differently between the large and small number of caps in one *baglog* . Then the One Way Anova analysis test was carried out with SPSS 20, showing that F count > F table, namely 2,951 > 2,372, so there was an effect of adding cassava peel powder with a different composition on the productivity of the brown oyster mushroom, namely on the parameter number of mushroom caps.



(a) (b)

Figure 3. Comparison of the Highest (a) and the Lowest (b) Numbers of Brown Oyster Mushroom Caps

The first *pinhead* to appear in the M2 treatment (90% sengon sawdust + 10% cassava peel) was faster than the other treatments, with an average *pinhead appearance* of 40.2 days after inoculation. Whereas the M3 treatment (85% sengon sawdust + 15% cassava peel) had the longest *pinhead* appearance time of 72.6 days after inoculation. *Pinhead* emergence time is influenced by the growth rate of the mycelium. If the mycelium spreads quickly, the formation of fruiting bodies will also be faster (Elfandari et al. 2021). And Agustine et al. (2017) states that the speed of mycelium growth is influenced by environmental factors such as the condition of the kumbung. Kumbung humidity in week 1 to week 6 is 84% -86%. While the 7th to 11th week is 69% -76%. This condition causes the humidity of the kumbung to decrease from the 7th to the 11th week. The lower the humidity of the kumbung will affect the decrease in the biological efficiency of the oyster mushroom. Kumbung humidity affects the humidity in the media. Kumbung humidity that is too low during the mushroom growth period can cause primordia to dry and not develop (Erlinda et al. 2022). So to get the ideal temperature and humidity, watering is always done regularly. Then the One Way Anova analysis test was carried out with SPSS 20, showing that F count > F table, namely 3,224 > 2,372, so there was an effect of adding cassava peel powder with a different composition on the productivity of the brown oyster mushroom, namely on the parameter when the first pinhead appeared .

Based on the data that has been obtained and the analysis that has been carried out, these three parameters indicate the effect of adding cassava peel powder with different compositions on the productivity of brown oyster mushrooms. It can be seen that the M2 treatment (90% sengon wood powder + 10% cassava peel powder) is treatment with the best results on both parameters, namely the wet weight of the fungus and the time of appearance of the first *pinhead* . This is in line with Wabali & Favor's research (2021), which created an alternative in the form of adding cassava peel powder to white oyster mushroom growing media with 8 different treatments. Optimal results were obtained by adding 10% cassava peel powder. According to him, sawdust supplementation with agricultural waste can improve several growth parameters. And the M5 treatment (75% sengon wood powder + 25% cassava peel powder) produced the highest number of fruit caps compared to other treatments. This is in line with Pratama's research (2017) using 4 types of treatment that the growing media for white oyster mushrooms mixed with 25% cassava

peel powder can increase the productivity of white oyster mushrooms. Then the two studies were applied to varieties of brown oyster mushrooms, and the results showed the effect of adding cassava peel powder on the productivity of brown oyster mushrooms.

Nutrition for oyster mushroom growth in the form of cellulose is the largest substrate needed as a carbon source to obtain growth energy in the formation of mushroom fruiting bodies which are found in sengon wood sawdust and cassava peel powder (Erlinda et al., 2022 (Erlinda et al. 2022). The two substrates used in this study had a fairly high amount of cellulose, sawdust of sengon wood containing 49.40% cellulose, and the cellulose content of cassava peel was 43.63%. It is proven by the three parameters that have been tested, showing the effect of increasing in terms of the wet weight of the mushroom, number of mushroom caps, and the time of appearance of the first pinhead.

4. CONCLUSIONS

Based on the research that has been done, it can be concluded that the addition of cassava peel powder mixed with sengon wood powder has an effect on the productivity of the brown oyster mushroom. Brown oyster mushrooms with M2 treatment, i.e., variations in the composition of the planting medium 90% sengon sawdust and 10% cassava peel powder, obtained the best results on both parameters. On the wet weight parameter, the mushrooms obtained the best results, with an average wet weight of 84.9 g. Then on the parameter of the appearance of the first *pinhead, the pinhead* managed to appear the fastest with an average of 40.2 days after inoculation. On the parameter number of mushroom caps with M5 treatment, namely variations in the composition of the planting medium, 75% sengon sawdust and 25% cassava peel powder obtained the best results with an average number of fruit caps of 22.8 caps. Based on the One Way Anova analysis test, the three parameters have F count > F table. So that in this study, there was an effect of adding cassava peel powder on the productivity of brown oyster mushrooms.

Then the limitation in the research is the length of time for drying cassava peels which reaches 3 months, because at that time it has entered the rainy season. In addition, the limitations of tools to grind cassava skin into powder are also obstacles in this study.

5. REFERENCES

Adawiyah, R., Hidayat, N., and Rahmah, N. L. 2017. Penambahan Ampas Tebu dan Jerami Padi pada Medium Tanam Serbuk Gergaji Kayu Sengon (Albizia chinensis) terhadap Pertumbuhan dan Produktivitas Jamur Tiram Putih (Pleurotus ostreatus). *Industria: Jurnal Teknologi dan Manajemen Agroindustri* 6(3): 159–166. doi: 10.21776/ub.industria.2017.006.03.7

Agustine, M., Tambaru, E., and Abdullah, A. 2017. Efektifitas Media Tanam Sabut Kelapa terhadap Pertumbuhan dan Produktivitas Jamur Tiram Pleurotus sp. *Jurnal Biologi Makassar* 2(2): 19–27.

Apriyani, S., Budiyanto, and Bustamam, H. 2020. Produksi dan Karakteristik Jamur Tiram Putih (Pleurotus ostreatus) pada Media Tandan Kosong Kelapa Sawit (TKKS). *Jurnal Agroekoteknologi* 1(1): 1–9.

Elfandari, H., Yusanto, and Septiana. 2021. Pertumbuhan dan Produktivitas Jamur Tiram Putih (Pleurotus ostreatus) pada Komposisi Media Tanam Sengon dan Jerami. *Jurnal Agrotektropika* 9(2): 301–305. doi: 10.23960/jat.v9i2.4915

Erlinda, C., Prasetyaningsih, A., and Madyaningran, K. 2022. Pengaruh Pengomposan Ampas Tebu sebagai Media Alternatif dan Pengaruhnya terhadap Produktivitas Jamur Tiram Putih (Pleurotus ostreatus). *Lentera Bio* 11(1): 161–173.

Istiqomah, N., and Fatimah, S. 2014. Pertumbuhan dan Hasil Jamur Tiram pada Berbagai Komposisi Media Tanam. *Ziraa'ah* 39(3): 95–99.

Jakiyah, E., Hasanah, H. U., and Sari, D. N. R. 2017. Persilangan Jamur Tiram Coklat (Pleurotus. cytidiosus) dengan Jamur Tiram Putih (Pleurotus. ostreatus) Varietas Grey oyster Menggunakan Metode Fusi Miselium Monokarion. *Bioma* 6(2): 11–19.

Nasution, J. 2016. Kandungan Karbohidrat dan Protein Jamur Tiram Putih (Pleurotus ostreatus) pada Media Tanam Serbuk Kayu Kemiri (Aleurites moluccana) dan Serbuk Kayu Campuran. *Jurnal Eksakta* 1: 38–41.

Ntelok, Z. R. E. 2017. Limbah Kulit Singkong (Manihot esculenta L.): Alternatif Olahan Makanan Sehat. *Jurnal Inovasi Pendidikan Dasar* 1(1): 115–121.

Okere, S. E., Ibeanu, C. A., Ojiako, F. O., Nwokeji, E. M., and Emma-Okafor, L. C. 2021. Bioconversion and Yield Evaluation of an Edible Mushroom (Pleurotus ostreatus) Cultivated on Cassava and Sugarcane Peels with Wheat Bran. *Mycopath* 19(1): 7–13.

Pratama, S. 2017. Pengaruh Penambahan Kulit Singkong pada Media Tumbuh terhadap Produksi dan Kandungan Gizi Jamur Tiram Putih (Pleurotus ostreatus) serta Pemanfaatan sebagai Buku Nonteks. *Skripsi*. Universitas Jember.

Ramadhan, M. F. 2019. Tiram Cokelat Anyar. *Trubus Online* <https://www.trubus-online.co.id/tiram-cokelat-anyar/> (Oct. 29, 2022).

Santoso, S. P., Sanjaya, N., Ayucitra, A., and Antaresti. 2012. Pemanfaatan Kulit Singkong sebagai Bahan Baku Pembuatan Natrium Karboksimetil Selulosa. *Jurnal Teknik Kimia Indonesia* 11(3): 124–131.

Sastri, I. G. A. A. D. A. D., and Putra, G. P. G. 2015. Optimasi Konsentrasi Substrat Kulit Singkong (Manihot esculenta crantz.) dan Lama Fermentasi terhadap Aktivitas Filter Paperase dari Kapang Trichoderma viride FNCC 6013. *Jurnal Rekayasa dan Manajemen Agroindusri* 3(1): 31–38.

Seswati, R., Nurmiati, and Periadnadi. 2013. Pengaruh Pengaturan Keasaman Media Serbuk Gergaji terhadap Pertumbuhan dan Produksi Jamur Tiram Cokelat (Pleurotus cystidiosus O.K. Miller.). *Jurnal Biologi Universitas Andalas* 2(1): 31–36.

Suparti, and Marfuah, L. 2015. Produktivitas Jamur Tiram Putih (Pleurotus ostreatus) pada Media Limbah Sekam Padi dan Daun Pisang Kering sebagai Media Alternatif. *Jurnal Bioeksperimen* 1(2): 37–44.

Suryani, T., and Carolina, H. 2017. Pertumbuhan Dan Hasil Jamur Tiram Putih Pada Beberapa Bahan Media Pembibitan. *Jurnal Bioeksperimen* 3(1): 73–86.

Tolera, K., and Abera, S. 2017. Nutritional Quality of Oyster Mushroom (Pleurotus ostreatus) as Affected by Osmotic Pretreatments and Drying Methods. *Food Science & Nutrition published by Wiley Periodicals* 1(5): 989–996.

Wabali, V. C., and Favour, O. 2021. Performance of Different Substrates on Growth Parameters of (Pleurotus ostreatus) Mushroom. *European Journal of Agriculture and Food Sciences* 3(2): 56–59. doi: 10.24018/ejfood.2021.3.2.265

Wahyuningtyas, E. A., and Damanhuri. 2019. Karakterisasi dan Identifikasi Keragaman Jamur Tiram di Kabupaten Malang, Jawa Timur. *Jurnal Produksi Tanaman* 7(10): 1835–1843.

Widyastuti, P. 2019. Pengolahan Limbah Kulit Singkong sebagai Bahan Bakar Bioetanol melalui Proses Fermentasi. *Jurnal Kompetensi Teknik* 11(1): 41–46.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Analysis of Misconceptions on Reproductive System Material in Class XI IPS 2 Students of SMA Negeri 6 Madiun

Jevi Milda Rahmawati[1*], Ima Agung Nurcahyo [2], Cicilia Novi Primiani [3]
[1]Teacher Professional Education Department, Faculty of Teacher Training and Education, Universitas PGRI Madiun. Jl. Setiabudi No. 85, Madiun 63118, Jawa Timur, Indonesia
[2]SMA Negeri 6 Madiun. Jl. Suhud Nosingo No. 1 Madiun 63132, Jawa Timur, Indonesia
[3]Teacher Professional Education Department, Faculty of Teacher Training and Education, Universitas PGRI Madiun. Jl. Setiabudi No. 85, Madiun 63118, Jawa Timur, Indonesia
[*]Corresponding Author. E-mail address: primiani@unipma.ac.id

KEYWORDS:
Biology,
Misconception,
Reproductive System

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Conceptual understanding forms the basis of an important component in mastering higher-order thinking skills. This ideal condition is not in accordance with the fact that there are still many students who experience misconceptions. This study aims to determine the level of misconceptions that occur in students of class XI IPS 2 SMA Negeri 6 Madiun. The research method used in this study is descriptive-quantitative with survey techniques. The sample used was 34 students. The results of this study were that 64.7% of students did not understand the process of birth or gestation, 61.8% did not understand the stages of embryo development, 58.8% did not understand the stages of the ovarian cycle, 67.6% experienced misconceptions about the types of material contraception, 52.9% had misconceptions about reproductive system disorders sub-material, 48.5% had misconceptions about oogenesis stages sub-material, 41.2% understood reproductive system disorders sub-material, 38.2% understood spermatogenesis stages sub-material (38.2%), and 38.2% understood the benefits of breastfeeding for mothers and babies.

1. INTRODUCTION

Cross-interest subjects are included in the 2013 curriculum. Students from the Natural Sciences, Social Sciences, and Languages groups can take other subjects from other disciplines in which they are interested (Permendikbud 2018). The selection of free cross-interest subjects is determined by each student (Herpanda and Nirwana 2022; Kementerian Pendidikan dan Kebudayaan 2018), but in order to be more focused and useful for career development, the determination of cross-interest subjects is usually assisted by a counseling teacher (Herpanda and Nirwana 2022).

Biology is a cross-interest subject for groups of students specializing in social sciences at SMA Negeri 6 Madiun. The determination of cross-interest subjects is based on the results of counseling on students conducted by guidance counselors (results of interviews with biology teachers at SMA Negeri 6 Madiun). The application of cross-interest learning has a good purpose, namely to develop the interests and talents of students outside the main specialization (Permendikbud 2014).

Biology, which is the chosen subject across the interests of the IPS specialization program, is a branch of knowledge required in several professional work fields. Mastery of biology will direct students to understand environmental conditions, increase awareness of various health issues (Baram-Tsabari et al. 2010; Chavan and Patankar 2018), and train other scientific skills (Chavan and Patankar 2018). Some people think biology is a branch of science that is easy to learn, but the fact is that it is not so. Biology contains a lot of material that is abstract and invisible to the eye,

contains many foreign terms, and is related to material from other branches of science (Çimer 2012).

The reproductive system is a sub-material contained in biology material for class XI in the 2013 curriculum, which is contained in Basic Competency (KD) 3.12, 4.12, 3.13, and 3.13 (Kemdikbud 2018). Based on these regulations, it is known that the achievements that must be mastered by students are that they must be able to analyze the structure of the reproductive organ network with their functions, analyze the application of the reproductive system in humans, analyze exclusive breastfeeding programs, and analyze family planning (KB) programs. The results of being able to analyze are categorized as high-order thinking skills (Yani, A. & Mulyadi 2022). These skills can be mastered when students have a good understanding of concepts (Cindiati 2021). However, the fact is that many students have poor understanding of concepts, or what are called misconceptions.

A misconception is a condition of understanding an individual that is not in accordance with generally accepted scientific agreements (Galvin and Mooney Simmie 2015). Several studies have shown that misconceptions occur in many biological materials, such as cell biology material (Suwono et al. 2021), the reproductive system (Ardiyanti and Rahmawati Utami 2018; Hasyim et al. 2018), archaebacteria and eubacteria (Kurniasih and Haka 2017), genetics (Wulandari et al. 2021), as well as viruses and bacteria (Zulfia et al. 2019). Misconceptions have a negative impact on the learning process, mainly hindering understanding of related material (Nakhleh 1992).

Understanding concepts or material has an important role in determining student learning outcomes. Based on previous research, it is known that understanding concepts has a significant influence on student learning outcomes (Nastiti & Syaifudin, 2020). This statement also applies within the scope of biology, which contains facts, concepts, principles, attributes, and theories that are interrelated with one another. If the wrong concept occurs within the scope of biology, it will affect student learning outcomes (Chavan & Patankar, 2018).

Misconceptions can be detected in various ways, namely using two-tier instruments (Ardiyanti and Rahmawati Utami 2018; Kurniasih and Haka 2017), three-tier instruments (Hasyim, 2018; Zulfia, 2019), and four-tier instruments (Wulandari et al. 2021). Misconception analysis using two tiers is the simplest and easiest to use (Kurniasih and Haka 2017). The addition of a second level (tier) will make students more careful in choosing their answers (Yusrizal and Halim 2017) and stimulate them to think at a higher level (Maulita et al. 2019). Misconception research needs to be done because it can be used to understand misunderstood concepts and explore problems. The results of this study can be used as a basis for determining appropriate improvement strategies going forward (Andariana et al. 2020; Chavan & Patankar 2018; Desstya et al. 2019).

Based on the background above, this study aims to analyze the level of misconceptions among students in class XI IPS 2 at SMA Negeri 6 Madiun. The instrument used in this study consisted of two tiers of reproductive system material. It is hoped that the results of this study can be used as a reference for teachers to determine the right steps to overcome these misconceptions.

2. MATERIALS AND METHODS

2.1. Research Design

The type of research used is descriptive quantitative with survey techniques. The purpose of this study is to provide information about the level of misconceptions that occur in a group. Group determination was carried out using a purposive sampling technique. The selected group then took a multiple-choice test regarding the reproductive system. The results of the test work were analyzed by grouping them according to the category of misconceptions that can be seen in Table 1. Then the grouping results were analyzed for percentages to find out the number of students who had misconceptions about the reproductive system material.

2.1.1. Population & Samples

The population used in this study was 100 students in class XI Social Studies, SMA Negeri 6 Madiun. The sample used in this study was 34 students in class XI IPS 2. The sample selection

technique used is simple random sampling. This technique was chosen because the third class has relatively the same cognitive value, so random sample selection can still represent the entire population.

2.1.2. Instruments

The instrument used in this study was 15 two-tier multiple-choice questions. The questions contained reproductive system material that had been internally validated (construction validation) by material experts. Construction validation results must be 100% so that they can be used. Furthermore, the questions were tested on 69 class XI MIPA students who had studied reproductive system material. The trial was used as external validation. The trial results were analyzed using ANATES. The results of the analysis show that the overall correlation value of XY items is 0.78 and the reliability value is 0.88. Of the 15 questions, there were four that were omitted because the results of the item analysis were not significant. The omitted questions are questions numbers 1, 3, 9, and 15.

2.1.3. Procedures

The stages carried out in this study were: 1) the preparatory stage, including determining the sample, developing questions, conducting construct validation, and external validation; 2) The implementation stage is giving questions that have been tested for construct validation and external validation to students in class XI IPS 2 on April 3, 2023; 3) The analysis stage is to analyze the data on the results of students' answers using Microsoft Excel to find out the level of misconceptions. The following is an example of questions tested on students to analyze the level of misconceptions that can be seen in Table 1.

Tabel 1. Examples of questions tested for students

No	Indicators of Competence Achievement	Question	Cognitive Level
1	Analyze the stages of oogenesis	*Tier 1*: Five Class XI students had a discussion about the process of oogenesis. They have different opinions: • Sandy: Oogenesis produces 1 ovum cell and 2 polar bodies • Rina: The process of oogenesis goes through the stages of mitosis and amitosis; • Rafi: The process of oogenesis goes through the stages of mitosis and meiosis; • Vinka: The process of oogenesis produces primary oocyte cells through meiotic division • Mifta: The process of oogenesis produces secondary oocyte cells through mitotic division The following is the most appropriate statement made by….. a. Sandy b. Rina c. Rafi d. Vinka e. Mifta **Key answer: c** *Tier 2*: The reason you chose the answer above is….. a. Oogenesis occurs through mitotic division, which produces primary oocytes, and meiotic division, which produces 1 ovum cell and 3 polar bodies	C4

	b. Oogenesis occurs through mitotic division, which produces secondary oocytes, and meiotic division, which produces 1 ovum cell and 3 polar bodies c. Oogenesis occurs through mitotic division, which produces primary oocytes, and meiotic division, which produces four ootid cells d. Oogenesis occurs through mitotic division to produce secondary oocytes and meiotic division to produce 4 ootid cells e. Oogenesis occurs through mitotic division, which produces secondary oocytes, and meiosis 1 division, which produces 1 ovum cell and 3 polar bodies. **Key answer: c**	
2	*Tier 1*: Analyze the following statements and reasons: Oogenesis will stop after approximately 500 cycles **Because** The ovaries lose their response to the hormones FSH and LH, which have implications for low production of the hormone estrogen a. Statement is correct, reason is correct, and related; b. Statement is correct, reason is correct, and unrelated; c. Statement is correct, reason is wrong; d. Statement is wrong, reason is right; e. Wrong statement, wrong reason **Key answer: a** *Tier 2*: The following statements are true and related to the above problems, namely: a. The oogenesis stage begins after entering puberty; b. The oogenesis stage completes its mitotic stage shortly after birth; c. The oogenesis stage stops its mitotic stage before the birth process; d. The oogenesis stage completes its meiosis stage before the birth process; e. The oogenesis stage completes its meiosis stage shortly after birth **Key answer: c**	C4

2.1.4. Data Analysis

The results of the students' answers were analyzed and categorized based on the pattern of the answers to determine the level of misconceptions. Misconception categories are in Table 2.

Tabel 2. Misconception Determination Category

No	Student Answer Patterns	Category
1	B – B (The first-tier answers are correct, and the second-tier answers are correct)	Understand
2	B – S (The first-tier answers are correct, and the second-tier answers are false)	Misconception
3	S – B (The first-tier answers are false, and the second-tier answers are correct)	Misconception
4	S – S (The first-tier answers are false, and the second-tier answers are false)	Not Understand

Source: (Stephanie, 2019)

3. RESULTS AND DISCUSSION

3.1.Result

This research uses 11 two-tier questions that have been tested for validity and reliability. These questions include indicators analyzing the stages of spermatogenesis, analyzing the stages of oogenesis, analyzing the ovarian cycle, analyzing the process of pregnancy, analyzing the process of birth or gestation, analyzing the benefits of breastfeeding for mother and baby, analyzing types of reproductive system disorders, and analyzing types of contraceptives. The following is the result of the analysis of determining the category of misconceptions for each item of question, which can be seen in Table 3.

Tabel 3. Misconception Determination Analysis

Question Number	**Misconception Determination Category Analysis**	**Amount**	**Percentage**
1	Not Understand	19	55,8%
	Misconception	14	41,2%
	Understand	1	3%
2	Not Understand	12	35,3%
	Misconception	17	50%
	Understand	5	14,7%
3	Not Understand	20	58,8%
	Misconception	11	32,4%
	Understand	3	8,8%
4	Not Understand	21	61,8%
	Misconception	7	20,6%
	Understand	6	17,6%
5	Not Understand	22	64,7%
	Misconception	9	26,5%
	Understand	3	8,8%
6	Not Understand	9	26,5%
	Misconception	12	35,3%
	Understand	13	38,2%
7	Not Understand	9	26,5%
	Misconception	23	67,6%
	Understand	2	5,9%
8	Not Understand	6	17,6%
	Misconception	15	44,1%
	Understand	13	38,2%
9	Not Understand	12	35,3%
	Misconception	18	53%
	Understand	4	11,7%
10	Not Understand	12	35,3%
	Misconception	19	55,9%
	Understand	3	8,8%
11	Not Understand	7	20,6%
	Misconception	16	47,1%
	Understand	11	32,4%

The questions given to students in class XI IPS 2 consisted of 9 indicators, namely: 1) analyzing the stages of oogenesis (numbers 2 and 11), 2) analyzing the stages of spermatogenesis (number 8), 3) analyzing the ovarian cycle (number 3), 4) analyzing the process of pregnancy (numbers 1 and 9), 5) analyzing the stages of embryo development (number 4), 6) analyzing the process of birth or gestation (number 5), 7) analyzing the benefits of breastfeeding for mother and baby

(number 6), 8) analyzing reproductive system disorders (number 10), 9) analyzing types of contraceptives (number 7). The following is a graph of the analysis of the categories of student answers for each indicator, which can be seen in graph 1.

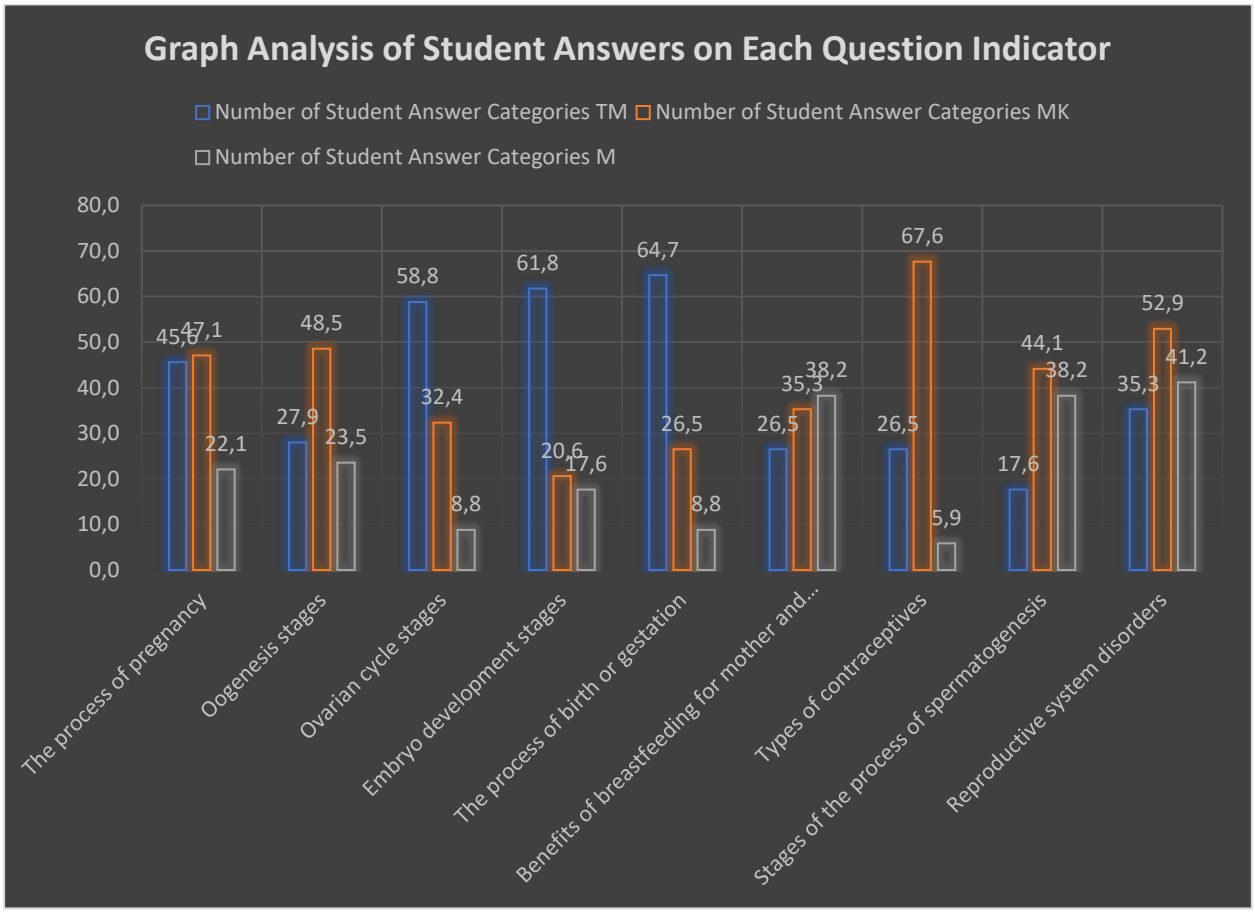
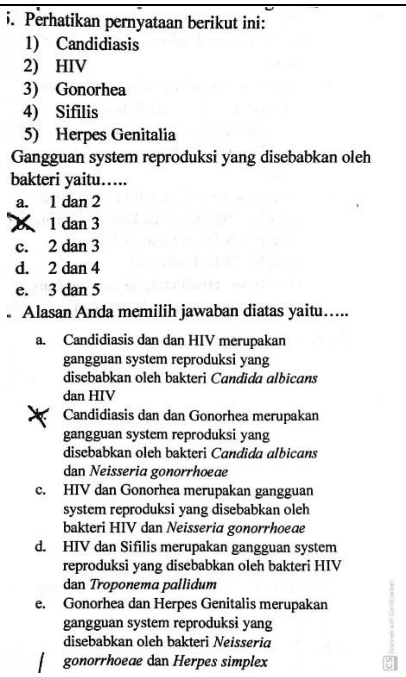


Fig. 1. Analysis of Student Answers on Each Question Indicator

From the graph above, it can be seen that there are three categories of student answers: not understanding (TM), misconceptions (MK), and understanding (M). The three concepts that students least understood were the process of birth or gestation (64.7%), the stages of embryonic development (61.8%), and the stages of the ovarian cycle (58.8%). The highest level of misconception occurred in the concept of types of contraception, namely 67.6%; reproductive system disorders, namely 52.9%; and the stages of oogenesis, namely 48.5%. The concepts that have the highest understanding are reproductive system disorders (41.2%), stages of spermatogenesis (38.2%), and the benefits of breastfeeding for mothers and babies (38.2%).

The definition of the misconception category is when students answer correctly (B) in the first tier and answer wrongly in the second tier, and vice versa. The first-tier questions relate to the second tier. If students can answer correctly on one of the tiers, then the answer is a guess, so it is categorized as a misconception. The following is an example of student answers, as seen in Table 4.

Tabel 4. Examples of Student Answers

Number of Participant	Question and Answer in Bahasa Indonesia	Question and Answer in English
2	 i. Perhatikan pernyataan berikut ini: 1) Candidiasis 2) HIV 3) Gonorrhea 4) Sifilis 5) Herpes Genitalia Gangguan system reproduksi yang disebabkan oleh bakteri yaitu….. a. 1 dan 2 b. 1 dan 3 c. 2 dan 3 d. 2 dan 4 e. 3 dan 5 . Alasan Anda memilih jawaban diatas yaitu….. a. Candidiasis dan dan HIV merupakan gangguan system reproduksi yang disebabkan oleh bakteri *Candida albicans* dan HIV b. Candidiasis dan dan Gonorrhea merupakan gangguan system reproduksi yang disebabkan oleh bakteri *Candida albicans* dan *Neisseria gonorrhoeae* c. HIV dan Gonorrhea merupakan gangguan system reproduksi yang disebabkan oleh bakteri HIV dan *Neisseria gonorrhoeae* d. HIV dan Sifilis merupakan gangguan system reproduksi yang disebabkan oleh bakteri HIV dan *Troponema pallidum* e. Gonorhea dan Herpes Genitalis merupakan gangguan system reproduksi yang disebabkan oleh bakteri *Neisseria gonorrhoeae* dan *Herpes simplex*	Note the following statements: 1) Candidiasis 2) HIV 3) Gonorrhea 4) Syphilis 5) genital herpes Disorders of the reproductive system caused by bacteria, namely a. 1 and 2 b. 1 and 3 c. 2 and 3 d. 2 and 4 e. 3 and 5 Answer key: b The reason you chose the answer above is….. a. Candidiasis and HIV are reproductive system disorders caused by Candida albicans and HIV bacteria b. Candidiasis and gonorrhea are reproductive system disorders caused by Candida albicans and Neisseria gonorrhoeae bacteria. c. HIV and Gonorrhea are reproductive system disorders caused by HIV and Neisseria gonorrhoeae bacteria d. HIV and Syphilis are reproductive system disorders caused by HIV bacteria and Troponema pallidum e. Gonorrhea and Genital Herpes are reproductive system disorders caused by Neisseria gonorrhoeae and Herpes simplex bacteria Answer key: b

3.2. Discussion

Based on the data above, it is known that the understanding of concepts related to reproductive system material in class XI IPS 2 SMA Negeri 6 Madiun is still low; that is, 64.7% of students do not understand the process of birth or gestation, and 67.6% of students experience misconceptions about the sub-material types of contraceptives. This is in line with previous research, which states that the highest misconceptions when learning human anatomy and physiology material occur in the reproductive system sub-material (Andariana et al. 2020). Material in the reproductive system is difficult to learn because the nature of the material is abstract (Çimer 2012; Wahyuni et al. 2019), it contains many foreign terms, and the scope of the content is so broad and deep that students have difficulty understanding it (Çimer 2012).

The highest misconceptions occurred in the sub-materials regarding types of contraception, reproductive system disorders, and the process of oogenesis. Understanding this sub-material requires students to be able to recognize images and functions of the reproductive organs. Students admit difficulties in memorizing foreign terms in the form of bacteria or viruses that cause reproductive system disorders. Students also have difficulty understanding the stages of the mitotic

and meiotic division processes that occur in the oogenesis stage. In addition, students also have difficulty distinguishing types of contraceptives that are hormonal, physical, or chemical in nature.

Reproductive system material is one of the scopes of biology material at the senior high school (SMA) level. The details of the concept in this material are deep and broad because it is the basic material needed by students when they are going to continue their studies in higher education in science programs. The implementation of biology as a cross-interest subject has not been regulated regarding differences in the depth of the material for social studies majors. Students in this department experience difficulties mastering the material. This is evidenced by the percentage of misconceptions on each indicator item, namely 67.6% on the concept of types of contraceptives. These results are higher than those in previous studies, namely only 32.5% on the concept of menstruation (Ardiyanti and Rahmawati Utami 2018). This condition is in accordance with previous research, which explains that the material of the reproductive system is very broad in scope, for example, in the oogenesis and spermatogenesis sub-materials. Many students know the definitions of mitotic and meiotic divisions, but are unable to identify gametes that are haploid or diploid (Kalas et al. 2013). Understanding the basic concepts regarding the processes of oogenesis and spermatogenesis will influence the understanding of subsequent concepts and problem solving (Sesli and Kara 2012).

Misconceptions about a material can be caused by many factors. Some of these factors include: teachers who do not master the material so that they convey inappropriate concepts (Chavan and Patankar 2018; Desstya et al. 2019; Sezen Vekli and Birinci Konur 2021; Zulfia et al. 2019); too much material coverage; the teacher's teaching style; the negative feelings and attitudes of students toward a material; the initial concept brought by students (Pane, K.M & Aina 2022), as well as the lack of sources of teaching materials or supporting media (Çimer 2012). This statement is supported by research results that explain that misconceptions are mainly influenced by students' initial knowledge obtained in the previous stage. They tend to maintain these perceptions when studying them in class (Pane, K.M & Aina 2022). In addition to the initial knowledge factor, it is also influenced by the ability of students (IQ). Students with low IQs need to get explanations repeatedly in order to be able to understand a concept (Ilmiah et al. 2020; Pane, K.M & Aina 2022).

Teacher factors contribute to the various causes of misconceptions. These causes include: 1) providing incomplete information to students so that they find it difficult to connect several concepts; and 2) the learning method used being inappropriate. The tendency for teacher-centered learning can cause students to get bored (Puspitasari and Yuliani 2020); the focus is split between writing and listening (Khairaty et al. 2018); and students tend to review notes, which are of temporary nature (Pane, K.M & Aina 2022). Discussion learning methods without reinforcement by the teacher can also cause students to have diverse perceptions of a material (Yulianti 2017). The textbook factor is also a cause of misconceptions. Textbooks that have been used so far often contain incomplete material, ambiguous language and analogies, and inappropriate or poor image quality (Pane, K.M & Aina 2022). Some of these causes were confirmed by students, namely: 1) students majoring in social studies had difficulty understanding too much biology material and had a lot of foreign terms; 2) students were used to learning in a teacher-centered way; 3) students did not have the motivation to study biology; they studied only to abort the obligation to fulfill cross-interest subjects; 4) there were very limited sources of teaching materials; and 5) lazy students have low literacy skills.

Based on this description, the results of this misconception analysis are expected to be a consideration for the school to pay attention to the quality of learning at school. Schools can carry out supervision activities for teachers so that teachers' skills in pedagogic mastery and content are better maintained, choose appropriate textbooks, or develop appropriate learning media (Chavan and Patankar 2018; Çimer 2012; Sezen Vekli and Birinci Konur 2021). With these efforts, it is hoped that the level of misconceptions can be reduced.

4. CONCLUSIONS

The implementation of cross-interest lessons in the form of biology in the social studies department encounters many obstacles, including understanding concepts. From the results of this study, it was found that 64.7% of students did not understand the process of birth or gestation, 61.8% of students did not understand the stages of embryo development, 58.8% of students did not understand the stages of the ovarian cycle, 67.6% of participants students experienced misconceptions about the types of contraceptives in the sub-material, 52.9% had misconceptions about the reproductive system disorders sub-material, 48.5% of students experienced misconceptions about the oogenesis stages sub-material, 41.2% of students understood the reproductive system disorders sub-material , 38.2% of students understood the sub-material of the stages of spermatogenesis (38.2%), and 38.2% of students understood the sub-material of the benefits of breastfeeding for mothers and babies. The profiling data was only carried out in one social studies major class. The existence of this data is expected to be a consideration for profiling other social studies classes so that the problem of misconceptions can be overcome.

5. ACKNOWLEDGMENTS

The author would like to thank the Directorate of Teachers and Education Personnel (GTK) of the Ministry of Education and Culture (Kemendikbud) for facilitating this research.

6. REFERENCES

Andariana, A., Zubaidah, S., Mahanal, S., and Suarsini, E. 2020. Identification of biology students ' misconceptions in human anatomy and physiology course through three-tier diagnostic test. 8(3): 1071–1085.

Ardiyanti, Y., and Rahmawati Utami, M. 2018. Identifikasi Miskonsepsi Siswa Pada Materi Sistem Reproduksi. *BIOSFER : Jurnal Biologi dan Pendidikan Biologi* 2(2). DOI: 10.23969/biosfer.v2i2.574

Baram-Tsabari, A., Sethi, R. J., Bry, L., and Yarden, A. 2010. Identifying students' interests in biology using a decade of self-generated questions. *Eurasia Journal of Mathematics, Science and Technology Education* 6(1): 63–75. DOI: 10.12973/ejmste/75228

Chavan, R., and Patankar, P. 2018. Perception of Biological Concepts Among HigherSecondary Teachers: a Study. *Aarhat Multidisciplinary International Education Research Journal* (48178): 144–153.

Çimer, A. 2012. What makes biology learning difficult and effective : S tudents ' views. 7(3): 61–71. DOI: 10.5897/ERR11.205

Cindiati, M. er al. 2021. The Correlation Between Critical Thinking Skills and The Learning Outcomes on Musculoskeletal System. *Bioedukasi: Jurnal Pendidikan Biologi* 14(2): 91. DOI: 10.20961/bioedukasi-uns.v14i2.52079

Desstya, A., Prasetyo, Z. K., Suyanta, Susila, I., and Irwanto. 2019. Developing an instrument to detect science misconception of an elementary school teacher. *International Journal of Instruction* 12(3): 201–218. DOI: 10.29333/iji.2019.12313a

Galvin, E., and Mooney Simmie, G. 2015. Identification of Misconceptions in the Teaching of Biology: A Pedagogical Cycle of Recognition, Reduction and Removal. *Higher Education of Social Science* 8(2): 1–8. DOI: 10.3968/6519

Hasyim, W., Suwono, H., and Susilo, H. 2018. Three-tier Test to Identify Students' Misconception of Human Reproduction System. *Jurnal Pendidikan Sains* 6(2): 48–54.

Herpanda, Y., and Nirwana, H. 2022. Studi Deskriptif Problematika Pelaksanaan Layanan Peminatan dan Layanan Karir pada Tingkat Sekolah Menengah Atas (Studi Kasus di SMA Negeri 1 Koto XI Tarusan Kabupaten Pesisir Selatan). *Jurnal Edukasi* 2(1): 1–9.

Ilmiah, B., Biologi, P., Matematika, F., Ilmu, D., Alam, P., and Biologi, Y. P. 2020. Laily Eka Pradina & Yuliani : Miskonsepsi Siswa pada Submateri Pertumbuhan 310 Laily Eka Pradina. 9(1): 310–318.

Kalas, P., O'Neill, A., Pollock, C., and Birol, G. 2013. Development of a meiosis concept inventory. *CBE Life Sciences Education* 12(4): 655–664. DOI: 10.1187/cbe.12-10-0174

Kemdikbud. 2018. Permendikbud nomor NOMOR 37 TAHUN 2018 TENTANG PERUBAHAN ATAS PERATURAN MENTERI PENDIDIKAN DAN KEBUDAYAAN NOMOR 24 TAHUN 2016 TENTANG KOMPETENSI INTI DAN KOMPETENSI DASAR PELAJARAN PADA KURIKULUM 2013 PADA PENDIDIKAN DASAR DAN PENDIDIKAN MENENGAH. *JDIH Kemendikbud* 2025: 1–527.

Kementerian Pendidikan dan Kebudayaan. 2018. Peraturan Menteri Pendidikan dan Kebudayaan Nomor 36 Tahun 2018 tentang Perubahan atas Peraturan Menteri Pendidikan dan Kebudayaan Nomor 59 Tahun 2014 tentang Kurikulum 2013 Sekolah Menengah Atas/Madrasah Aliyah. *Permendikbud* 1–12.

Khairaty, N. I., Taiyeb, A. M., and Hartati, H. 2018. Identifikasi Miskonsepsi Siswa Pada Materi Sistem Peredaran Darah Dengan Menggunakan Three-Tier Test Di Kelas Xi Ipa 1 Sma Negeri 1 Bontonompo. *Jurnal Nalar Pendidikan* 6(1): 7. DOI: 10.26858/jnp.v6i1.6037

Kurniasih, N., and Haka, N. B. 2017. Penggunaan Tes Diagnostik Two-Tier Multiple Choice Untuk Menganalisis Miskonsepsi Siswa Kelas X Pada Materi Archaebacteria Dan Eubacteria. *Biosfer: Jurnal Tadris Biologi* 8(1): 114–127. DOI: 10.24042/biosf.v8i1.1270

Maulita, S. R., Sukarmin, S., and Marzuki, A. 2019. The Content Validity: Two-Tier Multiple Choices Instrument to Measure Higher-Order Thinking Skills. *Journal of Physics: Conference Series* 1155(1). DOI: 10.1088/1742-6596/1155/1/012042

Nakhleh, M. B. 1992. Why some students don't learn chemistry: Chemical misconceptions. *Journal of Chemical Education* 69(3): 191–196. DOI: 10.1021/ed069p191

Nastiti, F. F., and Syaifudin, A. H. 2020. Hubungan Pemahaman Konsep Matematis Terhadap Hasil Belajar Siswa Kelas Viii Smp N 1 Plosoklaten Pada Materi Lingkaran. *PHI: Jurnal Pendidikan Matematika* 4(1): 8. DOI: 10.33087/phi.v4i1.80

Pane, K.M & Aina, M. 2022. A LITERATURE STUDY : MISCONCEPTIONS OF BIOLOGY MATERIALS IN HIGH SCHOOL IN JAMBI CITY. 1: 338–349.

Permendikbud. 2014. Permen No 64 Tahun 2014 Tentang Peminatan Pada Pendidikan Menengah. *Menteri Pendidikan dan Kebudayaan Republik Indonesia*.

Permendikbud. 2018. Peraturan Menteri Pendidikan dan Kebudayaan Nomor 36 Tahun 2018 Tentang Perubahan Atas Peraturan Menteri Pendidikan Dan Kebudayaan Nomor 59 Tahun 2014. *Permendikbud* 1–12.

Puspitasari, A. H., and Yuliani. 2020. Analisis Miskonsepsi Materi Enzim dengan Menggunakan TT-MCTE Terhadap Siswa SMA. *BioEdu Berkala Ilmiah Pendidikan Biologi* 9(1): 93–101.

Sesli, E., and Kara, Y. 2012. Development and application of a two-tier multiple-choice diagnostic test for high school students' understanding of cell division and reproduction. *Journal of Biological Education* 46(4): 214–225. DOI: 10.1080/00219266.2012.688849

Sezen Vekli, G., and Birinci Konur, K. 2021. Are Pre-Service Science Teachers Qualified Enough to Teach Human Reproductive System? *International Journal of Progressive Education* 17(5): 48–59. DOI: 10.29329/ijpe.2021.375.4

Suwono, H., Prasetyo, T. I., Lestari, U., Lukiati, B., Fachrunnisa, R., Kusairi, S., Saefi, M., Fauzi, A., and Atho'Illah, M. F. 2021. Cell Biology Diagnostic Test (CBD-Test) portrays pre-service teacher misconceptions about biology cell. *Journal of Biological Education* Routledge 55(1): 82–105. DOI: 10.1080/00219266.2019.1643765

Wahyuni, N., Suwono, H., and Lestari, U. 2019. Learning Difficulties of High School Students in Understanding the Material of Human Reproductive Systems Triggering Misconceptions. *Jurnal Pendidikan Sains* 7(4): 116–121.

Wulandari, S., Gusmalini*, A., and Zulfarina, Z. 2021. Analisis Miskonsepsi Mahasiswa Pada Konsep Genetika Menggunakan Instrumen Four Tier Diagnostic Test. *Jurnal Pendidikan Sains Indonesia* 9(4): 642–654. DOI: 10.24815/jpsi.v9i4.21153

Yani, A. & Mulyadi, A. 2022. Higher Order Thinking Skills (HOTS) - Oriented Learning in Geography Learning. 31: 101–113.

Yulianti, N. K. 2017. MISKONSEPSI SISWA PADA PEMBELAJARAN IPA SERTA REMEDIASINYA. *Jurnal Bio Educatio* 2(2): 50–58.

Yusrizal, and Halim, A. 2017. the Effect of the One-Tier , Two-Tier , and Three-Tier Diagnostic Test Toward the Students ' Confidence and. *Unnes Science Educational Journal* 6(2): 1583–1590.

Zulfia, F. A., Susilo, H., and Listyorini, D. 2019. Virus-bacteria diagnostic test (vbd-test) in identifying biology teacher's misconception. *Biosfer* 12(2): 144–156. DOI: 10.21009/biosferjpb.v12n2.144-156

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Inventory of Epiphytic Lichen Foliose on Tea Plants in Ngargoyoso, Karanganyar, Central Java

Dika Dwi Irnawati, Efri Roziaty*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: er375@ums.ac.id

KEYWORDS:
Epiphytes,
Foliose,
Lichen,
Ngargoyoso,
Tea Stem (Camellia Sinensis (L.) O. Kuntze)

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Lichen is a combined organism between algae and fungi. Lichen has various body shapes, one of which is foliose. Lichen is found living epiphytic on the stems of tea plants. This study aims to determine the types of epiphytic lichen foliose on tea plants in Ngargoyoso, Karanganyar, Central Java. The method used is an exploratory method with purposive sampling techniques. Sampling was carried out at three stations with different altitudes. Station 1 (900 m asl), Station 2 (1.000 m asl), and Station 3 (1.100 m asl). The study results obtained a number 12 species of lichen foliose consisting of *Parmotrema tinctorum* (Delise ex Nyl.) Hale, *P. austrosinense* (Zahlbr.) Hale, *P. reticulatum* (Taylor) M. Choisy, *P. hypotropum* (Nyl.) Hale, *P. perlatum* (Huds.) M. Choisy, *Flavoparmelia soredians* (Nyl.) Hale, *F. caperata* (L.) Hale, *Hypogymnia physodes* (L.) Nyl, *Physcia stellaris* (L.) Nyl, *P. aipolia* (Ehrh. ex Humb.) Fürnr, *Heterodermia japonica* (Satō) Swinscow & Krog, and *Dirinaria applanata* (Fée) D.D. Awasthi. The most dominant species found at all three stations were *Parmotrema austrosinense* (Zahlbr.) Hale with a total of 104 colonies. The least encountered species was *Physcia stellaris* (L.) Nyl with a total of 3 colonies.

1. INTRODUCTION

Lichen is a lower plant derived from a combination of algae and fungi (Suharno et al. 2021). Thallus lichen comprises green algae (Chlorophyta) or blue algae (Cyanobacteria) with fungi from the Ascomycetes or Basidiomycetes groups. Thallus lichen is generally found gray or greenish-gray. These lichen species are yellow, orange, and brown or red, with diverse habitats (Andrea et al. 2018). Lichens are divided into three groups, one of which is lichen foliose. Lichen foliose has a leaf-like structure composed of lobes. This lichen is attached relatively looser to its substrate (Pratama and Trianto, 2020). This lichen is attached to a tool called rhizines. Rhizines have a role as a tool to absorb food. Examples of lichen foliose are Xantoria, Physicia, Peltigera, and Parmelia (Roziaty, 2016).

Lichen is commonly found living epiphytic life on trees, rocks, moist places, and soil. Epiphytic plants are plant species whose lives depend on or attach to other plants but do not harm the plants on which they live. These plants can carry out photosynthesis for their growth, so they do not include parasitic plants because they do not take food sources from plants where they live (Sadili and Royyani, 2018). In general, epiphytic plants can grow and develop as a single individual or in colonies on the branches or trunks of trees on which they live. One of the plants used as a place for lichen to live is the tea plant (Shofiana, 2017).

The lichen inventory in Indonesia has not been widely conducted, so research on lichen is still a great opportunity. According to information recorded in Herbarium Bogoriensis Bogor, around 40.000 lichen species exist in Indonesia. This fact shows that only a few types are known through biology books, even though there are as many as 40.000. Many studies have been conducted on lichen, including its use as an indicator of air pollution (Muslim and Hasairin, 2018).

Inventory is an activity to collect information and facts about understory plant species found in certain areas (Rachmawati et al. 2021). Inventory activities consist of exploration and identification activities. The inventory results are compiled into a flora book listing the names of various plant species and other data related to the types of plants in the region. Therefore, an inventory of lichen in an area is essential so that it becomes evidence or data on the richness of plant species owned by the region (Sjakoer et al. 2022).

Tea (*Camellia Sinensis* (L.) O. Kuntze) is a plant belonging to the family Theaceae, tree-shaped with a height of up to 4.5 m in the wild. However, cultivated tea plants are only between 0.6 and 1.5 m (Pamungkas and Supijatno, 2017). The leaves have a light green color with a length of 5 – 30 cm and a width of ± 4 cm. Whiteare flowers are 2.5 – 4 cm in diameter. It has fruits of flattened and rounded shapes. Have one seed on each fruit. Tea plants live and grow well in humid climates with temperatures between 10 – 30 °C, rainfall of 2.000 mm per year, and altitudes of 600 – 2.000 m asl. One of the tea plantations in Central Java can be found in Ngargoyoso (Syahbudin et al. 2019).

Ngargoyoso is a highland area with a high level of plant diversity. Kemuning Tea Plantation is a tourist attraction in Ngargoyoso, Karanganyar, Central Java. Kemuning Tea Plantation has climatic conditions that support the existence of lichen. Kemuning Tea Plantation is located at an 800 – 1.500 m asl. This height supports the presence of crustal lichen such as thallus foliose-type lichen, which can live at an altitude of 600 – 3.500 m asl (Mercado-Díaz et al. 2015). The ambient temperature in Kemuning tea plantations is around 21 °C, and air humidity ranges 70 – 80 %.

Ngargoyoso is a highland area with climatic conditions that favor lichen growth. Therefore, the area has the potential to research data collection of one type of lichen, namely lichen foliose. However, there have been many previous researchers who researched lichen foliose. Until now, no information has been containing epiphytic lichen foliose on tea plants in Ngargoyoso, Karanganyar, Central Java. Therefore, this study needs to be conducted to determine the types of epiphytic lichen foliose on tea plants in Ngargoyoso, Karanganyar, Central Java.

2. Materials and Methods

2.1. Time and Place of Research

This research will be conducted in March 2023 in the Kemuning Ngargoyoso Tea Plantation Area, Karanganyar, Central Java. Sampling was carried out at three stations with different heights. Station 1 with an altitude of 900 m asl, station 2 with an altitude of 1.000 m asl, and Station 3 with an altitude of 1.100 m asl. The method used is an exploratory method carried out by exploring the research site to take the necessary lichen samples (Fatma et al. 2017). The sampling technique used is purposive sampling. Purposive sampling is a sampling technique based on specific considerations. The map of the research location can be seen in **Fig.1**.

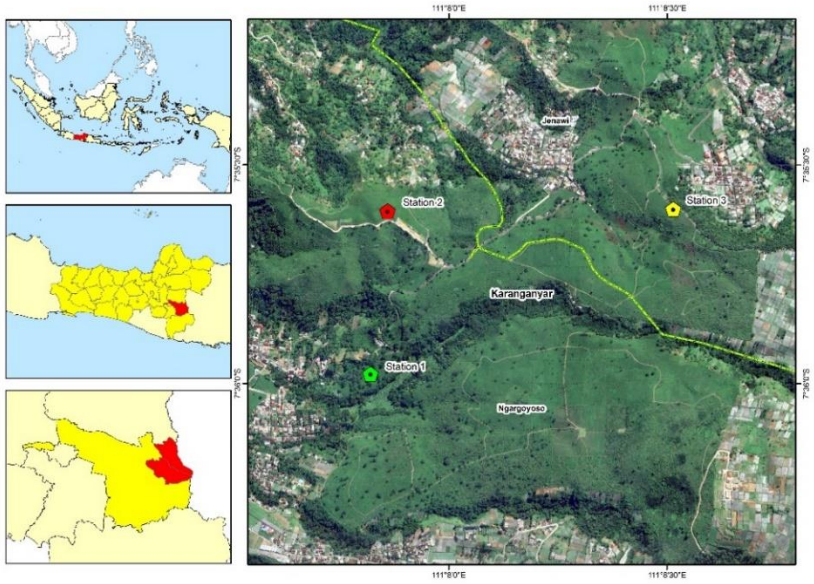


Fig. 1. Map of Research Location Points in Kemuning Tea Plantation Area, Ngargoyoso, Karanganyar, Central Java

2.2. Tools and Materials

Tools used include documentation tools (Handphone), Digital thermohygrometer, pH stick, Altimeter, Luxmeter, Roll meter, Stereo microscope, Permanent scalpel, Tweezers, Kitchen knife, Cutter, Plastic mica, Tissue, Ruler, Coins, Stationery, Libraries that are references for researchers for identification purposes such as lichen identification books, Journals about lichen foliose, Articles, Photos that are valid and relevant. The material used was samples of epiphytic lichen foliose on tea plants found at each research station.

2.3. Research Stages

The stages carried out in this study are: 1) Preparatory stage consists of field observation, preparation of tools and materials needed in research, and conducting literature studies. 2) Implementation stage consists of abiotic factor measurement activities, which include temperature, air humidity, light intensity, and altitude of the place. Document any foliose lichen samples found at each station before they were taken. Take lichen foliose samples by breaking the twigs of tea stems contained in samples or slowly scraping from the stems of tea plants using a scalpel or kitchen knife not to damage the colony, inserting the sample into plastic mica that has been perforated and giving a tissue base. 3) Identification stage, at this stage, lichen foliose samples are brought to the Biological Laboratory of FKIP UMS for identification. Observe samples using stereo microscopes and describe morphological structures in the form of color and shape of the thallus, as well as reproductive structures of lichen samples obtained one by one. Identify lichen samples by comparing the characteristics of the samples found with several sources that are used as references in identification, namely the determination book *The Lichens of British Columbia Illustrated Keys Part 1 – Foliose and Squamulose Species* (1994), *Field Oriented Keys To The Florida Lichens* (2015), books, and research journals related to lichen foliose.

2.4. Data Analysis

The results of research data obtained from the field were then grouped using a correlation test using the SPSS 23rd edition application, which was based on the correlation between environmental conditions (abiotic factors) and the presence of lichen foliose. Furthermore, data processing is carried out in a qualitative descriptive manner by writing down the scientific name, classification of lichen foliose, key determination, and describing the morphology of the types of lichen foliose found along with their habitat characteristics. The research data results are presented as descriptions, tables, and figures.

3. RESULTS AND DISCUSSION

3.1. Inventory Results of Epiphytic Lichen Foliose on Tea Plants in Ngargoyoso, Karanganyar, Central Java

Based on research that has been done, several types of epiphytic lichen foliose were obtained on tea plants in Ngargoyoso, Karanganyar, Central Java (**Table 1**).

Table 1. Types of epiphytic lichen foliose on tea plants in Ngargoyoso, Karanganyar, Central Java at each station

No	Species	Station			∑ Colony
		1	2	3	
1	*Parmotrema tinctorum* (Delise ex Nyl.) Hale	12	10	60	82
2	*P. austrosinense* (Zahlbr.) Hale	23	35	46	104**
3	*P. reticulatum* (Taylor) M. Choisy	15	24	33	58
4	*P. hypotropum* (Nyl.) Hale	-	-	20	20
5	*P. perlatum* (Huds.) M. Choisy	32	18	13	63
6	*Flavoparmelia soredians* (Nyl.) Hale	10	21	30	61
7	*F. caperata* (L.) Hale	5	9	16	30
8	*Hypogymnia physodes* (L.) Nyl	-	-	8	8
9	*Physcia stellaris* (L.) Nyl	-	-	3	3*
10	*P. aipolia* (Ehrh. ex Humb.) Fürnr	8	7	25	50
11	*Heterodermia japonica* (Satō) Swinscow & Krog	-	-	32	32
12	*Dirinaria applanata* (Fée) D.D. Awasthi	29	13	26	68
	Total	134	137	312	583

Note:
Station altitude 1 : 900 m asl
Station altitude 2 : 1.000 m asl
Station altitude 3 : 1.100 m asl
** Total colonies found the most
* Total colonies found least

Based on an inventory of epiphytic lichen foliose on tea plants in Ngargoyoso, Karanganyar, Central Java, a total of 12 lichen foliose were found (**Table 1**). At three stations with different heights, each species with a different number was found. The station 1 found eight species, Station 2 had 8 species, and Station 3 had as many as 12. The species found at all three stations belong to 3 families, namely Parmeliaceae, Physciaceae, and Caliciaceae. From the observations that have been made, there are 12 types of lichen foliose that can be identified, namely species *Parmotrema tinctorum* (Delise ex Nyl.) Hale, *P. austrosinense* (Zahlbr.) Hale, *P. reticulatum* (Taylor) M. Choisy, *P. hypotropum* (Nyl.) Hale, *P. perlatum* (Huds.) M. Choisy, *Flavoparmelia soredians* (Nyl.) Hale, *F. caperata* (L.) Hale, *Hypogymnia physodes* (L.) Nyl, *Physcia stellaris* (L.) Nyl,

P. aipolia (Ehrh. ex Humb.) Fürnr, *Heterodermia japonica* (Satō) Swinscow & Krog, and *Dirinaria applanata* (Fée) D.D. Awasthi.

At Station 1, which has an altitude of 900 m asl, 134 lichen colonies are found. The number of colonies found is the least compared to Station 2 and 3. The station 1 is on the side of the main road that is often traveled by vehicles, so lichen growth is not as much as in other stations. The species found come from 4 genera: Parmotrema, Flavoparmelia, Physcia, and Dirinaria. Station 2 has an altitude of 1.000 m asl, located in a tourist center area with a high level of human activity. At this station found as many as 8 species, the same as station 1, but with a more significant number of colonies of 137. The species found come from 4 genera: Parmotrema, Flavoparmelia, Physcia, and Dirinaria. Station 3 has an altitude of 1.100 m asl and is in an area that is quiet of visitors and rarely traversed by vehicles. Therefore, this station found more diverse species than other stations, with as many as 12 species with a colony of 312. The species found come from 6 genera: Parmotrema, Flavoparmelia, Hypogymnia, Physcia, Heterodermia, and Dirinaria. It shows that the level of pollution affects the number and variety of lichen colonies are found. This is in line with research of Ramadhanti et al. (2021) which stated that the small number of lichens found was also influenced by air pollution conditions.

Based on previous research conducted by Supriati et al. (2021) regarding the diversity of lichens in tea plants (*Camellia sinensis* (L.) Kuntze) in the PT Sarana Mandiri Mukti plantation, Kepahiang Regency, Bengkulu Province, the results of the registration of lichen found as epiphytes on the bark substrate of the tea plant (*Camellia sinensis* (L.) Kuntze), namely as many as 12 species of lichen foliose from the genera Parmelia, Parmotrema, Dirinaria, and Heterodermia. The number of these species is the same as the number of lichen foliose species found as epiphytes on tea plants in Ngargoyoso, Karanganyar, Central Java, but with less genus diversity.

The most dominating species of the three stations is *Parmotrema austrosinense* (Zahlbr.) Hale (**Fig. 2**). This species is found with 104 colonies. Based on observations, this lichen foliose species have a thallus measuring 4 – 10 cm, loosely attached to the substrate of tea stem bark. The lobes are spherical with a width of 5 - 15 mm, the edges of the thallus overlap, they are sinuous. The upper surface is grey to greenish-grey, shiny, and smooth, and older parts have cracks. The lower surface is smooth wrinkled, yellowish-brown, and light brown to blackish. It has rhizines measuring 1 mm arranged sparsely, still simple, and unevenly distributed. Species *Parmotrema austrosinense* (Zahlbr.) Hale was found scattered in large numbers at all three stations. This is because this species has a higher tolerance level than other species so that it can grow well in polluted environments. Species *Parmotrema austrosinense* (Zahlbr.) Hale is famous for its role as a bioindicator of an area's air quality. This is supported by Andrea (2018) research which states that lichen can grow well even in a polluted environment. This is because there are rhizines that function to absorb food. In addition, Parmotrema can also survive for a long time in environments that lack water.

Fig. 2. *Parmotrema austrosinense* (Zahlbr.) Hale

The fewest species found with 3 colonies are *Physcia stellaris* (L.) Nyl (**Fig. 3**). Based on observations, *Physcia stellaris* (L.) Nyl has a rounded or irregular thallus measuring 3 cm. The upper surface is coarse-textured, green to grayish-green. There are short-sized cilia arranged rather tightly at the edges of the thallus. It has a brown to black rounded saucer-shaped apothecia widely scattered in the middle of the thallus. The undersurface is brown to whitish-brown with brownish rhizines. This species is found only at station 3. This is because *Physcia stellaris* (L.) Nyl has a low tolerance level for air pollution. The physcaceae family includes lichens sensitive to pollution or poor air quality. Therefore, *Physcia stellaris* (L.) Nyl can only grow in environments where human activity or exposure to vehicle occlusion is rare. That is why this species is not found at Stations 1 and Station 2 which have higher pollution exposure levels than Station 3. This is in line with Hutasuhut (2021) research which states that the small number of physciaceae families found in an area is due to the low level of tolerance to pollutants (air quality).

Fig. 3. *Physcia stellaris* (L.) Nyl

3.2. Environmental Conditions

The results of abiotic factor measurements at each station are presented in **Table 2** below:

Table 2. Abiotic Environmental Parameters in Ngargoyoso Tea Plantation Area, Karanganyar, Central Java

No	Parameters	Station 1	Station 2	Station 3	Range
1	Altitude (m asl)	900	1.000	1.100	900 - 1.100
2	Ambient temperature (°C)	23,7	23,6	22,8	22,8 – 23,7
3	Air Humidity (%)	75	79	80	75 - 80

The existence of different types and total colonies of epiphytic lichen foliose found is influenced by the environmental conditions in which lichen foliose grows. Environmental parameters in this study consist of altitude, ambient temperature, and humidity. This is supported by Nasriyati et al. (2018) research which states that the growth of lichen is supported by abiotic factors. Abiotic factors in the form of environmental temperature and air humidity are important factors in supporting lichen growth.

Measurements of environmental parameters in the form of abiotic factors were carried out at three stations with different heights. Based on (**Table 2**) it can be seen that lichen foliose grows well in the range of altitude 900 – 1.100 m asl, ambient temperature ranges from 22,8 °C – 23,7 °C, and air humidity ranges from 75 – 80 %. The results of measuring abiotic parameters in the field show that the higher the research location, the lower the temperature and the higher the air humidity level. Research by Roziaty and Utari (2017) indicates that the higher the sampling site, the more total lichen colonies will be found. In addition, the total colony will increase in a low-temperature environment with high humidity.

To determine whether or not there is a correlation between environmental parameters and the total lichen foliose colonies found, a correlation test was carried out using SPSS edition 23. Effect of ambient temperature on the total lichen foliose colonies found can be seen in (**Fig. 4**). Based on the results of the correlation test, a significance value was obtained between the air humidity parameter and the total lichen foliose colony of 0.002 smaller than 0.05 with a coefficient value of - 0.510. This means that the correlation between air temperature and total colonies of epiphytic lichen foliose is negatively correlated, meaning the higher the air temperature, the fewer epiphytic lichen foliose found. Conversely, the lower the air temperature, the more epiphytic lichen foliose is found, provided that the temperature is still within the limits of lichen growth tolerance. This is in line with Murningsih (2016) research which states that the optimum temperature for lichen growth is below 40 °C because temperatures above 45 °C cause lichen chlorophyll to be damaged and interfere with the process of lichen photosynthesis.

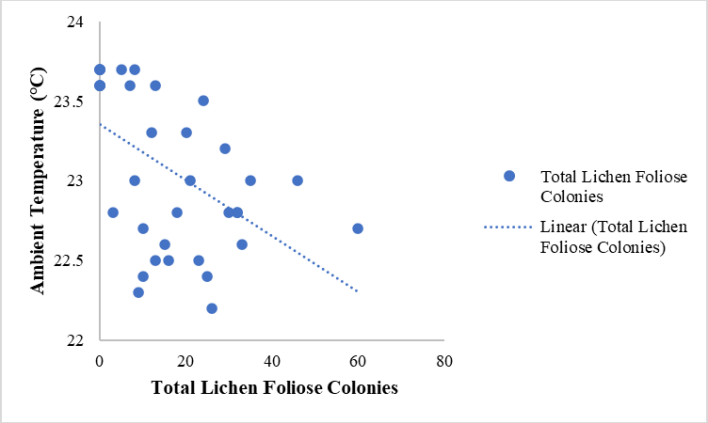


Fig. 4. Correlation of ambient temperature with total colonies of lichen foliose

The effect of humidity on the total lichen foliose colonies found can be seen in (**Fig. 5**). Based on the results of the correlation test, a significance value was obtained between the air humidity parameter and the total lichen foliose colony of 0.003 smaller than 0.05 with a coefficient value of 0.482, this means that there is an influence between air humidity and total lichen foliose colonies. The correlation between air humidity and total colonies is quite strong, and a positive correlation (+) formed. This means the higher the humidity, the more epiphytic lichen foliose will be found. This is supported by Roziaty et al. (2021) theory which states that the higher the air humidity in an area, the more types and total lichen found living in the area.

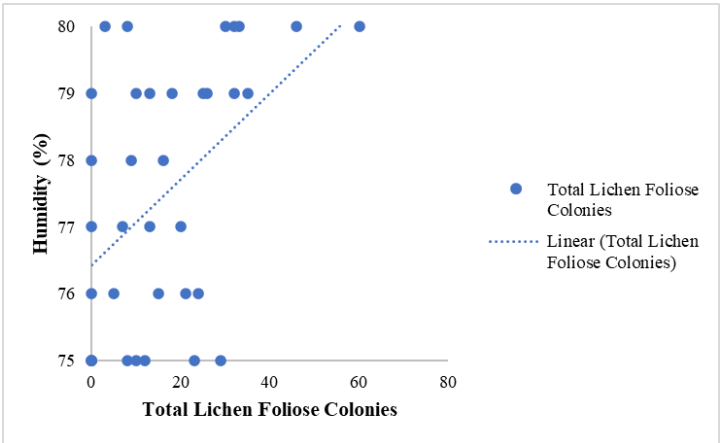


Fig. 5. Correlation of air humidity with total colonies of lichen foliose

4. CONCLUSION

The conclusion obtained from the results of the research conducted is that the epiphytic lichen foliose on tea plants in Ngargoyoso, Karanganayar, Central Java, consists of 12 species from 3 families, namely 1) family Parmeliaceae consisting of *Parmotrema tinctorum* (Delise ex Nyl.) Hale, *P. austrosinense* (Zahlbr.) Hale, *P. reticulatum* (Taylor) M. Choisy, *P. hypotropum* (Nyl.) Hale, *P. perlatum* (Huds.) M. Choisy, *Flavoparmelia soredians* (Nyl.) Hale, *F. caperata* (L.) Hale, and *Hypogymnia physodes* (L.) Nyl, 2) family Physciaceae consists of *Physcia stellaris* (L.) Nyl, *P. aipolia* (Ehrh. ex Humb.) Fürnr and *Heterodermia japonica* (Satō) Swinscow & Krog, 3) family Caliciaceae comprise *Dirinaria applanata* (Fée) D.D. Awasthi. The most dominant species at all three stations is *Parmotrema austrosinense* (Zahlbr.) Hale with a total of 104 colonies. The least encountered species was *Physcia stellaris* (L.) Nyl with a total of 3 colonies.

As for the suggestions that the author can convey regarding this research, it is necessary to conduct further research regarding the role of lichen foliose as an indicator of air quality in Ngargoyoso, Karanganyar, Central Java.

5. ACKNOWLEDGMENTS

The author would like to thank the Biology Study Program at Muhammadiyah University of Surakarta for providing material support for the publication of this article.

6. REFERENCES

Andrea, E. S., Zuhri, R., & Marlina, L. (2018). Identifikasi Jenis Lichen di Kawasan Objek Wisata Teluk Wang Sakti. *BIOCOLONY: Jurnal Pendidikan Biologi dan Biosains* 1(2): 7-14.

Fatma, Y., Susriyati, M., & Murni, S. (2017). Keanekaragaman Familia Physciaceae dan Lobariaceae di Taman Hutan Raya Raden Soerjo Sebagai Bahan Ajar pada Matakuliah Mikrobiologi. *Jurnal Pendidikan: Teori, Penelitian Dan Pengembangan* 2(2): 179–185. DOI: http://dx.doi.org/10.17977/jp.v2i2.8513

Hutasuhut, M. A., Febriani, H., & Devi, S. (2021). Identifikasi dan Karakteristik Habitat Jenis Lumut Kerak di Taman Wisata Alam Sicikeh-Cikeh Kabupaten Dairi Sumatera Utara. *Jurnal Biolokus* 4(1): 43-54. DOI: https://doi.org/10.30821/biolokus.v4i1.957

Mercado-Díaz, J. A., Gould, W. A., Gonzalez, G., & Lücking, Robert. (2015). *Lichens in Puerto Rico: An ecosystem approach*. U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. DOI: https://doi.org/10.2737/IITF-GTR-46

Murningsih, M., & Mafazaa, H. (2016). Jenis-Jenis Lichen Di Kampus Undip Semarang. *Bioma : Berkala Ilmiah Biologi* 18(2): 20–29. DOI: https://doi.org/10.14710/bioma.18.2.20-29

Muslim, M., & Hasairin, A. (2018). Eksplorasi Lichenes pada Tegakan Pohon di Area Taman Margasatwa (*Medan Zoo*) Simalingkar Medan Sumatera Utara. *Jurnal Biosains* 4(3): 145-153 . DOI: https://doi.org/10.24114/jbio.v4i3.9715

Nasriyati, T., Murningsih, M., and Utami, S. (2018). Morfologi Talus Lichen *Dirinaria Picta* (Sw.) Schaer. Ex Clem pada Tingkat Kepadatan Lalu Lintas yang Berbeda di Kota Semarang. *Jurnal Akademika Biologi* 7(4): 20–27.

Pamungkas, M. A., and Supijatno. (2017). Pengaruh Pemupukan Nitrogen Terhadap Tinggi dan Percabangan Tanaman Teh (Camelia Sinensis (L.) O. Kuntze) untuk Pembentukan Bidang Petik. *Buletin Agrohorti* 5(2): 234–241. DOI: https://doi.org/10.29244/agrob.v5i2.16804

Pratama, A., and Trianto, M. (2020). Diversity of Lichen in Mangrove Forest of Tomoli Village Parigi Moutong Regency. *BIO-EDU: Jurnal Pendidikan Biologi* 5(3): 140–150. DOI: https://doi.org/10.32938/jbe.v5i3.730

Rachmawati, E., Rahayuningsih, T., Rahmaningtyas, L., & Aminsyah, A. (2021). *Perencanaan Interpretasi Alam di Kawasan Wisata*. Syiah Kuala University Press, Aceh.

Ramadhanti, Z. N., Inggit Amellia Harnum, Nadia Riza Pratiwi, Zahra Wihanifa Putri, Mieke Miarsyah, and Annisa Wulan Agus Utami. (2021). Inventarisasi Liken di Kawasan Kebun Raya Bogor. *Proceeding of Biology Education* 4(1): 120–129. DOI: https://doi.org/10.21009/pbe.4-1.11

Roziaty, E. (2016). Review: Kajian Lichen : Morfologi, Habitat dan Bioindikator Kualitas Udara Ambien Akibat Polusi Kendaraan Bermotor. *Bioeksperimen: Jurnal Penelitian Biologi* 2(1): 54-66. DOI: https://doi.org/10.23917/bioeksperimen.v2i1.1632

Roziaty, E., Asngad, A., and Kusuma, A. I. (2021). *Lichen Perspektif Ekologi*. Universitas Muhammadiyah Surakarta Press, Surakarta.

Roziaty, E., and Utari, R. T. (2017). Jenis dan Morfologi Lichen Fruticose di Kawasan Hutan Sekipan Desa Kalisoro Tawangmangu Karanganyar Jawa Tengah. *Proceeding Biology Education Conference* 14(1): 114 –117.

Sadili, A., dan Royyani, M. F. (2018). Keanekaragaman, Persebaran dan Pola Tata Ruang Tumbuhan Epifit pada Hutan Bekas Tebangan di Kiyu, Pegunungan Meratus, Kalimantan Selatan. *Jurnal Berita Biologi* 17(1): 1–8. DOI: https://doi.org/10.14203/beritabiologi.v17i1.2749

Shofiana, W. (2017). Inventarisasi Jenis-Jenis Tumbuhan Epifit Di Kebun Biologi FMIPA UNY. *Jurnal Prodi Biologi* 6(2): 121–130.

Sjakoer, N. A. A., Sulistyowati, E., Purnomo, Y., Diniyah, I., dan Ma'ruf, M. (2022). *Koleksi Tanaman Berkhasiat di Griya Jamu Kota Batu*. Inara Publisher (Kelompok Penerbit Intrans Publishing), Malang.

Suharno, S., Sufaati, S., Sujarta, P., & Agustini, V. (2021). *Liken (LumutKerak): Struktur Morfologi, Anatomi, Fungsi Ekologi, dan Manfaat Bagi Manusia*. IPB Press, Bogor.

Supriati, R., Helmiyetti, H., & Agustian, D. (2021). Keragaman Lumut Kerak pada Tanaman Teh (*Camellia sinensis* (L.) Kuntze) di Perkebunan Teh PT. Sarana Mandiri Mukti Kabupaten Kepahiang Provinsi Bengkulu. *Berita Biologi* 20(1): 137–145. DOI: https://doi.org/10.14203/beritabiologi.v20i1.3944

Syahbudin, A., Widyastuti, A., Masruri, N. W., & Meinata, A. (2019). Morphological Classification of Tea Clones (*Camellia sinensis*, Theaceae) at the Mount Lawu Forest, East Java, Indonesia. *IOP Conference Series: Earth and Environmental Science* 394(1): 1-9. DOI: https://doi.org/10.1088/1755-1315/394/1/012014

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Manuscript Writing Guidelines: Analysis of Creative thinking skills profile of Senior High school students in Madiun City on Biotechnology topic

Herning Nurdiana[1*], Ima Agung Nurcahyo[2], Cicilia Novi Primiani[3]
[1]Biology Education Department, Faculty of Teacher Training and Education, Universitas PGRI Madiun. Jl. Setiabudi No 85, Kanigoro, Kartoharjo, Madiun 63118, Jawa Timur, Indonesia
[2]SMA Negeri 6 Madiun, Jl. Suhud Nosingo No. 1 Madiun 63132, Jawa Timur, Indonesia
[3]Biology Education Department, Faculty of Teacher Training and Education, Universitas PGRI Madiun. Jl. Setiabudi No 85, Kanigoro, Kartoharjo, Madiun 63118, Jawa Timur, Indonesia
[*]Corresponding Author. E-mail address: dyana.hern@gmail.com

KEYWORDS:
Creative thinking skill
Biotechnology
Kurikulum Merdeka
Biology
Senior High School

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Currently, the world of education has returned to normal after the outbreak of Covid-19. The newest curriculum implemented in Indonesia is the independent curriculum. One of the important competencies trained in the independence curriculum is creative thinking skills. Creative thinking skills are important for long-term success because they help see problems and situations from different perspectives to solve problems. The purpose of this study was to analyze the profile of students' creative thinking skills in biotechnology material. This research is a descriptive research with a written test method that includes creative thinking skills. The subjects of this study were 35 students of SMAN 6 Madiun who were selected using a purposive sampling technique. The results obtained show that the percentage of achievement of creative thinking skills as measured using 4 aspects of adaptive creative thinking skills according to Torrance and Guildford namely fluency 60%, flexibility 44,64%, originality 40,36%, and elaboration 57,85%.

1. INTRODUCTION

Seeing the current conditions, education around the world including Indonesia has gradually recovered from the effects of the covid 19 pandemic which is implementing social distancing as a policy to prevent the spread of covid-19 (Hamid 2020). This policy has changed all aspects of life, one of which is in the field of education. In order for learning to continue, the Indonesian government has implemented online learning. But now the pandemic is over so it is no longer implementing distance learning.

The era of the industrial revolution 4.0 in the 21st century demands developments in all sectors of life, including education and learning. The progress of human life is influenced by technological developments, including in the field of education. Changes in information systems that develope and human resources that have been replaced by technology affect the education system. Most high schools in Indonesia have implemented the latest curriculum, namely the independent curriculum. Unlike other programs, the Merdeka Curriculum has a distinctive feature which is defined as an emphasis on the use of teaching methods that focus on students and reduce pressure by using a teaching model based on Project based learning (PjBL) (Pratiwi 2019) is part of the independent curriculum which presents interesting and innovative teaching.

To face the demands of the 21st century in implementing independent curriculum, the prioritized skills in learning known as 4C according to are; critical thinking and problem solving, communication and collaboration, as well as creativity and innovation (Bernie Trilling & Charles Fadel 2009). Characteristics of the 21st century to solve life's increasingly complex problems requires effective and efficient solutions (Saputri et al. 2018). One of them is creative thinking skills, in fact, according to the results of the Global Creativity Index, Indonesia is ranked under

the creative and innovative index (Florida et al. 2015). Looking at these results, it is necessary to emphasize that creative thinking skills must be improved so that students are ready to face the era of the industrial revolution 4.0 even though in this post-pandemic period. Creative thinking skills are the ability of individuals to find new ideas, new possibilities, new discoveries that use their minds based on originality in their work (Daud et al. 2012). Creative thinking is an activity that generates new ideas, allows something to be seen from a different perspective, is imaginative, has the potential to produce advanced ideas and changes, is capable of generating many ideas and is skilled at solving problems (Ülger 2016). According to Torrance and Guildford there are 4 aspects of creative thinking, namely; 1) fluency is the skill to create many ideas, 2) flexibility is the skill to propose several approaches or ways to solve a problem, 3) originality is the skill to create authentic ideas as a result of their own thinking and not cliches, 4) elaboration is the skill to describe something in detail. Therefore, this study uses an open test with 4 aspects of creative thinking such as fluency, flexibility, originality, and elaboration (Guilford, 1987). This research aims to identify and describe the creative thinking skills of SMAN 6 Madiun students in learning Biology on biotechnology material.

2. MATERIALS AND METHODS

This research is a qualitative descriptive study. Measurement of students' creative thinking skills using description questions with each indicator was developed based on 4 aspects of creative thinking skills adapted from Torrance and Guildford, these four aspects are fluency, flexibility, originality, and elaboration. The questions tested consisted of eight questions, while each aspect of creative thinking skills was represented by two questions. The subjects in this study were 35 students of SMAN 6 Madiun who were selected through a purposive sampling technique. Where the students who were given the test were students who had taken Biotechnology material. The development of a question instrument using aspects of creative thinking skills adapted from Torrance and Guilford in (Anjarwati et al., 2018) can be seen in table 1

Table 1. Creative Thinking Skills Profile Test Instrument.

Number of question	Creative thinking skill's aspect	Creative thinking skill's indicator
1,2	Fluency	a. Mention many ideas that are relevant to the problem
		b. Flow of thought smoothly
3,4	Flexibility	a. Provide an interpretation of a picture or a phenomenon
		b. The skills to view things from different perspectives
		c. solve a problem from various points of view
5,6	Originality	a. Generating answers from one's own thoughts that are relevant and different from answers in general
		b. Generating new ideas on a problem
		c. Creates unusual or rare answers that no one else has thought
7,8	Elaboration	a. Developed or enrich existing ideas
		b. Extend answers and link between concepts

Number of question	Creative thinking skill's aspect	Creative thinking skill's indicator
		c. Analyze and finding various approaches to solving a problem
		d. Determining an opinion about a thing

The data were obtained from students 'answers by coding each student's answers and students' answers based on table rubrics. The persentage scores obtained by students in each creative thinking skills aspects are then converted into proportions using the formula:

$$\text{Persentage Score} = \frac{obtained\ score}{maximum\ score} \text{ x } 100$$

The result of the percentage score of each aspect is indicated by the criteria according to this article (Riduwan 2010). These categories areshown in table 2 The Percentage Category of Creative Thinking Skills.

Table 2. The Percentage Category of Creative Thinking Skills

Percentage	Category
81 – 100 %	Very creative
61 – 80 %	Creative
41 – 60 %	Moderate
21 – 40 %	Low
0 – 20 %	Very low

The results of the analysis of students' creative thinking skills are displayed in graphic form and analyzed descriptively.

3. RESULTS AND DISCUSSION

The results of students' creative thinking skills tests can be shown in Figure 1. This figure shows the highest results on the aspect of fluency as much as 60% which fall into the medium category. Meanwhile, the other three aspects are included in the low category with the following details; flexibility 44.64%, originality 40.35%, and elaboration 57.85%.

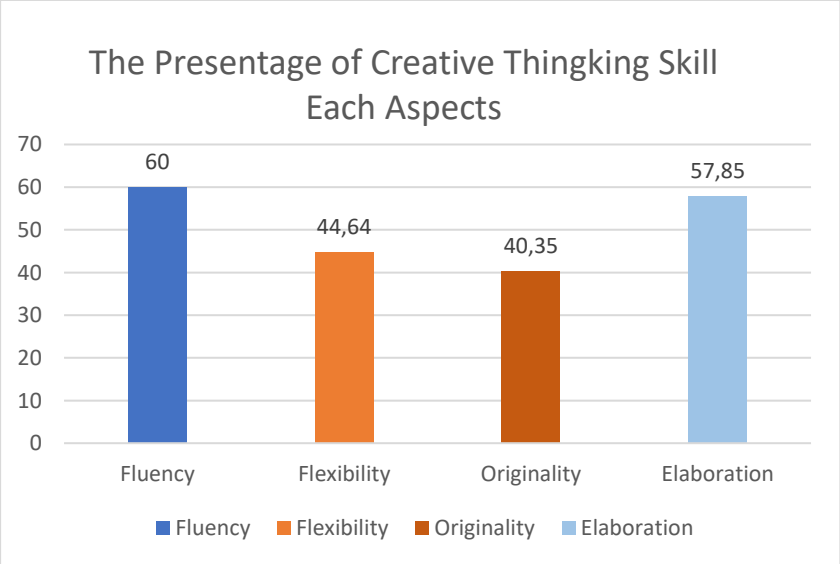
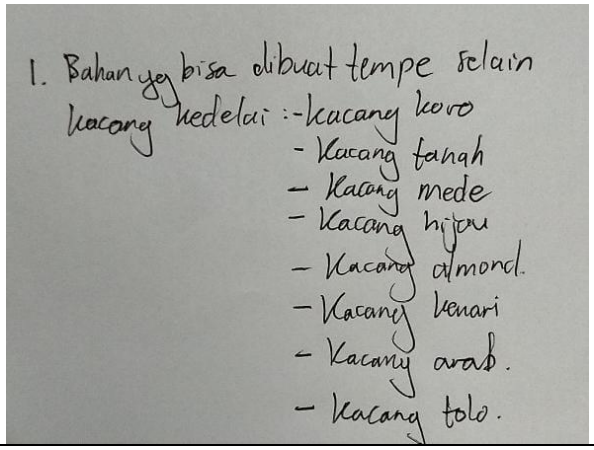


Figure 1. The Presentage of creative thingking skill each aspects

The four aspects of creative thinking skills, the Fluency aspect has the highest percentage and is included in the medium category with a percentage of 60%. Fluency can be seen from students who give correct, fluent, and varied answers (Nurdiana et al.2020). This shows that students are able to name many answers to the questions that have been given. There are more than half of the sample population can answer questions on this aspect. One way that can be done by the teacher to develop fluency is to frequently ask questions to students, so that students are accustomed to giving many answers (Munandar, 2009). The following are examples of questions and answers from students on the fluency aspect which can be seen in table 3 below.

Table 3. The examples of questions and answers from students on the fluency aspect

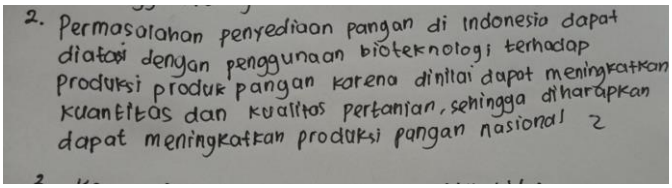
Original Question and Student answer	In English
Tempe merupakan produk bioteknologi yang dihasilkan dari fermentasi biji kedelai atau beberapa bahan pangan lainnya. Fermentasi menggunakan beberapa jenis kapang *Rhizopus*, seperti *Rhizopus oryzae*, dan beberapa jenis kapang *Rhizopus* lainnya.. Tempe merupakan makanan yang kaya akan serat pangan,seperti protein, kalsium, vitamin B dan zat besi. Coba kalian berikan contoh bahan pangan lain yang dapat diolah menjadi inovasi tempe selain kedelai sebanyak-banyaknya !	Tempe is a biotechnology product, its produced from fermented soybean seeds or some other food ingredients. Fermentation uses several types of *Rhizopus* mold, such as *Rhizopus oryzae*, and several other types of *Rhizopus* mold. Tempe is a food that is rich in dietary fiber, such as protein, calcium, B vitamins and iron. Try to give as many examples of other food ingredients that can be processed into tempeh innovations besides soybeans!
Students Answer : 	Students Answer : The ingredients that can be made into tempe besides soybeans are : “Koro” bean Peanut Cashew Almond Walnut Chickspeas Little red bean

Based on the student answers in table 2 above, it is good enough to provide answers in a fluent and varied manner, but there are still some students who have not been able to answer the questions with a perfect score. This happens because students more often use answers they remember from examples in textbooks so that they have not maximized the results of other thoughts to mention examples of correct answers but not as common as those already in the book. To provide examples of various answers to a problem, students can think broadly according to their understanding and abilities. The ability to think creatively can be obtained from everyday life experiences, apart from textbooks, namely sourced from information found on television or newspapers, as well as other learning sources so that students can respond smoothly to a question, in line with (Hennessey & Amabile 2009) is identifying, defining, and solving problems are important aspects of creative thinking

Flexibility is a skill that involves openness to create an idea in solving a problem from various perspective (Alrubaie & Daniel 2014). The flexibility aspect is the second lowest percentage after the originality aspect, which is 44.64% and is included in the low category. These results can be seen from the answers of students who are still not fully able to answer the questions given, besides

that students are also not able to produce new ideas that arise from other perspectives related to the problems presented in the questions. Students should be aware of how to generate new thoughts to solve problems but students only focus on convergent thinking processes because they are limited to verbal reasoning and logical thinking, so students are accustomed to convergent thinking, and if a problem is given, they will have difficulty solving the problem. creatively (Amalia et al. 2020). The following is an example of questions and answers from students on the flexibility aspect which can be seen in table 4 below.

Table 4. The examples of questions and answers from students on the flxibility aspect

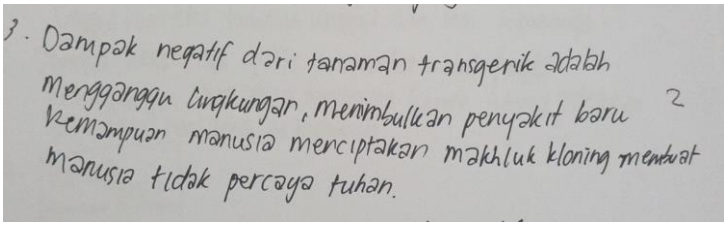
Original question and student answer	In English
Question : Scan Barcode dibawah ini menggunakan smartphone kalian kemudian baca artikel tersebut dengan teliti !	Question: Scan the barcode below using your smartphone then read the article carefully!
Link : http://bit.ly/3MVOsfX Setelah membaca artikel diatas, analisilah dan berikan tanggapan kalian tentang perananan bioteknologi terhadap produksi produk pangan!	Link : http://bit.ly/3MVOsfX After reading the article above, analyze and give your feedback about the role of biotechnology in the production of food products!
Student answer :  2. Permasalahan penyediaan pangan di Indonesia dapat diatasi dengan penggunaan bioteknologi terhadap Produksi produk pangan karena dinilai dapat meningkatkan kuantitas dan kualitas pertanian, sehingga diharapkan dapat meningkatkan produksi pangan nasional 2	Student answer : The problem of food supply in Indonesia can be overcome by using biotechnology for the production of food products, because it is considered to be able to improve the quality and quantity of agriculture, so that it is expected to increase national food production.

Based on student responses in table 4, students are able to answer questions but student answers are still not perfect in conveying new ideas or ideas in viewing and solving a problem. Supposedly, students are able to provide different interpretations of the questions presented, then students can classify various answers or write down ideas from the problems posed in these questions (Anderson, LW 2001). At the stage of creative thinking is part of the cognitive skills to propose a solution to a problem or make something useful and new than usual, as well as problem solving activities, can develop general cognitive skills that can be used to develop creative thinking skills (Trisnayanti et al. 2020).

After seeing the various student answers, the teacher realized that the students had not produced a new thought to solve the problem but the students only focused on convergent thinking processes because they were limited to verbal reasoning and logical thinking, so students were used to convergent thinking, and if a problem was given, they will have difficulty solving problems creatively (Amalia et al. 2020). One of the teacher's efforts to improve students' creative thinking skills in the aspect of flexibility, teachers can train students to use open or divergent questions. The combination of two thinking skills including convergent and divergent thinking skills can help students to develop creative thinking skills (Sumarmo et al. 2012).

The originality aspect obtained the lowest percentage score from other aspects, namely 40.36%. Originality is the ability of students to provide answers or opinions on a problem that is unusual or different from others where answers are rarely given by most people and the answers are original from the thoughts of each student. The answers contain ideas or ideas that are unique and different from those that exist. in books and other people's opinions. This aspect relates to aspects of fluency and flexibility where fluency and flexibility in students' thinking influences students' originality thinking, so if fluency and flexibility are maximally developed in learning activities, students' originality abilities will definitely also be visible (Fauziah et al. 2017). The following is an example of questions and answers from students on the originality aspect which can be seen in table 5 below.

Table 5. The example of question and answer from students on the originality aspect

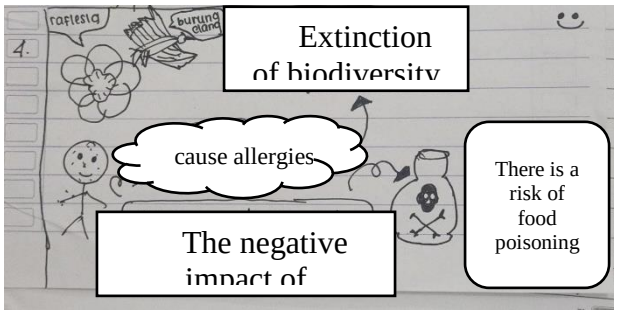
Original question and student answer	In English
Questions: Jelaskan menurut pendapat kalian bagaimana dampak negatif dari produk bioteknologi modern terhadap lingkungan ! Students Answer :  	Question : Explain in your opinion how the negative impact of modern biotechnology on the environment! Students Answer : The negative impact of transgenic plants is that they disturb the environment and cause new diseases. Human ability to create living things through cloning makes people do not believe in God

Based on the examples of student answers in table 5 above, it can be seen that student answers tend to have the same thoughts as their friends, and are still unable to provide more innovative and different solutions. This is in line with research conducted by other researchers on the same aspect, that aspects originality gets the lowest results from other aspects of creative thinking skills, because students still tend not to be able to, it is possible that students are still not able to create something original or original in accordance with the specified criteria. shows the wider the know-how, the more likely it is to bring up new ideas, so that they can influence one's original thinking abilities. (Trisnayanti et al. 2020).

The last aspect is Elaboration which gets a percentage score of 40.97%. In this aspect, the elaboration aspect occupies the second largest percentage score under the fluency aspect, even though the results are still in the low category. The elaboration aspect or detailed thinking is the student's ability to detail and find various approaches to problem solving (Munandar 2014). There are various efforts to develop creative thinking skills, teachers must cultivate curiosity in students, provide challenges to students, foster confidence that problems can be solved, and teach the ability that problems can definitely be solved. The following is an example of questions and answers from students on the flexibility aspect which can be seen in table 6 below.

Table 6. The examples of questions and answers from students on the elaboration aspect

Original Question and student answer	In English
Question: Buatlah rancanagan poster tentang dampak negatif penerapan bioteknologi ! Student answer:	Question : Make a poster design about the negative impact of applying biotechnology! Student answer:



Based on the examples of student answers in table 5 above, it can be seen that student answers are correct but still not detailed in making something more detailed and interesting. Effective training to enhance students' creative thinking usually focuses on strategies related to problem definition, conceptual combination, idea generation, and implementation planning (Walasari et al. 2019)

In general, the results of the average percentage of students' creative thinking skills in class X in biotechnology are still relatively low. This is because students are not used to facing questions that require them to think creatively. Students have not been trained to work on high-level thinking questions in accordance with the demands of 21st century skills and the demands of implementing an independent curriculum in which students are always given problems in each learning process that require students to think creatively. In addition, it also has to change learning that is used to using low-level thinking skills into learning that emphasizes higher-order thinking skills, one of which is creative thinking skills (Miri et al. 2007). Creative thinking skills are needed in online learning because students are required to learn independently and be able to find solutions to problems with new ideas. In the independent curriculum, creative thinking skills can be empowered through learning using models and PBL (Problem Based Learning) and PjBL, because each syntax of the learning model is able to direct students to apply higher-order thinking skills, one of which is creative thinking skills (Rahmawati 2023)

4. CONCLUSIONS

The results of data analysis and discussion can be concluded that the creative thinking skills of class X students in biotechnology material are still low. Judging from the four aspects of creative thinking skills, only the fluency aspect is in the moderate category and the other three aspects are in the low category. Therefore various efforts are needed to improve students' creative thinking skills in every aspect, especially in the aspects of flexibility, originality, and elaboration, because these three aspects are in the low category.

5. ACKNOWLEDGMENTS

Thank you to all parties who have assisted researchers in completing this research, especially to the Ministry of Education and Culture who have given me a PPG Prajabatan scholarship. In addition, thanks to the Universitas PGRI Madiun lecturers who guided and teached me and also the teachers at SMAN 6 Madiun who have given me the opportunity to complete this research.

6. REFERENCES

Alrubaie, F., & Daniel, E. G. S. (2014). Developing a Creative Thinking Test for Iraqi Physics Students. *International Journal of Mathematics and Physical Sciences Research*, *2*(1), 80–84. www.researchpublish.com

Amalia, Y., Sukarmin, & Suharno. (2020). Analysis of student's creative thinking skills profiles on work and energy topics. *AIP Conference Proceedings*, *2296*(April). https://doi.org/10.1063/5.0030396

Anderson, LW, & K. (2001). *Taksonomi untuk Belajar, Mengajar, dan Menilai: Revisi Taksonomi Tujuan Pendidikan Bloom*. Longman.

Anjarwati, P. G. P., Sajidan, S., & Prayitno, B. A. (2018). Problem-Based Learning Module of Environmental Changes to Enhance Students' Creative Thinking Skill. *Biosaintifika: Journal of Biology & Biology Education*, *10*(2), 313–319. https://doi.org/10.15294/biosaintifika.v10i2.12598

Bernie Trilling & Charles Fadel (2009). (2009). *21st Century Skills: Learning for Life in Our Times*. https://books.google.co.id/books?id=VUrAvc8OB1YC&printsec=frontcover&hl=id&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Daud, A. M., Omar, J., Turiman, P., & Osman, K. (2012). Creativity in Science Education. *Procedia - Social and Behavioral Sciences*, *59*, 467–474. https://doi.org/10.1016/j.sbspro.2012.09.302

Fauziah, R., Abdullah, A. G., & Hakim, D. L. (2017). Pembelajaran Saintifik Elektronika Dasar Berorientasi Pembelajaran Berbasis Masalah. *Innovation of Vocational Technology Education*, *9*(2). https://doi.org/10.17509/invotec.v9i2.4878

Florida, R., Mellander, C., & KIng, K. (2015). *Global Creativity Indeks*. 4–64. http://www-2.rotman.utoronto.ca/mpi/content/the-global-creativity-index-2015/

Guilford, J. P. (1987). *The Nature of Human IntelligenceNo Title*. McGraw-Hill.

Hamid, A. R. A. H. (2020). Social responsibility of medical journal: A concern for covid-19 pandemic. *Medical Journal of Indonesia*, *29*(1), 1–3. https://doi.org/10.13181/mji.ed.204629

Hennessey, B. A., & Amabile, T. M. (2009). Creativity. *Annual Review of Psychology*, *61*(1), 569–598. https://doi.org/10.1146/annurev.psych.093008.100416

Miri, B., David, B.-C., & Uri, Z. (2007). Purposely Teaching for the Promotion of Higher-order Thinking Skills: A Case of Critical Thinking. *Research in Science Education*, *37*(4), 353–369. https://doi.org/10.1007/s11165-006-9029-2

Munandar, U. (2009). *Mengembangkan Bakat Dan Kreativitas Anak Sekolah*. Gramedia.

Munandar, U. (2014). *Psikologi Kepribadian*. Grafindo Persada.

Nurdiana, H., Sajidan, & Maridi. (2020). Creative thinking skills profile of junior high school students in science learning. *Journal of Physics: Conference Series*, *1567*(2). https://doi.org/10.1088/1742-6596/1567/2/022049

Pratiwi, I. (2019). Efek Program Pisa Terhadap Kurikulum Di Indonesia. *Jurnal Pendidikan Dan Kebudayaan*, *4*(1), 51–71. https://doi.org/10.24832/jpnk.v4i1.1157

Rahmawati, Y. (2023). *Efektifitas Penggunaan E-Modul Berbasis Project Based Learning Terhadap Kompetensi Peserta Didik Pada Kurikulum Merdeka Belajar*. *4*, 293–300.

Riduwan. (2010). *Skala Pengukuran Variabel-Variabel Penelitian*. Alfa Beta.

Saputri, A. C., Sajidan, S., & Rinanto, Y. (2018). Critical thinking skills profile of senior high school students in Biology learning. *Journal of Physics: Conference Series*, *1006*(1). https://doi.org/10.1088/1742-6596/1006/1/012002

Sumarmo, U., Hidayat, W., Zukarnaen, R., Hamidah, M., & Sariningsih, R. (2012). KEMAMPUAN DAN DISPOSISI BERPIKIR LOGIS, KRITIS, DAN KREATIF MATEMATIK (Eksperimen terhadap Siswa SMA Menggunakan Pembelajaran Berbasis Masalah dan Strategi Think-Talk-Write). *Jurnal Pengajaran Matematika Dan Ilmu Pengetahuan Alam*, *17*(1), 17. https://doi.org/10.18269/jpmipa.v17i1.228

Trisnayanti, Y., Ashadi, Sunarno, W., & Masykuri, M. (2020). Creative thinking profile of junior high school students on learning science. *Journal of Physics: Conference Series*, *1511*(1). https://doi.org/10.1088/1742-6596/1511/1/012072

Ülger, K. (2016). Öğrencilerin Yaratici Düşünme Ve Eleştirel Düşünme Becerileri Arasindaki Ilişki. *Hacettepe Egitim Dergisi*, *31*(4), 695–710. https://doi.org/10.16986/HUJE.2016018493

Walasari, M., Widoretno, S., & Sutarno. (2019). The profile of interaction of creative thinking aspect through concept map based on content and context in the material of coordination system in human body. *AIP Conference Proceedings*, *2120*(March 2021). https://doi.org/10.1063/1.5115705

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Plasma Protein of Obese White Rats Treated with of Glucomannan Porang Tubers and Moringa Extract.

Sabila Dina Ikhsani, Endang Setyaningsih*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author e-mail address: es211@ums.ac.id

KEYWORDS:
Glucomanan
Moringa
Plasma Proteins
Obesity
White

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Living things have a fluid that flows throughout the body, namely blood. Blood contains blood cells as well as a fluid called blood plasma. Plasma is a mixture of blood with anticoagulants. Plasma protein levels are influenced by body weight, age, growth, etc. Weight in particular, is closely related to obesity. This study aimed to determine the blood plasma protein levels of obese white rats given a mixture of glucomannan porang tubers and moringa leaf extract. This research method uses true experimental which is prepared with a Complete Randomized Design (RAL) in the form of *posttest Only Control Design*. The data obtained were analyzed using One Way ANOVA SPSS version 20 followed by the Kruskal willis test. The results of this study showed plasma protein levels between groups, namely (P1) 1358.6; (P2) 1356.6; (P3)1356.6; (P4)1353.6; (P5)1356; (P6)1359; (P7)1357.6; (P8)1360 from the above results it can be concluded that the blood plasma protein levels of obese white rats treated with a mixture of glucomannan and Moringa leaf extract were the highest at 1360 g / dL and the lowest plasma protein levels of 1353.6 g / dL.

1. INTRODUCTION

Living beings have body fluids formed from living tissues and flow throughout the body through a network of vessels, the fluid is called blood. The total blood volume in the adult human body is about 3.6 L for women and 4.5 L for men. In the blood contains blood cells and a fluid called blood plasma which contains various nutrients and other substances about 55% of blood is a component of fluid or plasma, the remaining 45% is a component of blood cells; and the most blood cells are red blood cells or erythrocytes which account for 41% (Firani, 2018). Blood consists of two parts, namely blood plasma and blood cells. Blood cells are of three types, namely erythrocytes, leukocytes and platelets. The overall blood volume is one-twelfth of body weight or about five liters. About 55% is blood plasma, while the remaining 45% consists of blood cells (Fauzi et al ., 2019).

Plasma is a mixture of blood with anticoagulants. Anticoagulants are materials used to prevent blood clots. The most commonly used anticoagulants include EDTA, heparin, sodium citrate, ammonium oxalate, and calcium oxalate. Chemical tests, especially blood glucose tests, rarely even almost never use EDTA plasma specimens (Nur Ramadhani et al., 2019). Factors that affect blood plasma protein levels include weight, age, growth, hormonal, sex, pregnancy, lactation, nutrition, stress, and fluid loss. The biochemical concentration of blood plasma fluctuates with temperature and humidity fluctuations described in THI values. The decrease in triglyceride levels along with the increase in temperature and THI, indicates an increase in the catabolism of triglycerides into glycerol and fatty acids, so that these micronutires can be

involved in gluconeogenesis through the glyceraldehyde 3-phosphate pathway (Mushawwir et al., 2020).

Weight in particular, is closely related to obesity. Obesity and overweight are abnormal conditions of the body characterized by increasing excessive fat in the body. Excessive fat is generally stored in the subcutaneous tissue, around the organ, and sometimes infiltrated into the organ. Excessive accumulation of body fat results in various health problems. Low physical activity and consumption of foods high in simple sugars, fats, and proteins also have a role in the incidence of obesity (Suha & Rosyada, 2022). Excess body weight also affects differences in components in the body, there are significant differences in plasma chemerin levels in the obese group compared to non-obese. There was a significant difference in plasma chemerin levels in the group of obese with insulin resistance compared to non-insulin resistant obesity. There was a weak correlation of chemerin with HOMA-IR values in the obese group. There was a weak correlation of chemerin with HOMA-IR values in the insulin resistant obesity group (Dioni et al., 2020).

Obesity so far can be treated by improving a healthy diet by applying the principle of balanced nutrition to meet the Daily Value (RDA) both in meeting the needs of micronutrients and macronutrients and, doing physical activity, especially exercising is also one of the things that is often done to deal with obesity (Ardiani et al., 2021). But in addition to these two things, obesity can be treated with a diet using both generic and herbal drugs. Especially herbal medicines are often an option because they are considered more natural and safe for the body. One of the natural ingredients that can be used as an alternative to overcome obesity is porang tubers and moringa leaves.

Porang plant *(Amorphophallus muelleri Blume*) is one of the plants included in the family Araceae (taro-talasan) and belongs to the genus amorphophallus. The main content of porang plants is glucomannan found in tubers. Glucomannan is a hydrocolloid that has the ability to thicken and form gels so that it is widely used in various industries such as the food, chemical, biotechnology and pharmaceutical industries. The glucomannan content from the extraction contained in porang tubers is 38.5357±0.5014% (Wardani et al., 2021). Glucomannan can be used as a functional food provider of nutrients that provide satiety, because in it there is one of the active ingredients contained in porang and can be used by dissolving it in water. Glucomannan also has a role in decreasing and inhibiting blood lipids, inhibiting cancer, overcoming constipation, and reducing people with obesity (obesity) (Alamsyah, 2019).

While Moringa leaves (Moringa oleifera L), known to contain alkaloid compounds, saponins, phytosterols, tannins, polypheno, phenolics, and flavonoids that act as antioxidants. Moringa leaves are also known to contain Vitamin C 120 mg per 100gr. Moringa plant activity at a dose of 75 mg / kg is known to reduce total blood cholesterol levels of rats by 47.5%. The results of research that have been conducted can be concluded a significant decrease from the administration of Moringa leaf powder to blood glucose and cholesterol levels so as to improve lipid profiles by reducing cholesterol levels of obese individuals (Oktavisa et al., 2022). Based on research (Nahar et al., 2016) Moringa oleifera powder is useful as anti-obesity that can manage weight gain and administration of a single dose of Moringa leaf powder 50 mg / day / rat can reduce food intake and body mass index in obese control group rats, while the dose of 50 mg / day / rat for a day twice can result in a significant decrease in body mass index of obese control group rats.

Cholesterol testing at the laboratory level usually uses white rats (*Rattus norvegicus*). The white rat used in this study is a type of wistar strain with a characteristic wide head and ears, and a tail that is less than the length of its body (Wahyuni, 2022). White rats are test animals that are often used in obesity reduction research because white rats have more advantages compared to other test animals such as easy to handle, can be obtained in large quantities but the price is not too expensive, and has valid repeat results (Lahamendu et al., 2019). White rats

(Rattus norvegicus) are often used as food trials and food deficiencies in all types of animals including humans (Rejeki et al., 2018).

Porang has a relatively high glucomannan content of 50.84 – 70.70%, starch content 76.5%, protein 9.20%, fat 0.20%, fiber content 25 (Wigoeno et al., 2013). While according to (Nissa & Madjid, 2016) Giving a dose of 200 mg/kg body weight glucomannan in white rats induced with a high-fat diet was very effective in losing body weight and appetite of white rats. The yield of 70% ethanol extract of Moringa leaves is 357.85 g and the yield is 0.30% of the dry weight of simplisia 1180 g, while the yield of glucomannan porang tubers is 0.30% with purification results of 325.21 g from the dry weight of simplisia 2,500 g, flavonoid levels of ethanol extract 70% Moringa leaves maximum absorbance wave 420 nm, phenol content of ethanol extract 70% Moringa leaves maximum absorbance wave 730 nm, And the content in 100 g of glucomannan porang tubers has crude fiber 5.61%, soluble food fiber 10.32%, insoluble food fiber 9.53% and total dietary fiber 18.85% (Wati et al ., 2022).

2. MATERIALS AND METHODS

1.1. Place and time of study

This research will be carried out at the Biology Education Laboratory, Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta, Jl. A.Yani Tromol Post 1 Pabelan Kartasura Sukoharjo from October 2022 to September 2023 from taking the title to drawing conclusions.

1.2. Research tools and materials

The tools used in this study include (1) scales, (2) porang cutting tools, (3) flour selep machines, (4) sieves (40, 60 and 100 mesh), (5) ovens, (6) baking sheets, (7) centrifugation, (8) blenders, (9) matching vessels, (10) filter paper, (11) rotary evaporators, (12)digital scales, (13) rat cages, (14) oral sondes, (15) spaits, (16) freeze dryers, (17) centrifuges, (18)refectometer, (19)pipt drop, and (20)purple microtube. While the materials used include (1) porang tubers, (2) moringa leaves, (3) 24 white rats, (4) dreagendroff reagents, (5) iron (III) Chloride 1%, (6) HCl, (7) Magnesium powder, (8) ethanol 70%, (9) ethanol 50%, (10) aquades, (11) salt, (12) Comfeed BR-1, (13) high fat diet feed (Comfeed BR-1 (70%), duck egg yolk (5%), Beef oil (20%)), and (14) white rat blood.

1.3. Research design

This study used a *true experimental method* prepared with a Complete Randomized Design (RAL) in the form of *Posttest only control design* using 8 treatment groups, namely:

Group 1: Control group with normal feed.

Group 2: Control group with high-fat diet feed

Group 3: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 100 mg/kgBB (Nissa & Madjid, 2016) : 100 mg/kgBB.

Group 4: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 120 mg / kg BB : 80 mg / KgBB.

Group 5: High fat diet feed treatment group + glucomannan and Moringa leaf extract, 80 mg/kgBB: 120 mg/kgBB.

Group 6: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 50 mg/kgBB (Nugraheni et al., n.d.) : 50 mg/kgBB (Nahar, Faisal, Iqbal, et al., 2016)

Group 7: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 60 mg / kg BB : 40 mg / kg BB.

Group 8: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 40 mg/kgBB: 60 mg/kgBB.

1.4. Population and sample

The population of plasma level test animals used was 8 white rats of wistar *strain (Rattus norvegicus), while* the sample used white rats of wistar strain (Rattus norvegicus*) from the results of random sampling with criteria: male sex, age 2 months, weight 200 grams.*

1.5. Data analysis

The results of mouse blood plasma measurements were analyzed statistically using One Way Analysis of Variance (ANOVA) SPSS version 20 followed by the Willis crucial test.

3. RESULTS AND DISCUSSION

Normal standards of protein levels in rat blood serum according to (Sammad & Santoso, 2017) is 6-8 g/dl. Significant differences in plasma chemerin levels in the obese group compared to non-obese. There was a significant difference in plasma chemerin levels in the group of obese with insulin resistance compared to non-insulin resistant obesity. There was a weak correlation of chemerin with HOMA-IR values in the obese group. There was a weak correlation of chemerin with HOMA-IR values in the insulin resistant obesity group (Dioni et al., 2020). Based on the results of blood plasma protein levels in the treatment group can be seen in the following table:

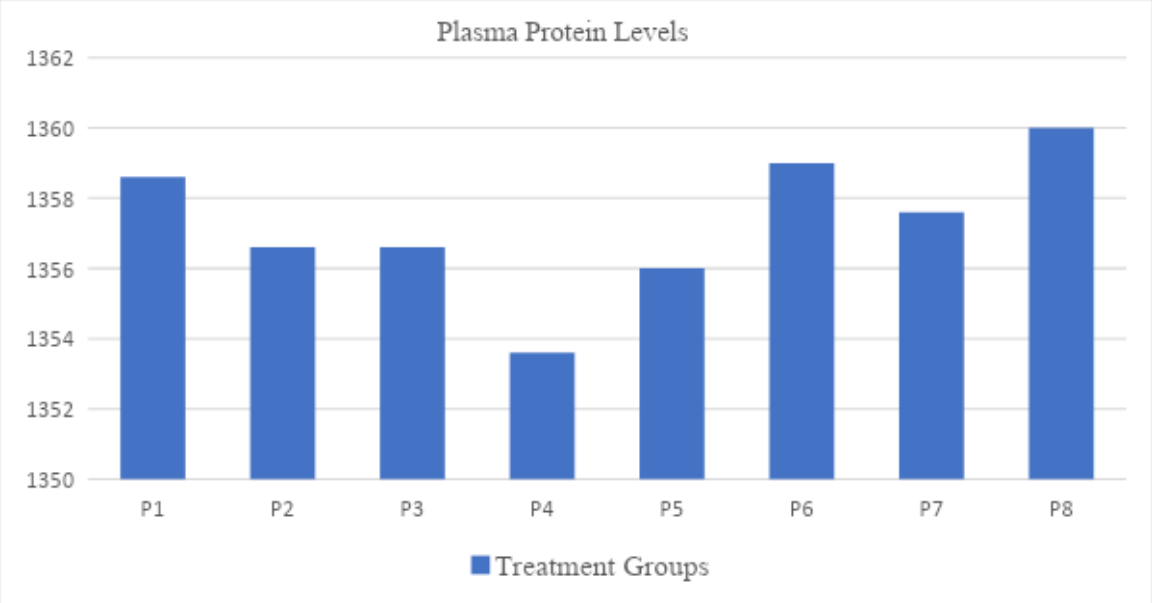


Figure 1. Results of plasma protein levels

Based on the results of the study, blood plasma protein levels of obese rats in the P1 treatment group of the control group with normal feed showed plasma protein levels of 1358.6 g / dL, in the P2 treatment group of the control group with high-fat diet feed showed plasma protein levels of 1356.6 g / dL, in the P3 treatment group of the control group with high-fat diet feed + glucomannan and Moringa leaf extract 100 mg / kg BB: 100 mg / kg BB showed

plasma protein levels of 1356.6 g / dL, in the control group P4 treatment group with high-fat diet feed + glucomannan and Moringa leaf extract 120 mg / kg BB: 80 mg / KgBB showed plasma protein levels of 1353.6 g /dL, in the control group P5 treatment group with high-fat diet feed + glucomannan and Moringa leaf extract, 80 mg/kgBB: 120 mg/kgBB showed plasma protein levels of 1356 g/dL, in the P6 treatment group control group with high-fat diet feed + glucomannan and moringa leaf extract 50 mg/kgBB: 50 mg/kgBB showed plasma protein levels of 1359 g/dL, in the P7 treatment group control group with high-fat diet feed + glucomannan and moringa leaf extract 60 mg/kgBB: 40 mg/kgBB showed plasma protein levels of 1357.6 g/dL, in the control group P8 treatment group with high-fat + glucomannan diet feed and moringa leaf extract 40 mg/kgBB: 60 mg/kgBB showed plasma protein levels of 1360 g/dL.

The highest plasma protein levels were found in the P8 treatment group, which was 1360 g / dL with a dose of Glucomannan 40: Moringa 60 (mg / kg BB) while the lowest plasma protein value was found in the P4 treatment group which was 1353.6 g / dL with a dose of Glucomannan 120: Moringa 80 (mg / kg BB), rat plasma protein levels that were close to normal levels at the lowest results or P4 treatment was due to normal standards of plasma protein levels of 6-8 g / dL. Obesity affects the increase in plasma protein levels in rats because there is a relationship between the incidence of obesity and protein consumption so that it will automatically affect plasma protein levels in the blood (Halim et al., 2022). The unnatural difference in normal plasma protein levels with the results in the treatment group was caused by several factors, one of which was when the blood serum separation process used centrifuges that were too long so as to make the serum too thin and increase the value on the refactometer. In addition, the increase in blood plasma protein levels is also caused by the use of EDTA plasma as in research (Munabari et al., 2022) regarding the effect of using serum specimens and EDTA plasma on total protein levels found that there is a marked difference in protein levels using EDTA plasma higher than serum.

Then, to determine the effect of a mixture of glucomannan porang tubers and Moringa leaf extract on blood plasma protein levels between the control and treatment groups, statistical tests were carried out which can be seen in the following table. Based on the results of the normality test, the significance value is 0.000 ($P < 0.05$), then the data is said to be abnormal and a follow-up test is carried out, namely the homogeneity test with the following results. The results obtained from the homogeneity test are 0.000 ($P < 0.05$), then the data is declared inhomogeneous. Because the data is not homogeneous, further tests are carried out using the crucial willis test with the results listed in the following table:

Table 2. Statistical test results of plasma protein levels (Tests of Normality and Homogeneity of Variance)

Treatments	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	f	Sig.
P1	.385	3	.	.750		.000
P2	.385	3	.	.750		.000
P3	.385	3	.	.750		.000
P4	.385	3	.	.750		.000
P5	.	3	.	.		.
P6	.	3	.	.		.
P7	.385	3	.	.750		.000
P8	.	3	.	.		.

Treatments	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	f	Sig.

		Levene Statistic		df1	df2	Sig.
	Based on Mean	10.286		7	16	.000
	Based on Median	.643		7	16	.715
	Based on Median and with adjusted df	.643		7	4.946	.713
	Based on trimmed mean	8.102			16	.000

Table 4. Test results of Kruskal-Wallis of plasma protein levels

Test Statistics[a,b]	
	plasma darah
Kruskal-Wallis H	14.612
df	7
Asymp. Sig.	.041

a. Kruskal Wallis Test
b. Grouping Variable: Kelompok Perlakuan

When viewed from the results of the Willis crucial test above, the significance value shows a number of 0.041 (P < 0.05) which means there is no difference between the treatment and control groups.

The statistical test carried out is a normality test with the aim of finding out whether the data is normally distributed or not. The results show a significance value of 0.000 (P < 0.05), then the data is said to be abnormal and a follow-up test is carried out, namely a homogeneity test with the aim of knowing that two or more groups of data samples are taken from populations that have the same variance. The homogeneity test results show a significance number of 0.000 (P < 0.05), so the data is declared inhomogeneous. Because the data is not homogeneous, further tests are carried out using the Willis crucial test. The results of the crucial willis test above, the significance value showed a number of 0.041 (P < 0.05) which means there is no difference between the treatment and control groups.

Porang flour can lose weight and reduce food intake in obese rats (Nissa & Madjid, 2016), So it is possible to reduce protein levels in the blood plasma of mice. The administration of bidara leaf extract was significantly different (P<0.05) on total plasma protein levels, but not significantly different (P>0.05) on albumin levels and Padjadjaran quail blood plasma globulin. Giving bidara leaf extract at a dose of 0.2% in the ration was able to increase the total blood plasma protein levels of Padjadjaran quail optimally within the normal range (Andini, 2022). However, based on statistical tests, the blood plasma protein levels of obese white rats with a significant value of 0.041 (P < 0.05) showed that the administration of a mixture of glucomannan in porang tubers and Moringa leaf extract did not have a real effect on the difference in plasma protein levels between the treatment and control groups seen from the measurement results (P1) 1358.6 g / dL; (P2) 1356.6 g/dL; (P3)1356.6 g/dL; (P4)1353.6 g/dL; (P5)1356 g/dL; (P6)1359 g/dL; (P7)1357.6 g/dL; (P8)1360 g/dL which did not undergo significant changes with different dose administrations.

The administration of a mixture of glucomannan porang tubers and Moringa leaf extract which had no effect on differences in blood plasma protein levels in obese white rats was in line with research (Sammad & Santoso, 2017) to determine the effect of giving methanolic extract of Scurrulla atropurpurea (Bl) Dans on total protein levels and serum albumin of female rats for 28 days. It was found that at doses of 250 mg / kg body weight (BB), 500 mg / kg body weight and 1000 mg / kg body weight had no effect on the levels of Total Protein and Albumin serum rats. Similar results were also found in the study (Afifah, I., & Sopiany, 2017) which was done to determine the toxicity effect of the presence of alginate extracted from brown seaweed Turbinaria sp. due to the content of blood protein, albumin, and globulin from the blood serum of wistar rats. The study was conducted with Complete Randomized Design (CRD) with alginate concentration treatment of 0.5%; 0.75%; 1%, and negative control. The results showed that treatment of up to 1% of the concentration of alginate did not exert a toxic effect on the liver. Both references support the results of this study that the mixture of glucomannan and Moringa leaf extract does not have a real effect or is not effective for reducing plasma protein levels.

4. CONCLUSIONS

Blood plasma protein levels of obese white rats treated with a mixture of glucomannan and Moringa leaf extract were the highest at 1360 g / dL and the lowest plasma protein levels at 1353.6 g / dL. A mixture of glucomannan and moringa daum extract had no significant effect on the difference in plasma protein levels between the treatment and control groups.

5. ACKNOWLEDGMENTS

Author would like to thank Miss Endang Setyaningsih S.Si.,M.Si as supervisor and University Muhammadiyah Surakarta as the location for this research.

6. REFERENCES

Afifah, I., & Sopiany, H. M. (2017). Efek Paparan Alginat Dalam Pangan Terhadap Kadar Protein Total, Albumin Dan Globulin Darah. Buana Sains, *87*(1,2), 149–200.

Alamsyah, M. (2019). *The effect of Glucomannan on reducing the risk of Ischemic Stroke Metode*. *Jurnal Ilmiah Kesehatan Sandi Husada*, *10*(2), 292–298. https://doi.org/10.35816/jiskh.v10i2.171

Andini, D. (2022). *Pengaruh Pemberian Ekstrak Daun Bidara (Ziziphus Spina- Christi L.) Dalam Ransum Terhadap Kadar Total Protein, Albumin, Dan Globulin Plasma Darah Puyuh Padjadjaran*. 156–166.

Ardiani, H. E., Permatasari, T. A. E., & Sugiatmi, S. (2021). Obesitas, Pola Diet, dan Aktifitas Fisik dalam Penanganan Diabetes Melitus pada Masa Pandemi Covid-19. *Muhammadiyah Journal of Nutrition and Food Science (MJNF)*, *2*(1), 1. https://doi.org/10.24853/mjnf.2.1.1-12

Dioni, S., Rini, E. A., & Yerizel, E. (2020). Hubungan Kadar Plasma Chemerin dengan Homeostasis Model Assessment Insulin Resistance pada Remaja Obesitas. *Sari Pediatri*, *22*(1), 24. https://doi.org/10.14238/sp22.1.2020.24-9

Fauzi, M., & Bahagia, S. N. (2019). Pengambilan Keputusan Komponen Darah Dalam Pengendalian Persediaan Dengan Menggunakan Metode Ahp Di Pmi Kota Bandung. *Jurnal Ilmiah Teknologi Infomasi Terapan*, *5*(2), 13–20. https://doi.org/10.33197/jitter.vol5.iss2.2019.276

Firani, novi khila. (2018). *mengenali sel-sel darah dan kelainan darah*. UBPRESS.

Halim, Ago; Bontong, Stella Irene; Rahfiludin, M. Z. (2022). *Relationship between Carbohydrate , Protein , and Fat Consumption with Obesity Incidence in 2014 UKI Faculty of Medicine Students*. *6*(4). https://doi.org/10.20473/amnt.v6i4.2022.385-391

Lahamendu, B., Bodhi, W., & Siampa, J. P. (2019). Uji Efek Analgetik Ekstrak Etanol Rimpang Jahe Putih (Zingiber Officinale Rosc.Var. Amarum) Pada Tikus Putih Jantan Galur Wistar (Rattus norvegicus). *Pharmacon*, *8*(4), 927. https://doi.org/10.35799/pha.8.2019.29372

Munabari, F., & Syahputra, A. (2022). Pengaruh Penggunaan Spesimen Serum Dan Plasma Edta Terhadap Kadar Total Protein. *Jurnal Pranata Biomedika*, *1*(2), 134–140. https://doi.org/10.24167/jpb.v1i2.5153

Mushawwir, A., Yulianti, A. A., Suwarno, N., Permana, R., Peternakan, F., & Padjadjaran, U. (2020). Profil Metabolit Plasma Darah dan Aktivitas Kreatin Kinase Sapi Perah Berdasarkan Fluktuasi Mikroklimat Lingkungan Kandangnya. *Jurnal Veteriner*, *21*(1), 24–30. https://doi.org/10.19087/jveteriner.2020.21.1.24

Nahar, S., Faisal, F. M., & Iqbal, J. (2016). *Antiobesity activity of Moringa oleifera leaves against high fat diet-induced obesity in rats IJBCP International Journal of Basic & Clinical Pharmacology Research Article Antiobesity activity of Moringa oleifera leaves against high fat diet-induced obesity in rats*. *August*. https://doi.org/10.18203/2319-2003.ijbcp20162427

Nahar, S., Faisal, F. M., Iqbal, J., Rahman, M., & Yusuf, A. (2016). *IJBCP International Journal of Basic & Clinical Pharmacology Research Article Antiobesity activity of Moringa oleifera leaves against high fat diet-induced obesity in rats*. *5*(4), 1263–1268.

Nissa, C., & Madjid, I. J. (2016). *Potensi glukomanan pada tepung porang sebagai agen anti-obesitas pada tikus dengan induksi diet tinggi lemak*. *13*(1), 1–6.

Nugraheni, B., Cahyani, I. M., & Herlyanti, K. (n.d.). *Efek Pemberian Glukomanan Umbi Porang (Amorphophallus oncophyllus Prain ex Hook . f .) Terhadap Kadar Kolesterol*. 32–36.

Nur Ramadhani, Q. A., Garini, A., Nurhayati, N., & Harianja, S. H. (2019). Perbedaan Kadar Glukosa Darah Sewaktu Menggunakan Serum Dan Plasma Edta. *JPP (Jurnal Kesehatan Poltekkes Palembang)*, *14*(2), 80–84. https://doi.org/10.36086/jpp.v14i2.407

Oktavisa, Anggeria; yuliana, Rahayu; fauziyah, E. (2022). *Serbuk Daun Kelor Efektif Menurunkan Kadar Glukosa Darah dan Kadar Kolesterol pada Individu Obese*. *12*(1), 10–16.

Rejeki, P. S., Putri, E. A. C., & Prasetya, R. E. (2018). Ovariektomi Pada Tikus Dan Mencit. In *Airlangga University Press*.

Sammad, F. H. A., & Santoso, H. (2017). *e − JBST 2017 e − JBST 2017 Material dan Metode*. *2*, 49–54.

Suha, G. R., & Rosyada, A. (2022). *Faktor-faktor yang berhubungan dengan kejadian obesitas pada remaja umur 13 – 15 tahun di Indonesia (analisis lanjut data Riskesdas 2018) Program Studi Ilmu Kesehatan Masyarakat , Fakultas Kesehatan Masyarakat , Universitas Sriwijaya*. *06*(01), 43–56.

Wahyuni, I. S. (2022). *Anti-Inflammatory Activity and Wound Healing Effect of Kaempferia galanga L . Rhizome on the Chemical-Induced Oral Mucosal Ulcer in Wistar Rats*. *April*, 2281–2294.

Wardani, N. E., Subaidah, W. A., & Muliasari, H. (2021). Ekstraksi dan Penetapan Kadar Glukomanan dari Umbi Porang (Amorphophallus muelleri Blume) Menggunakan Metode DNS. *Jurnal Sains Dan Kesehatan*, *3*(3), 383–391. https://doi.org/10.25026/jsk.v3i3.574

Wigoeno, Y. A., Azrianingsih, R., Roosdiana, A., Biologi, J., Kimia, J., & Timur, J. (1967). *Analisis kadar glukomanan pada umbi porang (*. *1*, 231–235.

Wati, D. P., & Setyaningsih, E. (2022). Efrektivitas Kombinasi Glukomanan Umbi Porang (*Amorphophallus muelleri Blume*) Dan Ekstrak Daun Kelor (*Moringa oleifera*) Terhadap Penurunan Obesitas. (Skripsi Sarjana, Universitas Muhammadiyah Surakarta)

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Effectiveness of *Flipped Classroom* Model with Instagram in Junior High School

Mega Amartya Istighfarin, Lina Agustina*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: la263@ums.ac.id

KEYWORDS:
Flipped Classroom
Instagram
Science Learning

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Science learning is still something that students avoid because it requires perseverance, seriousness, and many experiments. This problem can be overcome using interactive learning media and following the independent curriculum. However, learning media must align with technological developments in this digital era. Therefore, with the flipped classroom learning model, one uses Instagram social media as a science learning medium. This study aimed to determine the effectiveness of *flipped classroom* learning with Instagram media on ecology and biodiversity class VII material in one of the junior high schools in Klaten Regency. This quantitative experimental study uses the *N-Gain Score* test with a one-group pretest-posttest *design* to measure the improvement of cognitive learning outcomes before and after. The results showed that the application of *flipped classroom learning* assisted by Instagram media on ecology and biodiversity material on student learning outcomes was included in the practical category with an interpretation of the N-Gain value of 0.77.

1. INTRODUCTION

Science learning is learning that prioritizes process skills. Science learning has a crucial role in the development of technology and science. However, science learning is still a subject that students avoid because it requires perseverance and much experimentation (Azzahra et al., 2022). One can overcome this by using interactive learning media that are per the application of the independent curriculum and can provide meaningful learning for students (Wahyu et al., 2020). An effort to improve education to meet the challenges of the times is the implementation of an independent curriculum. So that an implementation of this new curriculum must be welcomed with maximum readiness so as not to have a destructive impact that reduces the quality of education and learning (Taupik, 2022). The implementation of this independent curriculum was followed by the Industrial Revolution 4.0 towards Society 5.0, so that teachers are required to be more creative and innovative in learning. The creation of advanced technology that can expand the distribution of information is a characteristic of the Industrial Revolution Era 4.0 (Dwipayana et al., 2020).

In the digital era like today, learning media must align with technological developments. Learning media must be attractive to students and can be attached to them. Today, most children in the digital age like and enjoy using Instagram and other social media. So that Instagram can be used as an exciting and interactive science learning medium because its use is easy and various features are available (Mufidah & Mufidah, 2021). Various features on Instagram support the science learning process, including feed posts useful for sharing material before learning, Instagram TV, which is helpful for teachers in explaining the material, and Instagram Live, which

is useful for interaction with students about learning (Veygid et al., 2020). Because Instagram provides photo editing options that make it better and more pleasant, it can also encourage and boost creativity in its users (Dwi, 2012). The use of Instagram as a learning medium allows teaching and learning activities to be carried out outside the classroom. So that the learning model that can be applied is the flipped classroom.

According to (Octavia, 2020), A learning model is a plan or pattern that can be used to determine teaching patterns and learning tools. The learning model where students learn the material first at home before learning it in class is the "flipped classroom" model (Agustini, 2021). The flipped classroom is a learning model in general teaching, and learning activities carried out in the classroom will be carried out outside the classroom or at home. However, when in class, the activities carried out by students only discuss things that have been learned outside the classroom or at home (Damayanti & Sutama, 2016). This "flipped classroom" learning model applies technology as a medium of learning. The application of technology in question is the use of video or other media as learning content for students to learn at home before doing face-to-face activities in class (Yulianti & Wulandari, 2021). The principle of using the media itself is effective and efficient, helps shorten the delivery time of teaching materials, and can stimulate the creativity of educators when getting new information through the media (Budiyono, 2020).

The "flipped classroom" learning model has advantages and disadvantages. The advantages of Flipped Classroom are: a) students can repeat the video until they understand the material; unlike in ordinary learning, if students do not understand, then the teacher must explain again until they can understand, so it is less efficient; b) students can access the video from anywhere as long as they have an internet connection; it can even be downloaded, and they are more satisfied to watch it repeatedly; and c) efficient, because students are asked to study the material at home and in class, they can focus more on their difficulties in understanding the material or their ability to solve problems related to the material (Damayanti & Sutama, 2016).

The disadvantages of flipped classroom learning are: a) students do not ask for material that has not been understood when experiencing internet problems when accessing videos and learning materials at home; and b) teachers cannot ascertain whether students have learned videos and learning materials at home (Yildirim & Kiray, 2016). The weaknesses of this learning model can be overcome by maximizing the advantages of the flipped classroom learning model and Instagram media. Likewise, during face-to-face learning, teachers can review the material through Instagram media to determine whether students have understood it.

In research from Pratama (2021), it was stated that applying the Flipped Classroom learning model can improve the learning outcomes of grade VIII Junior High School students in the Bojonegoro area. The results showed that the N-Gain score of 75% means that it is in the high category. Strengthened by research from Sinatrya (2020), there are differences in student learning outcomes, which shows that the Flipped Classroom learning model using Instagram is effective. The study results obtained a pretest score of 63.31 and a posttest score of 96.37, meaning a significant increase. This study aimed to determine the learning outcomes of Flipped Classroom learning with Instagram media on class VII ecology and biodiversity material in one of the Junior High Schools of Klaten Regency.

2. METHODS

2.1. Types of Research

This study is a pre-experimental study using a one-group pretest-posttest design. Pre-experimental research is a form of experimental research design that manipulates independent variables to influence the formation of dependent variables. The research approach is quantitative because the data is in the form of numbers and is analyzed using statistics. The study consisted of two research variables: the flipped classroom learning model as an independent variable and student learning outcomes as a dependent variable.

2.2. Place And Time of Research

This research was conducted at SMP Negeri 1 Cawas in Klaten district, Central Java. The study was conducted from February to April 2023.

2.3. Population, Sample dan Sampling

The population in this study was all grade VII students of SMP Negeri 1 Cawas. The sample taken in this study was class VII SMP Negeri 1 Cawas, which amounted to 32 students using random sampling, namely simple random sampling.

2.4. Data Collection Techniques

2.4.1. Test

The test used in this study is a written test consisting of an initial test (pretest) before learning flipped classroom with Instagram and a final test (posttest) after learning flipped classroom with Instagram. The number of pretest and posttest questions is 20 with multiple-choice question types.

2.4.2. Observation

In this study, observation was carried out by observing the discussion activities of students during classroom learning. The instrument used in making observations is a checklist in the form of a Likert scale in the range of points 1-3.

2.5. Implementation Procedure

Before carrying out research, research instruments are made necessary for classroom learning. After that, a validity test is carried out to determine whether or not the research instrument to be used is valid. After the instrument is declared valid, research is carried out using an initial test (pretest) before the application of flipped classroom learning and a final test (posttest) after the provision of flipped classroom learning. During the flipped classroom, student activities were observed using observation sheets. The final stage is processing pretest and posttest data with the N-Gain Score test using SPSS 20, while student activity observation data is processed using descriptive statistical analysis. Only then is a conclusion made.

2.6. Data Analysis Techniques

2.6.1. Prerequisite Test

2.6.1.1. Normality Test

The normality test is used to determine whether or not the data taken is from a normally distributed population. The normality test using the Shapiro-Wilk test is calculated with SPSS 20.

2.6.1.2. Homogeneity Test

The homogeneity test is used to find out whether the sample groups used to come from the same varied population (homogeneous) or not. The homogeneity test is calculated with SPSS 20.

2.6.2. N-Gain Test

To calculate the results of the pretest and posttest using the formula according to (Hake, 1999)

$$\text{N-Gain} = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimum - Skor\ Pretest} \times 100\%$$

The categorization of the results of the N-Gain test corresponds to the following Table 1:

Table 1. Category of N-Gain Score Test

Persentage	Category
<40	Ineffective
40 – 55	Less Effective
56 – 75	Quite Effective
>76	Effective

2.6.3. Statistical Descriptive Analysis

To find out the value of the results of observing student activities by using the formula (Arikunto, 2019)

$$\text{NA} = \frac{Jumlah\ skor\ yang\ diperoleh}{Jumlah\ skor\ maksimal} \times 100\%$$

Categorizing the results of the final value calculation according to the following Table 2:

Table 2. Categories of Statistical Descriptive Values

Percentage	Category
86% - 100%	Excellent
76% - 85%	Good
66% - 75%	Enough
56% - 65%	Less
30% - 55%	Very Lacking

3. RESULTS AND DISCUSSION

3.1. Result

This research was conducted at SMP Negeri 1 Cawas using one experimental class, namely class VII, totaling 32 students in the even semester of the 2022–2023 school year. The study used pre-experiment research with a pretest-posttest group design to determine the effectiveness of the flipped classroom learning model using Instagram on student learning outcomes on ecology and biodiversity material in grade VII junior high school. The experimental class was given a treat, namely the application of the flipped classroom learning model in the science learning process

with the help of Instagram media. Cognitive data were obtained through pretests and posttests, while affective data were obtained through observation of student activity.

3.1.1. Normality Test

The normality test results using the Shapiro-Wilk test in the SPSS 20 program, with significant criteria if < 0.05, then the data are not normally distributed. If > 0.05, then the data are typically distributed, as can be seen in Table 3:

Table 3. Normality Test Results Data Using Shapiro-Wilk Test Learning Outcomes Cognitive Grade VII Junior High School in Klaten Regency

Statistisc test	**Student Learning Outcomes Test**	
	Pretest	***Posttest***
Sig.	0.127	0.90
Uji *Shapiro-Wilk*	0.05	0.05
Kesimpulan	**Normal**	**Normal**

Based on Table 3 shows that pretest and posttest data are normally distributed. This corresponds to the normally distributed data significance criterion if the *Sig*. Value is more significant than 0.05. So it can be concluded that the pretest and posttest data from the learning outcomes in class VII in one of the Junior High Schools of Klaten Regency are normally distributed.

3.1.2. Homogeneity Test

The homogeneity test results were calculated using SPSS 20, with significant criteria if > 0.05, then the variance in each homogeneous group can be seen in Table 4:

Table 4. Data on the Homogeneity Test Results of Class VII Cognitive Learning Outcomes Junior High School in Klaten Regency

Statistics	**Student Learning Outcomes Test**
Sig.	0.313
Homogeneity of Variance	0.05
Conclusion	**Homogen**

Based on Table 4 shows that the Sig. score on the student learning outcome test is more significant than 0.05. Following the test criteria, if the value of *Sig*. > 0.05, then the sample has a homogeneous variance. Based on this explanation, it can be concluded that class VII in one of the Junior High Schools of Klaten Regency comes from a homogeneous population.

3.1.3. N-Gain Test

N-Gain test results were calculated after prerequisite tests (normality and homogeneity tests) using SPSS 20, with percentage criteria < 40 categorized as ineffective, 40 – 55 categorized as less effective, 56 – 75 categorized as quite effective, and > 76 categorized as effective. It can be seen in Table 5:

Table 5. N-Gain Score Test Results Data Class VII Cognitive Learning Outcomes Junior High School in Kabupaten Klaten

	Pretest	***Posttest***	**N-Gain *Score* (%)**
Lowest Rated	15	65	77.46
Top Rated	80	100	
Average	39.06	84.53	
Category			**Effective**

Based on Table 5 shows that the mean value is 77.46, which means > 76. Therefore, it can be concluded that the average pretest and posttest data of grade VII students in one of the Junior High Schools of Klaten Regency.

3.1.4. Statistical Descriptive Analysis

The results of descriptive statistical analysis of the results of observations of student activities during learning, with average percentage criteria of 86% - 100% = excellent, 76% - 85% = good, 66% - 75% = sufficient, 56% - 65% = less, 30% - 55% = significantly less. It can be seen in Table 6:

Table 6. Data from Descriptive Analysis of Student Activity Observation Statistics During Class VII Junior High School Science Learning in Klaten Regency

Meeting	**Percentage (%)**	**Average**
I	85.6%	89.6%
II	92.4%	
III	90.7%	
Category		**Very Good**

Based on Table 6 shows that the average acquisition of descriptive statistical analysis is 89.6%, so effective learning outcomes are categorized as very good.

3.2. *Discussion*

This flipped classroom learning was carried out in one of the junior high schools in Klaten Regency. This study aims to determine the effectiveness of the flipped classroom learning model with Instagram media on student learning outcomes in science learning. To obtain data on student learning outcomes, tests are carried out: the initial test (pretest) before being given Flipped Classroom learning and the final test (posttest) after being given Flipped Classroom learning. Then the pretest and posttest results are compared to find out whether there is a difference before and after being given flipped classroom learning with Instagram.

Based on a descriptive analysis of student activity statistics during flipped classroom learning with Instagram, results were obtained that fall into the excellent category, namely 89.6%. Assessment of student activities during flipped classroom learning using Instagram by observing student behavior when discussing group learning in class and through Instagram media The results of the teacher's observations of student activities are written on observation sheets that the teacher has prepared before learning according to the rubric. The discussion activities carried out by students during group learning are excellent because students have learned the material and activities that will be carried out in class through Instagram media. So that students already know what will be discussed and what must be prepared for group learning in class.

The following is a data display from the results of a descriptive analysis of student activity statistics during flipped classroom learning with Instagram:

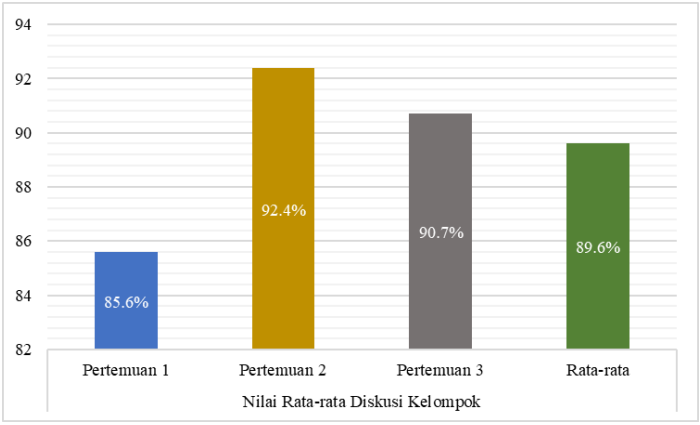


Figure 1. Chart of Descriptive Analysis Results of Student Activity Statistics During Learning Flipped Classroom with Instagram at one of the junior high schools in Klaten Regency

The lowest result was at the first meeting, and the highest was at the second. At the time of the first meeting, students were still adapting to learning the flipped classroom model using Instagram. Instagram is currently a social media platform in great demand among teenagers. Although Instagram is familiar to junior high school students, its use is less than a learning medium. And also, the flipped classroom learning model has never been applied to science learning in this school, so students still feel the concept of flipped classroom learning with Instagram. However, the second and third meetings showed high results, meaning that students already understand and feel suitable for applying Flipped Classroom with Instagram to science learning.

Before conducting the N-Gain test, prerequisite tests were carried out, namely the normality and homogeneity tests. The results of the normality test with the Shapiro-Wilk test using SPSS 20 showed that pretest and posttest data from grade VII learning outcomes in one of the junior high schools in Klaten district had a significance of > 0.05, namely 0.127 for the pretest and 0.90 for the posttest. From these results, it can be concluded that the data is normally distributed. Then a homogeneity test showed that the sig. value on the student learning outcomes test (pretest and posttest) was more significant than 0.05, which is 0.313, so it can be concluded that class VII comes from a homogeneous population. Based on the results of the normality test, which shows normally distributed data, and the homogeneity test, which shows a homogeneous class, it can proceed to the N-Gain test to calculate the effectiveness of the treatment given.

The results of the N-Gain test showed the average percentage of effective cognitive learning outcomes, which was 77.46%. These results indicate that flipped classroom learning using Instagram in grade VII junior high school science learning is effective. It is said to be effective because the average percentage of cognitive learning outcomes obtained is > 76, which means there is a significant difference between the pretest and posttest results. From the results of the N-Gain test, which states that it is effective, the application of flipped classroom learning using Instagram in science learning can be accepted and followed well by students. Flipped classroom learning encourages students to be more active and creative with group learning. So learning is not boring because it is not only teacher-centered, and learning in the classroom is more efficient because the material has been delivered through Instagram. The use of Instagram media is also

very interesting for students because the display of material is more interesting, and learning resources are also getting more comprehensive and can be easily accessed.

The application of learning media using social media, namely Instagram, certainly influences students. There are two types of influences: good influence and bad influence. The destructive effects of using Instagram include reducing student learning time because there is a lot of information that students can access when using Instagram. Students become less socialized with the surrounding environment if they are not controlled by the application. Positive influences from the use of online applications and media include socializing (Hasiholan et al., 2020). Second, sharing knowledge with the Instagram application can indirectly provide convenience and effectiveness for students to share knowledge. Third, by updating themselves through the Instagram application, students can easily find new things or knowledge, like what happens and when. Fourth, learning from various sources: advances in communication technology in the current era make it easy for individuals to obtain lessons from various sources (Madhani et al., 2021).

Based on the results of the research that has been done, the influence of using Instagram as a learning medium is positive. Students become more active in group discussion activities and can work well together. Similarly, students' cognitive learning outcomes show that Instagram media can help students with problems with improving grades. Using Instagram in learning, students can explore knowledge widely from various sources they need. Students can also interact with other friends on Instagram to exchange information and knowledge. In this way, teachers teach students to be more able to use social media for positive things, one of which is to learn.

The flipped classroom learning model emphasizes not just learning to use images and videos displayed through Instagram media but also utilizing time in class to make learning more meaningful (Yulietri & Mulyoto, 2015). By studying the material at home first, time in class can be maximized for experimental activities, which are often rushed and not optimal when implemented due to time constraints. In addition, flipped classroom learning creates good communication between teachers and students (Sumarni et al., 2020). The flipped classroom learning model is very efficient in science learning, so students can accept it because it does not take too much time to listen to material in class. Especially when group learning and experiments will be carried out, this learning model is beneficial for shortening time.

Every time you do an activity, you will undoubtedly encounter an obstacle, both small and large. The application of the flipped classroom learning model with Instagram in science learning in grade VII junior high school also encounters obstacles. When learning through Instagram, two students still do not have personal cell phones, so they still use their parents' cell phones. This causes students to sometimes need to catch up when accessing information submitted through Instagram. However, this obstacle can be overcome by reminding students to turn on notifications on Instagram accounts to be included. During science learning, students are still expected to have adequate internet access. In addition, the teacher reviews the material delivered via Instagram when in the classroom. The teacher also asked students to summarize the material on Instagram before class lessons.

Research from Pratama (2021) oncluded that the application of the flipped classroom learning model could improve the learning outcomes of grade VIII junior high school students in the Bojonegoro area with an N-Gain score of 75%, which means it is in the high category. Research from Sinatrya (2020) concluded that there are differences in student learning outcomes, which shows that the flipped classroom learning model using Instagram is effective. The study results obtained a pretest score of 63.31 and a posttest score of 96.37, meaning a significant increase. Both

studies are in line with the results of this study, which concludes that the application of flipped classroom learning using Instagram is effective.

4. CONCLUSIONS

Based on the data analysis and discussion above, it can be concluded that the flipped classroom learning model using Instagram in science learning materials in one of the junior high schools in Klaten Regency is included in the effective category.

5. REFERENCE

Agustini, M. (2021). Meningkatkan aktivitas dan hasil belajar siswa menggunakan model flipped classroom melalui aplikasi google classroom. *Indonesian Journal of Educational Development*, *2*(2), 280–289.

Arikunto, S. (2019). *Prosedur penelitian suatu pendekatan praktik*.

Azzahra, S., Khasanah, N. I., Kurniawan, D. A., & Maison, M. (2022). Analisis Kebutuhan Media Pembelajaran Fisika Berbasis Teknologi Di Sman 8 Tanjung Jabung Barat Pada Era Merdeka Belajar. *Prosiding Amal Insani Foundation*, *1*(1), 167–176.

Budiyono, B. (2020). Inovasi Pemanfaatan Teknologi Sebagai Media Pembelajaran di Era Revolusi 4.0. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *6*(2), 300–309.

Damayanti, H. N., & Sutama, S. (2016). Efektivitas flipped classroom terhadap sikap dan ketrampilan belajar matematika di SMK. *Manajemen Pendidikan*, *11*(1), 2–7.

Dwi, A. (2012). Instagram Handbook Tips Fotografi Ponsel. *Jakarta: Media Kita*.

Dwipayana, P. A. P., Redhana, I. W., & Juniartina, P. P. (2020). Analisis kebutuhan pengembangan multimedia interaktif berbasis konteks budaya lokal untuk pembelajaran IPA SMP. *Jurnal Pendidikan Dan Pembelajaran Sains Indonesia (JPPSI)*, *3*(1), 49–60.

Hake, R. R. (1999). American educational research association's division d, measurement and research methodology: analyzing change/gain scores. *USA: Woodland Hills*.

Hasiholan, T. P., Pratami, R., & Wahid, U. (2020). Pemanfaatan media sosial tik tok sebagai media kampanye gerakan cuci tangan di indonesia untuk mencegah covid-19. *Communiverse: Jurnal Ilmu Komunikasi*, *5*(2), 70–80.

Madhani, L. M., Sari, I. N. B., & Shaleh, M. N. I. (2021). Dampak Penggunaan Media Sosial Tiktok Terhadap Perilaku Islami Mahasiswa Di Yogyakarta. *At-Thullab: Jurnal Mahasiswa Studi Islam*, *3*(1), 604–624.

Mufidah, R., & Mufidah, A. (2021). Aplikasi Tik-Tok dan Instagram sebagai Salah Satu Alternatif dalam Media Pembelajaran IPA. *PISCES: Proceeding of Integrative Science Education Seminar*, *1*(1), 60–69.

Octavia, S. A. (2020). *Model-model pembelajaran*. Deepublish.

Pratama, F. Y., Cacik, S., & Agustin, I. (n.d.). *Efektifitas Model Pembelajaran Flipped Classroom untuk Meningkatkan Hasil Belajar IPA di Masa Pandemi Covid-19*.

Sinatrya, P., & Aji, S. U. (2020). Efektivitas Model Pembelajaran Flipped Classroom Daring Menggunakan Media Sosial Instagram di Kelas X SMK. *Primatika: Jurnal Pendidikan Matematika*, *9*(2), 81–90.

Sumarni, R. A., Bhakti, Y. B., Astuti, I. A. D., Sulisworo, D., & Toifur, M. (2020). Analisis Kebutuhan Guru SMP Mengenai Metode Pembelajaran Flipped Classroom. *ORBITA: Jurnal Kajian, Inovasi Dan Aplikasi Pendidikan Fisika*, *6*(2), 236–242.

Taupik, R. P. (2022). ANALISIS KEBUTUHAN PENGGUNAAN MEDIA PEMBELAJARAN IPA BERBASIS TEKNOLOGI DI ERA MERDEKA BELAJAR. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, *8*(2), 2770–2780.

Veygid, A., Aziz, S. M., & SR, W. S. (2020). Analisis fitur dalam aplikasi instagram sebagai media pembelajaran online mata pelajaran biologi untuk siswa Sekolah Menengah Atas. *ALVEOLI: Jurnal Pendidikan Biologi*, *1*(1), 39–48.

Wahyu, Y., Edu, A. L., & Nardi, M. (2020). Problematika pemanfaatan media pembelajaran IPA di Sekolah Dasar. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 107–112.

Yildirim, F. S., & Kiray, S. A. (2016). Flipped classroom model in education. *Research Highlights in Education and Science*, *2*(6).

Yulianti, Y. A., & Wulandari, D. (2021). Flipped classroom: Model pembelajaran untuk mencapai kecakapan abad 21 sesuai kurikulum 2013. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *7*(2), 372–384.

Yulietri, F., & Mulyoto, M. (2015). Model Flipped Classroom dan Discovery Learning Pengaruhnya Terhadap Prestasi Belajar Matematika Ditinjau Dari Kemandirian Belajar. *Teknodika*, *13*(2).

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Application of the NHT Model Combined with Question Cards on Biology Learning Outcomes

Nabilla Riska Nurjannah, and Djumadi*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
Corresponding Author. e-mail address: djum204@ums.ac.id

KEYWORDS:
Activeness
NHT Learning Model
Student Learning Outcomes

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Online learning that lasts more than two years makes it difficult for teachers to measure learning outcomes in the attitude and psychomotor aspects of students. Students tend to be silent and passive which makes learning difficult to be interactive. Teachers need to apply learning innovation strategies so that students are more enthusiastic in learning. This study aims to determine the learning outcomes of class XI MIPA students at SMA Negeri 5 Surakarta in the 2022/2023 school year on the subject of the human reproductive system by applying the Numbered Head Together (NHT) learning model combined with question cards. This study used a quantitative approach with a quasi-experimental method involving two classes, namely class XI MIPA 1 as the experimental class and class XI MIPA 4 as the control class, each of which consisted of 36 students. The instruments used in this study were multiple choice question sheets to determine students' cognitive learning outcomes and observation sheets to determine student activity. The posttest average score for the cognitive aspects of the control class was 78.5 and that of the experimental class was 87.72. Meanwhile, the average percentage of student activity (PKS) for the affective aspect of the control class was 71.14% and that of the experimental class was 82.27%. The data analysis technique uses the Independent Sample T-Test, which was previously tested for normality and homogeneity. The results of the F test show that there is a difference in the average values in the two classes (sig. 0.000 <0.05). The application of NHT is able to increase student activity in class.

1. INTRODUCTION

The development of a nation is denoted by progress across various domains, with education being a crucial one. It can be asserted that education is effective when it contributes to the advancement of a nation. This holds true for Indonesia, where the caliber of education necessitates enhancement, particularly with regard to elevating the educational standards. Additionally, education serves as the principal asset for a nation to attain optimal growth (Lestari, 2018).

The attainment of maximum learning outcomes by students is an indication of a thriving learning process. These outcomes refer to modifications in behavior that are accomplished within a particular timeframe, encompassing cognitive, affective, and psychomotor aspects of learning (Gracia and Anugraheni, 2021). As a result, it is imperative to adopt a suitable, non-teacher-centered learning approach that can encourage students to take a keen interest, display enthusiasm and dedication towards learning, culminating in an upswing in their learning outcomes.

As a result of the pandemic that broke out in mid-2019, it also had an impact on the education sector. More than a year of online learning has found a negative impact on students. Students begin to lose interest in learning and even discipline. School work is taken over by parents as a result of which teachers experience difficulties in measuring the learning outcomes of their students (Ramadhan et al., 2022).

The impact of post-pandemic learning has also greatly affected student activity in class. According to Handita, Prasetyo, and Sugiyem (2022) a decrease in the level of activity is seen in students who do not pay attention to collecting homework and when students are carrying out distance learning activities (PJJ) students wish to be silent and passive. During limited face-to-face learning (PTMT), students are still sensitive so learning is not interactive. This learning causes students to feel difficult because the teacher always focuses on demonstrating material and learning that is still teacher centered (Bano, Supu, and Lantik, 2019). As a result, educators must incorporate various pedagogical techniques, including introducing novelty in the learning experience, to foster greater engagement and excitement among learners (Widyasari, 2022).

Furthermore, the relationship between students is also not good because the learning process is still in the nature of one instruction, namely only between the teacher and students. This unfavorable relationship between students will affect the relationship between students. For example, there will be a lack of capacity for cooperation and communication. Active learning learning styles can be applied on students. Different types of learning make it easier for teachers to choose the style most relevant to the subject, educational object, classroom atmosphere, and student situation. An example of active learning that can be applied is Numbered Head Together (NHT) (Bano, Supu, and Lantik, 2019). It is easier for students to pursue learning (Risnawati and Saefuloh, 2019) and students can play an active role in improving their learning outcomes (Sari, 2017).

Therefore, researchers are interested in testing the application of Numbered Head Together (NHT) learning media combined with question cards in improving aspects of student biology learning outcomes in the material of the human reproductive system class XI MIPA SMA Negeri 5 Surakarta Academic Year 2022/2023.

2. MATERIALS AND METHOD

The research was conducted in March-May 2023 at SMA Negeri 5 Surakarta

2.1. Population

The population in this study were students in class XI MIPA 1-5 SMA Negeri 5 Surakarta Academic Year 2022/2023.

2.2. Sample

The samples used in this study were students of class XI MIPA 1 as the experimental class and class XI MIPA 4 as the control class.

2.3. Sampling Technique

The sampling technique used in this study was a purposive sampling technique in which samples were taken from the entire population according to certain criteria, such as the recommendations and considerations of the biology teacher.

2.4. Data Analysis Technique

The data analysis technique uses SPSS Statistics 20 which begins with testing the level of difficulty and validity of the items. Then the cognitive learning outcomes data obtained will be analyzed using the normality test and homogeneity test. If the data is normally distributed, it will be followed by testing the hypothesis with the Independent Sample T Test.

3. RESULT AND DISCUSSION

3.1. Result

Based on the validity test of the items conducted in class XI MIPA 5 as an instrument test class, the following results were obtained:

Table 1. Test results of the validity of the items.

Question item	r count	r table	Criteria
1	0,007	0,355	Invalid
2	0,670	0,355	Valid
3	0,423	0,355	Valid
4	0,206	0,355	Invalid
5	0,338	0,355	Invalid
6	0,559	0,355	Valid
7	0,289	0,355	Invalid
8	0,225	0,355	Invalid
9	0,739	0,355	Valid
10	0,290	0,355	Invalid
11	0,456	0,355	Valid
12	0,391	0,355	Valid
13	0,589	0,355	Valid
14	0,408	0,355	Valid
15	0,285	0,355	Invalid
16	0,583	0,355	Valid
17	0,153	0,355	Invalid
18	0,060	0,355	Invalid
19	0,463	0,355	Valid
20	0,353	0,355	Invalid
21	0,417	0,355	Valid
22	0,080	0,355	Invalid
23	0,190	0,355	Invalid
24	0,023	0,355	Invalid
25	0,302	0,355	Invalid

$$r\ table: DF = number\ of\ samples - 2$$
$$= 33 - 2$$
$$= 31 \rightarrow 0.355$$

Based on the reliability test of questions conducted in class XI MIPA 5 as an instrument test class, the following results were obtained:

Table 2. The results of the reliability test questions.

Cronbach's Alpha	**Reliability scale**	**Criteria**
0,674	0,6	Reliable

Based on the different power tests conducted in class XI MIPA 5 as an instrument test class, the following results were obtained:

Table 3. The results of the power test are different questions.

Question item	**Corrected item**	**Different power scale**	**Criteria**
1	-0.112	0.4	Bad
2	0.587	0.4	Good
3	0.344	0.4	Bad
4	0.127	0.4	Bad
5	0.217	0.4	Bad
6	0.500	0.4	Good
7	0.155	0.4	Bad
8	0.160	0.4	Bad
9	0.665	0.4	Good
10	0.175	0.4	Bad

Question item	Corrected item	Different power scale	Criteria
11	0.372	0.4	Bad
12	0.264	0.4	Bad
13	0.498	0.4	Good
14	0.301	0.4	Bad
15	0.152	0.4	Bad
16	0.488	0.4	Good
17	0.025	0.4	Bad
18	-0.031	0.4	Bad
19	0.343	0.4	Bad
20	0.280	0.4	Bad
21	0.329	0.4	Bad
22	-0.049	0.4	Bad
23	0.067	0.4	Bad
24	-0.116	0.4	Bad
25	0.170	0.4	Bad

Based on the problem difficulty level test conducted in class XI MIPA 5 as an instrument test class. the following results were obtained:

Table 4. The test results of the difficulty level of the questions.

Question item	Mean	Criteria
1	0.76	Easy
2	0.67	Medium
3	0.12	Hard
4	0.09	Hard
5	0.30	Medium
6	0.91	Easy
7	0.55	Medium
8	0.94	Easy
9	0.52	Medium
10	0.24	Hard
11	0.85	Easy
12	0.45	Medium
13	0.27	Hard
14	0.24	Hard
15	0.42	Medium
16	0.70	Medium
17	0.30	Medium
18	0.12	Hard
19	0.48	Medium
20	0.09	Hard
21	0.15	Hard
22	0.30	Medium
23	0.27	Hard
24	0.48	Medium
25	0.42	Medium

Based on the normality test conducted in class XI MIPA 1 as the NHT treatment class and class XI MIPA 4 as the control class, the following results were obtained:

Table 5. Normality test results.

	Kolmogorov-Smirnow	Saphiro-Wilk
	Sig.	Sig.
Pretest NHT	0.200	0.110
Pretest Kontrol	0.200	0.250
Posttest NHT	0.118	0.080
Posttest Kontrol	0.018	0.017

Based on the homogeneity test conducted in class XI MIPA 1 as the NHT treatment class and class XI MIPA 4 as the control class, the following results were obtained:

Table 6. Homogeneity test results.

Based on mean	Keterangan
0,418	Homogen

Based on the Independent Sample T-Test test conducted in class XI MIPA 1 as the NHT treatment class and class XI MIPA 4 as the control class, the following results were obtained:

Table 7. Independent Sample T-Test results.

Hasil uji hipotesis	Sig	Keterangan
Uji F	0.088	The variance is homogeneous
Equal Variance Assumed (Sig 2-tailed)	0.000	There is significant difference

Based on the percentage value of student learning activity carried out in class XI MIPA 1 as the NHT treatment class and class XI MIPA 4 as the control class, the results are as follows:

Table 8. Percentage value of Student Learning Activeness.

Treatment class	Percentage value (%)	Criteria
NHT	82.27	High
Control	71.14	Medium

3.2. Discussion

3.2.1. Cognitive aspect research result

The results of Table 1 test the validity of the items tested using the product moment correlation equation (rxy) to test the validity of the questions. The validity value of the questions obtained will be compared with the value of r table, if r count > r table then the research instrument has a significant correlation with the total score (the question instrument is declared valid). However, if r count < r table, the research instrument does not have a significant correlation with the total score (the item instrument is declared invalid). Value N = 33 with a significance level of 5% obtained r table = 0,355. The questions were given to class XI MIPA 5 with 33 students. Of the 25 questions tested, 10 questions were valid and 15 questions were invalid.

The reliability test results in table 2 with reference to the reliability coefficient (r11) > 0.6 or 0.7 or according to table r (Product Moment) obtained a coefficient value of Cronbach's alpha of 0.674 (0.674 > 0.6). So this research instrument has a high level of reliability.

If the corrected item > 0.4 in table 3 the results of the test for different power of the questions then the questions have good criteria. Of the 25 questions tested, 5 items had different criteria for good questions and 20 questions had bad criteria.

Table 4. The test results for the difficulty level of the questions obtained mean which is categorized according to Arifin (2014), namely the difficulty level of the item (p) has a range of $p > 0.70$ which is in the easy category, 0.30, 0.30 $\leq p \geq 0.70$ which is in the medium category, and $p < 0.30$ categorized as difficult. Of the 25 questions tested, 9 questions were in the difficult category, 12 questions were in the medium category, and 4 questions were in the easy category.

The objective of conducting the normality examination in Table 5 is to determine if the data follows a normal distribution. The normality examination using the SPSS software generates a p-value in the NHT pretest 0.200 (0.200 > 0.05), the control pretest 0.200 (0.200 > 0.05), the NHT posttest 0.118 (0.118 > 0.05), and the control posttest 0.018 (0.018 <0.05) indicating that the data follows a normal distribution.

Table 6 displays the outcomes of the homogeneity test, which was conducted using the average value of 0.418 (0.418 > 0.05). This indicates that the data is uniform or possesses equivalent initial capabilities, making it suitable for various test analyses (such as the Independent Sample T-Test)..

The statistical depiction examination comprises of the mean, standard deviation, variability, and the number of pupils based on the evaluation of the cognitive domain of pupil achievement. Information on pupil achievement was collected using examination tools in the shape of multiple-choice queries totaling 25 queries provided to each experimental group and control group. The examination tool provided is a matter that has been tested for validity, reliability, discriminatory ability, and level of complexity. Examinations were provided at the start of learning and at the end of learning in the shape of a pretest and posttest to determine pupil achievement during the treatment. The highest pretest value in the control group was 68 and in the experimental group was 80. The initial capability of the experimental group was higher than that of the control group, with an average pretest of the control group 48.89 and the experimental group 50.56.

The results obtained from the students' final learning capabilities (posttest) have shown an increase. The highest posttest scores in the control and experimental classes were 92 and 96. The final capability of the experimental class was higher than that of the control class, with an average posttest score of 87.72 for the control class and 78.5 for the control class. This aligns with the research conducted by Imam and Taufik (2022), which suggests that the Numbered Head Together (NHT) learning model has an impact on enhancing learning outcomes in Science Physics Class X SMA Negeri 1 Sanggar for the 2021/2022 academic year, with the experimental class having an average score of 79.00 and the control class having an average score of 69.35. This is also supported by the findings of Nandhitha and Wirdati (2023), which indicate that the average academic achievement of PAI students who implement the Numbered Head Together (NHT) learning approach is superior to the average score of students who receive traditional education in Islamic studies, with an average score of class IV-D (experimental class) being 92.35 and class IV-A (control class) being 72.23.

Moreover, in order to determine whether there are disparities in the learning outcomes of the control and experimental groups, it is essential to

conduct a hypothesis test. The aim of this study was to investigate whether the Numbered Head Together (NHT) instructional model, when combined with question cards, can enhance students' cognitive learning outcomes. The Levene test in Table 4.9 is utilized to ascertain whether the Equal Variance Assumed variant will be employed in a homogeneous manner or not. The hypothesis is then formulated as follows: H0 = There is no difference in the test scores of the experimental and control groups, and Ha = There is a difference in the test scores of the experimental and control groups. According to Table 4.7, the F test value is 0.088 (0.088 > 0.05). Therefore, H0 is accepted and Ha is rejected. Hence, it can be concluded that there is a disparity in the test score data between the experimental and control groups.

The Independent Sample T-Test is utilized to ascertain the hypothesis, specifically: H0 = There is no distinction in the average values of the experimental and control groups, and Ha = There is a distinction in the average values of the experimental and control groups. Based on the F test, the value of Equal Variance Assumed (Sig 2-tailed) was 0.000 (0.000 <0.05), resulting in the rejection of H0 and acceptance of Ha. Therefore, it can be concluded that there is a disparity in the average value between classes using the Numbered Head Together (NHT) model combined with question cards and the control class using the traditional model. This outcome aligns with Pulungan's study (2023) which confirms that the utilization of Numbered Head Together (NHT) as a learning tool in Biology class on the subject of human movement systems for class XI IPA 4 SMAN 1 Batang Angkola has an impact on enhancing student learning outcomes, with the experimental group achieving an average posttest score of 90.6 and the control group scoring 83.9. The t-test results yielded a significance of 0.000, indicating that the use of NHT had an influence on student learning outcomes. Furthermore, in Nurgufriani, Uyun, and Saputra's study (2023), the effectiveness of the Numbered Heads Together approach using cards in enhancing mathematics learning outcomes for elementary students exhibited an average difference, with the NHT card group scoring 79.38, while the NHT group without cards scored 64. This demonstrates that NHT with numbered cards and pictures has a slightly greater impact than NHT without media in enhancing mathematics learning achievement in elementary schools.

3.2.2. Result of student learning activeness research

The percentage value of Student Learning Activeness (KBS) can be categorized with intervals (Arikunto, 2016): 75% $\leq$ KBS $\leq$ 100% is in the high category, 50% $\leq$ KBS $\leq$ 75% is in the medium category, 25% $\leq$ KBS $\leq$ 50% is in the low category, and 0 % $\leq$ KBS $\leq$ 25% is very low category.

Based on the results of the percentage value of Student Active Learning (KBS) in table 8, the average KBS in the experimental class was 82.27% (high category) and in the control class was 71.14% (medium category). The affective domain is in the form of an assessment given to learning residents based on their feelings and emotional aspects. This refers to interests, attitudes, judgments, and adaptation potential (Hamdani and Nurdin, 2020). The application of Numbered Head Together (NHT) combined with question cards is considered capable of arousing student activity in learning. This is in line with the research of Viani, Bahar, and Elvinawati (2017) that student learning outcomes assisted by Tournament Question Cards media have an average pretest score of 28.24 and a posttest average score of 85.59 with a difference in average scores pretest and posttest mean of 57.35. The use of this media can also change the learning

situation to be fun and exciting which can trigger a competitive spirit for each group to be able to solve all questions well.

The application of the Numbered Head Together (NHT) model can encourage students to be more active, creative, and explore student understanding through their knowledge and can increase interaction between peers in discussions which can improve student learning outcomes (Nourhasanah and Aslam, 2022).

According to the research conducted by Sriyanti (2019), incorporating supportive tools can enhance the comprehension of mathematical theories among students in class VIII SMPN 1 Sanrobone. The pretest score, which was in the low category with an average of 27.11, improved to a posttest score of 55.74, falling in the medium category. This signifies a noteworthy advancement of 37% in students' understanding of math concepts.

4. CONCLUSIONS

Based on the findings of a study conducted in class XI MIPA 1 and XI MIPA 4 at SMA Negeri 5 Surakarta for the academic year 2022/2023, it can be inferred that the utilization of the Numbered Head Together (NHT) approach in conjunction with question cards in teaching the topic of the human reproductive system has the capability to enhance students' cognitive learning outcomes, with the experimental class averaging at 87.78. Additionally, the students' engagement in the learning process, as measured by the Student Learning Involvement (KBS) index, achieved an average score of 82% (falling within the high category).

5. ACKNOWLEDGMENTS

I would like to thank all those involved and have given support to the writer.

6. REFERENCES

Arifin, Z. 2014. Penelitian Pendidikan: Metode dan Paradigma Baru. Bandung: PT Remaja Rosdakarya.

Arikunto, S. 2017. Pengembangkan Instrumen Penelitian dan Penilaian Program. Yogyakarta: Pustaka Belajar

Bano, N. D. N., Supu, A., & Lantik, V. (2019). Penerapan Model Pembelajaran Numbered Heads Together (NHT) dan Model Pembelajaran Group Investigation (GI) Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas XIP IPA SMA 5 Kupang. Edufisika: Jurnal Pendidikan Fisika, 4(02), 56-64.

Gracia, A. P., & Anugraheni, I. (2021). Meta Analisis Model Pembelajaran Kooperatif Tipe Numbered Head Together Terhadap Hasil Belajar Siswa di Sekolah Dasar. Edukatif: Jurnal Ilmu Pendidikan, 3(2), 436-446.

Hamdani, M. F., & Nurdin, E. (2020). Kemampuan Koneksi Matematis berdasarkan Minat Belajar Siswa. JURING (Journal for Research in Mathematics Learning), 3(3), 275-282.

Handita, Y. H., Prasetyo, P. W., & Sugiyem, S. (2022). Penerapan Model Discovery Learning Untuk Meningkatkan Keaktifan Belajar Siswa Saat Pandemi. Jurnal Derivat: Jurnal Matematika dan Pendidikan Matematika, 9(1), 82-94.

Imam, H., & Taufik, M. (2022). Pengaruh Model Pembelajaran Kooperatif Tipe Numbered Heads Together (NHT) Terhadap Hasil Belajar Siswa Kelas X SMAN 1 Sanggar Tahun Pelajaran 2021/2022. Jurnal Pendidikan Fisika Dan Teknologi, 8(SpecialIssue), 58-66.

Kurniawan, N. (2023). Pembelajaran Kooperatif Numbered Heads Together (NHT) Untuk Meningkatkan Hasil Belajar Menghitung Faktor Persekutuan Terbesar (FPB) Kelas IV SDN Gunungsari 04 Kota Batu. Jurnal Pendidikan Taman Widya Humaniora, 2(2), 1128-1151.

Lestari, N. P. C. (2018). Penerapan Model Pembelajaran Kooperatif Tipe NHT Berbantuan Media Audio Visual Untuk Meningkatkan Hasil Belajar IPA. Journal of Education Action Research, 2(4), 355-362.

Lestari, N. N. L., Rahmah, N., & Mustapa, K. (2023). Penerapan model NHT berbatuan pop up book untuk meningkatkan hasil belajar kognitif siswa pada materi sumber energy. Practice of The Science of Teaching Journal: Jurnal Praktisi Pendidikan, 2(1), 1-10

Nanditha, Y., & Wirdati, W. (2023). Pengaruh Model Pembelajaran Kooperatif Tipe Numbered Head Together (NHT) Terhadap Hasil Belajar PAI. An-Nuha, 3(2), 228-239.

Nurgufriani, A., Uyun, N., & Saputra, A. (2023). Implemetasi Numbered Heads Together Berbantuan Media Kartu Angka Bergambar Pada Mata Pelajaran Matematika Siswa Sekolah Dasar. Bima Journal of Elementary Education, 1(1), 29-33

Nourhasanah, F. Y., & Aslam, A. (2022). Efektivitas Model Pembelajaran Kooperatif Tipe Numbered Head Together (NHT) Terhadap Hasil Belajar Matematika Siswa Sekolah Dasar. Jurnal Basicedu, 6(3), 5124-5129.

Pudjawan, K., & Suranata, K. (2019). Pengaruh Model NHT berbantuan Kartu Pertanyaan Kontekstual Terhadap Hasil Belajar Ipa Siswa Kelas III. INOPENDAS: Jurnal Ilmiah Kependidikan, 2(2), 61-70

Pulungan, N. A. (2023). Pengaruh Model Pembelajaran Numbered Heads Together (NHT) Terhadap Hasil Belajar Siswa Kelas XI di SMA Negeri 1 Batang Angkola. Jurnal Pembelajaran Dan Matematika Sigma (JPMS), 9(1), 303-311.

Putri, H. V., Putri, D. H., & Setiawan, I. (2023). Analisis Aktivitas dan Hasil Belajar Siswa dalam Pembelajaran Fisika Menggunakan Model Pembelajaran Kooperatif Tipe Numbered Head Together (NHT) Materi Elastisitas. Jurnal Penelitian Pembelajaran Fisika, 14(1), 49-56.

Ramadhan, I., Manisah, A., Angraini, D. A., Maulida, D., Sana, S., & Hafiza, N. (2022). Proses Perubahan Pembelajaran Siswa dari Daring ke Luring Pada Saat Pandemi Covid-19 di Madrasah Tsanawiyah. EDUKATIF: Jurnal Ilmu Pendidikan, 4(2), 1783-1792.

Risnawati, E., & Saefuloh, H. (2019). Pengaruh Metode Active Learning Strategi Number Head Together (NHT) terhadap Pembelajaran Kitab Nahwu Wadlih dalam Penguasaan Materi nahwu (Siswa Kelas 3 (Tiga) Pondok Pesanten Azziyaadah Kanggraksan Kota Cirebon). EL-IBTIKAR: Jurnal Pendidikan Bahasa Arab, 8(2).

Sriyanti, A., Idris, R., & Rahman, R. (2019). Efektivitas Penerapan Model Pembelajaran Numbered Heads Together (NHT) Berbantuan Media Pembelajaran Question Card Dalam Meningkatkan Pemahaman Konsep Matematika Siswa Kelas VIII SMPN 1 Sanrobone. Al Asma: Journal of Islamic Education, 1(1), 18-28.

Viani, D. S., Bahar, A., & Elvinawati, E. (2017). Perbandingan Hasil Belajar Siswa Menggunakan Media Chemopoly Game dan Tournament Question Cards. Alotrop, 1(1), 55-59.

Widyasari, N. F. (2022). Strategi Pelaksanaan Tatap Muka (Pembelajaran Luring) Pasca Pandemi Covid-19. Journal of Instructional and Development Researches, 2(4), 153-161.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Growth Red Spinach (*Amaranthus amoena)* by Hydroponics Using Charcoal Media Husk

Isherdini, Dyah Salma Nurlaila, and Suparti*
Biology Education Department, Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta. Jl. A. Yani Tromol Pos I, Pabelan, Kartasura , Surakarta 57162, Central Java , Indonesia
* Corresponding Author. e-mail address: Sup168@ums.ac.id

KEYWORDS:
Ab mix
Chaff charcoal
Red Spinach
Hydroponics

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Red spinach is a vegetable plant of the most common varieties of spinach. This plant has good content for the body such as vitamin A, vitamin C, protein and high polyphenols antioxidants content. Red spinach production in Indonesia is still very low. This can happen because the majority of our people are not very familiar with red spinach and cause its cultivation and marketing to be not very intense. Hydroponics is a farming method without using soil media, but with nutrient solutions or other materials that contain nutrients. The aim of the study was to find out the differences and yields of red spinach plants if the concentration of AB MIX fertilizer was different. The research used the research method used was experimental with an environmental design in the form of a Factorial Randomized Block Design (RBD), with 5 treatments. P0 = husk charcoal, P1 = husk charcoal + 1000 ppm, P2 = husk charcoal + 800 ppm, P3 = husk charcoal + 1200 ppm, P4 = husk charcoal + 600 ppm, and P5 = husk charcoal + 1400 ppm. Analysis using the Honest Significant difference Test (BNJ) with a level of 5% was carried out to determine whether there was an interactions of each treatments. The results showed that the best treatments was P1 with a plant heights of 1.5 cm, a leaf width of 0.7 cm, and a total of 6 leaves.

1. INTRODUCTION

Red spinach is a vegetable plant that has a special characteristic, namely that the plant is red. Some can be found in Indonesia. These plants have concentrations that are good for the body, such as vitamin A, vitamin C, protein and high polyphenol antioxidant content (Pebrianti et al., 2015) . Many uses of red spinach have been discovered in recent years, such as root dysentery and leaf asthma (Hidayanti and Kartika, 2019). Spinach contains nutrients that can improve blood circulation, lower cholesterol and high blood pressure. When growing red spinach, the soil is used the most to grow it. Good growth requires a substrate that is equipped with elements needed by plants (Mardhiana Et Al., 2017) . In addition, along with the development of civilization, every year it is increasingly felt that it is difficult to obtain agricultural land.

Production of red spinach (*Amaranthus tricolor L*) is still relatively low and unstable. This can be seen from BPS data (Central Statistics Agency, 2017). Red spinach production in Indonesia continues to fluctuate: in 2016 red spinach production was 160,000 tons, in 2017 it fell to 148,000 tons and rose again to 162,000 tons in 2018, only to drop again to 157 thousand tons in 2019 and 2019 and became . , 2022). This can happen because most of our people are not familiar with red spinach. The lack of popularity of red spinach causes less intensive cultivation and marketing (Pebrianti et al., 2015) .

Hydroponics is a step to overcome the problem where red spinach production is still very low and unstable. One of the advantages of the hydroponic system is that it can replace soil with

water and does not require too much land (Roidah, 2014) . Water is an essential element that plants need to grow, and hydroponics can solve this problem. The addition of nutrients to the aquatic environment combined with an irrigation system using a pump allows plants to grow well (Wibowo & Asriyanti, 2013) There are several types of hydroponics, including the Nutrient Film Technique (NFT), which involves growing plant roots in a nutrient solution to provide water and sufficient oxygen for plants (Mosa et al., 2016) .

Hydroponics can fold double the productivity of spinach plants compared to conventional planting. Hydroponics is a method of growing plants without soil and using a nutrient solution mixed with water as the nutrient source. One excellent hydroponic system for growing vegetables is the NFT (*Nutrient Film Technique*) hydroponic system. The NFT hydroponic system is a method of plant cultivation in which plant roots grow in a shallow, circulating layer of nutrients, allowing the plants to absorb water, nutrients, and oxygen (Chairani et al., 2017) . The working principle of this NFT hydroponic system is that water or nutrients flow through the grow tank. The planter is angled to allow nutrients to flow.

kindly traditional, when plant plant spinach, seeds only sown in the ground without notice distance between seeds. Too much spacing near will resulted competition nutrition, so happen even distribution growth spinach all over plant. because it, to achieve growth maximum spinach with the system hydroponics, spacing plant effective must guarded. On research This election distance plant aimed to get distance the most ideal planting that can be used moment plant spinach in a manner hydroponics.

Plant plant by method hydroponics more efficient Because can arranged such shape so that No need long distance like match plant. With technology hydroponics, nutrients needed _ plant can distributed in a way dissolve these nutrients to in the water that became the planting medium, so direct absorbed by the roots plant. When using hydroponics, time plant it more short, so plant Can more fast harvested. because that, when match plant method hydroponics, cost production become more cheap when soil, water and nutrients are used in a manner efficient as well as production and yield increase (Zamriyetti et al., 2019) .

Success cultivation spinach hydroponics determined by the nutrients it contains element macro and micro, as well addition substance regulator supportive and stimulating growth growth plant . Giving nutrition AB mixture with a concentration of 5mL/L and the addition of 2mL ZPT as nutrition addition is the optimal combination to increase growth hydroponics plant spinach red on the substrate based sand (Hidayanti & Kartika, 2019) .

Sufficient nutrients must be given to plants so that the right amount of nutrients is available and plants can easily absorb them (Fitriansyah et al., 2019). AB Mix Nutrients contain macro and micronutrients needed to support plant growth and performance. These nutrients are composed of several chemical elements needed for plant growth (Hidayanti & Kartika, 2019) . In addition to nutrients, growth regulators (ZPT) are also needed to support plant growth, which must be applied externally. The addition of ZPT at the right concentration has a positive effect on plant growth (Darwis, 2021).

Charcoal husks or roasted husks used as plant material are obtained from the combustion process with imperfect combustion techniques. Charcoal shell contains high carbon and is often used as a planting medium. Charcoal husk is widely used by farmers as soil conditioner, planting medium, planting substrate and compost material. The mixed composition consisted of 2 parts of soil, 1 part of compost and 1 part of shell coal (2:1:1). Mix well. Prepare a pot or polybag and pour the mixture into it. The growing media is ready to use. Chaff charcoal is made by incomplete (partial) burning of rice husks. Harvesting carbon waste from rice husks can increase productivity

and protect the environment (Rahmiati et al., 2019). Increased productivity can be seen in the response of plants to rice husk carbon. Charcoal responds better to plant growth (Gustia, 2013) ; (IRAWAN, 2015) .

The use of different media (rockwool, coconut coir, and shell charcoal) with core types (flannel, coconut coir, and banana stem fibers) affects the hydroponic growth of red spinach. The use of charcoal growing media with flannel leaf axils was the best treatment, because it produced the highest root volume of 4.67 cm3 and produced 5.56 leaves, plant fresh weight of 17.40 g and plant dry weight of 1.24 g, the highest in spinach plants. and brown rice. cultivated hydroponically (Vanesaputri et al., 2022) As a planting medium, charcoal has the advantages of (1) keeping the soil loose because of its high porosity and light weight, (2) encouraging the growth of microorganisms in plants, (3) regulating soil pH under certain conditions, (4) maintain moisture, (5) fertilize soil and plants, (6) increase crop production, (7) act as an absorbent to reduce the number of pathogenic microbes, and (8) increase absorption and bind soil to water.

One form of agricultural waste is husk. In general, the waste generated from the processing of agricultural products contains high levels of nutrients and starch to produce compounds that can stimulate plant growth (Irianto, 2015) . Husk is bran produced from the rice milling process which separates the rice from the chaff. Rice husks are usually stacked and only become a waste material at the Rice Mill. Utilization of rice yields is not matched by waste utilization. In general, rice husks can be used as a growth substrate, charcoal husk briquettes, animal feed mats, or destroyed by indiscriminate and uncontrolled burning which pollutes the environment. According to several studies, agricultural waste such as rice can be used as animal feed and the use of chemical fertilizers can be saved (Agustono et al., 2018) ; (Karyaningsih, 2012)

According to research (Muhammad Fuad Syah et al., 2021) , it is known that in this study the concentrations of AB Mix 1000, 1200, 1400, 1600 and 1800 ppm had no significant effect on all parameters observed. , i.e. plant height, number. leaves, leaf area, root volume, fresh plant weight and consumption weight. The AB Mix concentration of 1000ppm is the best among several concentrations because it is more effective, economical and saves the use of nutrient solutions.

According to study (Wijaya et al., 2020) , treatment with values highest for this parameter is L2M3 (mix AB 4 mL/L + charcoal skin), L3M3 (mixture AB 6 ml/L + charcoal shell) L2M1(AB) 4 ml/l mixture + rockwool) and L2M3 (AB 4 ml/l mixture + shell coal). The best planting medium to support growth plant is originating _ from charcoal husk rice. L2M3 treatment (4 ml/l AB mixture + charcoal shell) has mark highest fresh weight that is 21.65 grams Because content nutrition the AB mixture used as needed plant. Besides that is, content growing media chemistry form coal shell in form SiO2 reaches 31% at 52 °C. Content chemistry in amount small in the form of Fe2O3 also contains MnO, Cu, CaO, MgO and K_2O. So that, we examined growth hydroponics spinach red with addition charcoal husk, because production spinach red in Indonesia is still very little and no stable.

The growth and development of hydroponic plants is largely determined by the availability of nutrients in metabolic processes. The availability of nutrients plays an important role in the formation of proteins, enzymes and hormones due to cell division in plant tissues which affects the formation of flora. Buds, leaves and roots multiply. Nutrients are obtained by dissolving a mixture of dissolved nutrients in water. These nutrients are obtained from a mixture of mineral salts with a certain composition, a certain amount can be adjusted according to the needs of the flora. Even though they look the same, each plant requires different nutrients and nutrients. In addition to nutrition, the population must also be considered when planting, because stock management is directly related to the level of plant density, which can affect the quality and

quantity of plants. To maintain a complete population for optimal growth, cropping intervals must be considered to allow for effective nutrient protection.

Mix nutrients are nutrients used in aquaculture. The three must not be mixed in a concentrated state so as not to cause precipitation because when the sulfate anion (SO_4^{2-}) in Mixture B mixes with the calcium cation (Ca) in Mixture A, calcium sulfate ($CaSO_4$) is formed. Precipitate so that the roots cannot take Ca and S elements, and when the calcium cation (Ca) from Mixture A meets the phosphate anion (PO_4^{3-}) from Mixture B, calcium phosphate ($Ca_3(PO_4)^{2}$) precipitates. formed so that Ca and P cannot be absorbed by the roots. (Sastro, 2016) .

Hydroponics involves growing plants using water without soil as a growing medium. When growing plants in a hydroponic system, the emphasis is on meeting the nutritional needs of growth. Nutritional needs are very important for the growth and development of hydroponic plants. When nutritional needs are not met, plant growth and development slows down. Research (Izzuddin, 2016) shows that hydroponics is a method of farming that does not use soil but rather a nutrient solution or other nutrient-rich materials such as coconut, mineral fiber, sand, brick chips, sawdust, etc. Several factors affect hydroponic results including temperature, nutrients and water pH.

Rice husk charcoal has more fragile characteristics compared to other plant materials. This feature is thought to facilitate the penetration of the roots of the Cempaka Wasian seedlings tested into the environment, as well as a larger root extension area and can accelerate root development. Based on the difference in the percentage of growth, it is also seen that the dry weight of the roots has a higher growth value compared to the growth of the dry weight of the shoots. This could indicate that the addition of shell charcoal had a greater effect on the root development of Cempaka Wasian seedlings compared to the addition of shoots which also had a positive effect on shoot growth. Root dry weight.

Using organic matter such as sawdust and rice husk charcoal as a substrate is also considered better than humus. This is because organic matter can provide nutrients for plants. This results in good air circulation, high water absorption and lower seed weight compared to terrestrial media , making it easier to transport. This is probably because husk charcoal has many pores which can increase ventilation and high porosity. Therefore, rice husk charcoal is weaker than other antioxidants. Conversely, if the seeds are planted in a medium that is too dense with low aeration and porosity, it will be difficult for the media to penetrate the roots and the root elongation zone will be shorter. (Aksa et al., 2018) .

Therefore, from the explanation above, research was conducted on the growth of red spinach hydroponically which aims to find out the differences and yields of red spinach plants if the concentration of AB MIX fertilizer is different.

2. MATERIALS AND METHODS

2.1. Material

As for the tools and materials to be used for research This namely, basins, trays, polybags, glasses measure, shovel, glass, cloth flanneland bottle used. As for the materials used namely, seeds spinach red, charcoal husk, soil, water, AB Mix.

2.2. Method

Study growth spinach red with the addition of AB Mix is done at the green house of the Faculty of Education, University of Muhammadiyah Surakarta to find out rate growth plant spinach red. Method used in study This is Draft Random Complete (RAL) one composed factors of five treatments :

P0 : Treat without AB Mix
P1 : Treatment charcoal husk + 1000 ppm of AB Mix nutrition
P2 : Treatment charcoal husk + 800 ppm of AB Mix nutrition
P3 : Treatment charcoal husk + 1200 ppm of AB Mix nutrition
P4 : Treatment charcoal husk + 600 ppm of AB Mix nutrition
P5 : Treatment charcoal husk + 1400 ppm of AB Mix nutrition

Analysis variance by Design Random Factorial group (RBD). used for data analysis. If F count more big from F table so Duncan Multiple Range Test (DMRT) was performed at 5% level.

3. RESULT AND DISCUSSION

3.1.Results

On results study this P1 has results growth best at the moment tall plant 1.5 cm, wide leaves 0.7 cm and the number leaves 6 strands. And growth worst occurs at P0 moment tall 1 cm plant. 0.3cm leaf width and number 6 leaves. While P3 and P5 were obtained same result that is tall plant 1.2cm, wide 0.5cm leaves and amount 6 leave. And for P2 and P4, height plant 1 cm, wide leaves 0.3 cm, and the number leaves 6 strands. this shown in Table 1.

Table 1. Average growth plant spinach red (*Amaranthus amoena*)

Treatment	***Plant Height (cm)***	***Leaf Width (cm)***	***Amount Leaf (strand)***
P0	1	0.3	6
P1	1.5	0.7	6
P2	1	0.3	6
P3	1.2	0.5	6
P4	1	0.3	6
P5	1.2	*0.5*	*6*

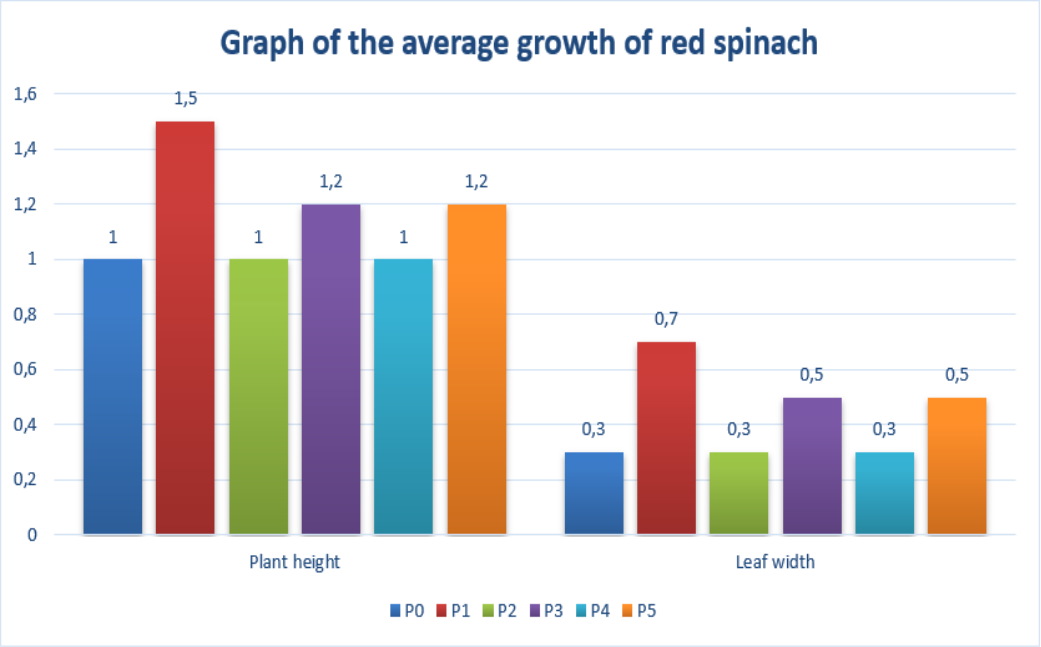


Figure 1. Graph average growth

Giving coal in processing it also offers Lots profit. Charcoal can repair porosity and aeration land, as well tie nutrients that are not absorbed plant. this useful for plant when rare nutrient, because plant can absorb it from carbon skin released wood in a manner slowly. Charcoal also delivers more influence Good to tall plant spinach compared to husks, because charcoal husk paddy own more abilities Good in increase porosity ground, so land become more loose and ability absorb water increases. Besides that's skin wood No contains harmful salt for plant or pathogen dangerous, because generated from the combustion process.

3.2 Discussion

3.2.1. Plant Height

Research results showing high average value plants on each treatment. This is caused difference ppm level. The treatment which showed the ideal plant height was obtained from P1 (charcoal husk + 1000 ppm AB Mix). Condition This due to charcoal husk and nutrition AB Mix has balanced content. However If use AB Mix nutrition too Lots or too A little so nutrients needed by plants will excessive or less. And on charcoal husk has good aeration so that air circulation goes well. This shown in the picture following.

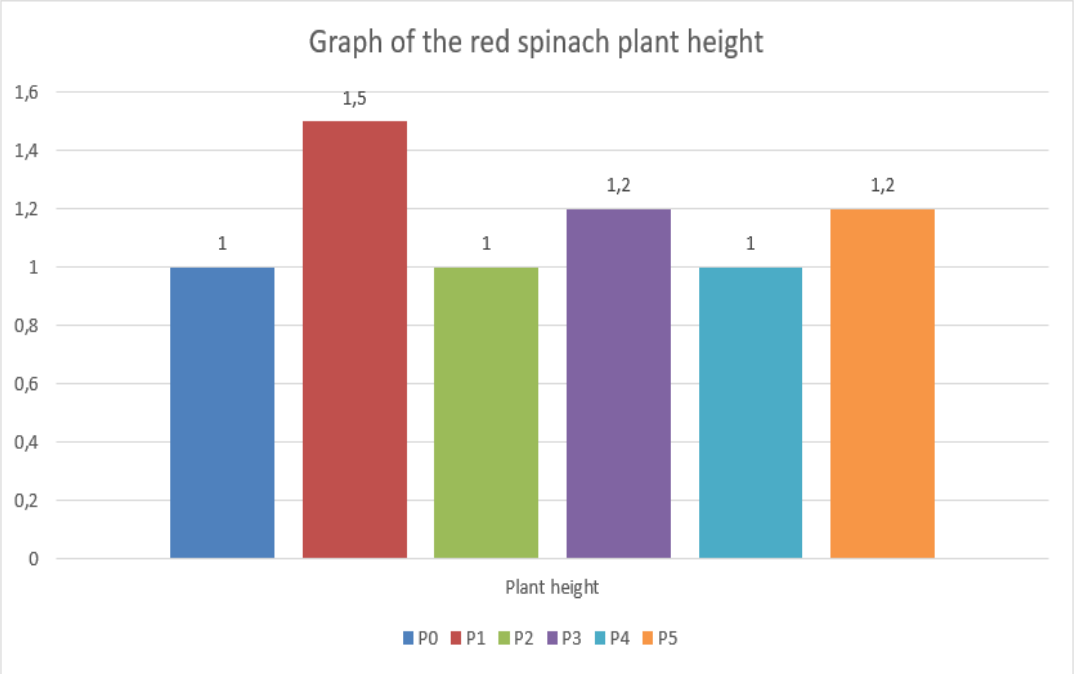


Figure 2. Chart high average value plant spinach red

3.2.2. Leaf number

Research results of 5 treatments show same result that is relatively lots of 6 leaves. this caused content nutrition a mixture of AB and charcoal husk. Besides good mix, they got too give retention more roots well and flow good air to absorb nutrition from root plant. The more Lots leaves, increasingly wide leaves (no each other shade), allows more Lots energy the sun is captured for the process of photosynthesis, so assimilation more high, and plants that experience drought during growth vegetative own more leaves narrow than plant. who get enough water. this shown in the picture following

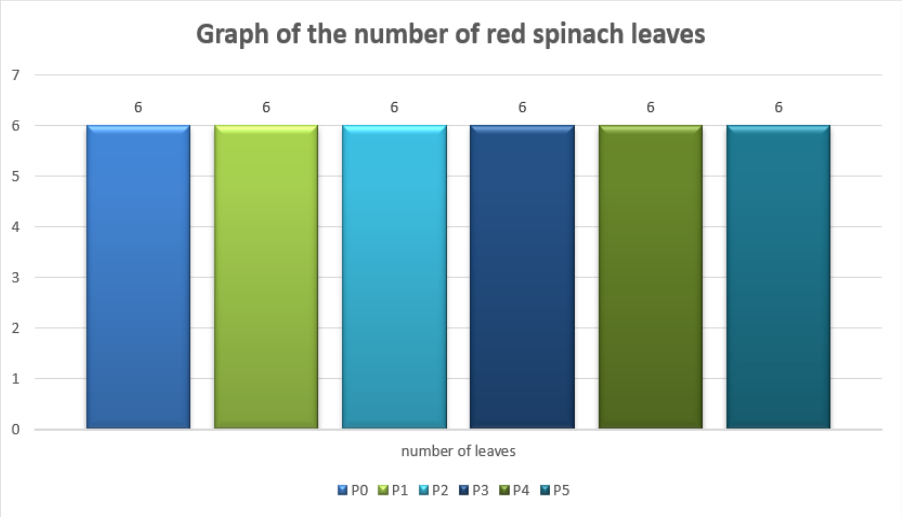


Figure 3 . Graph of the average value of the number of leaves of the red spinach plant

3.2.2. Leaf Width

In vegetable plants, especially red spinach, leaf area is an important factor in the rate of plant photosynthesis. The main function of the leaf is where photosynthesis takes place for plant development. Leaf area can also be used to determine the chlorophyll content of plants. The wider the leaf surface, the more chlorophyll there is. The best leaf width research results were P1 with a width of 0.7 cm. For P0, P2 and P4 the results were not good, the leaf width was 0.3 cm. whereas in P3 and P5 the results are the same, namely 0.5 cm. Because the carbon environment in the bark is able to bind water optimally, so that the roots bind firmly, absorb nutrients properly and growth develops properly. this shown in the picture following.

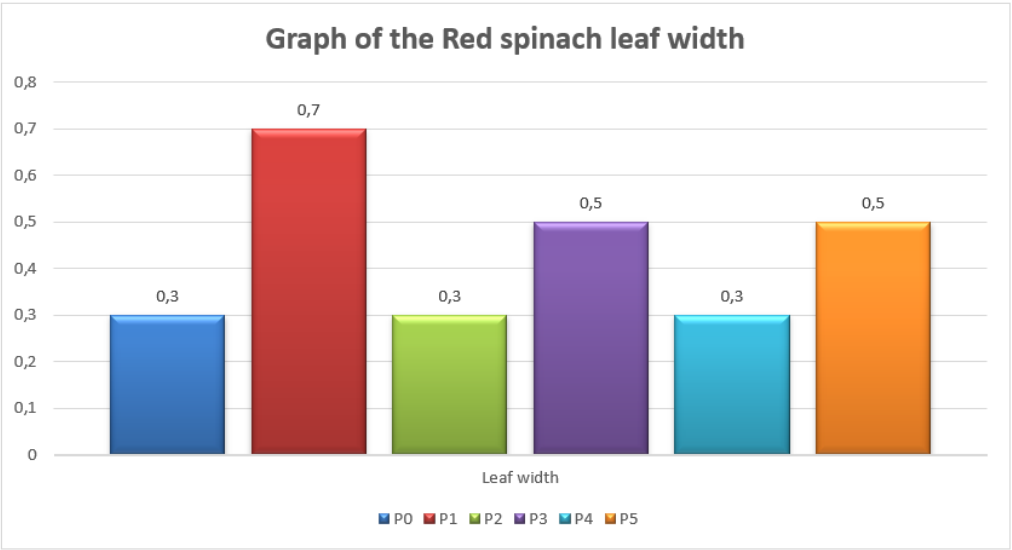


Figure 4. Chart width average value leaf plant spinach red

4. CONCLUSION

On research This can concluded that treatment best is on the mix charcoal shell P1 + AB nutrient 1200 ppm with high plant 1.5 cm, wide leaves 0.7 cm and 6 leaves. And treatment worst is P0 with height plant 1 cm, wide leaves 0.3 cm and the number leaves 6. In the treatment P2, P3, P4 and P5 the results balanced meaning. No results best and worst. this is caused by several factors, namely light, environment, temperature and seeds which cause growth in red spinach to have the same value even though the concentration of AB Mix fertilizer is different.

5. SUGGESTION

This useful for plant when rare nutrient, because plant can absorb it from carbon skin released wood in a manner slowly. Charcoal also delivers more influence Good to tall plant spinach compared to husks, because charcoal husk paddy own more abilities Good in increase porosity ground, so land become more loose and ability absorb water increases.

6. ACKNOWLEDGMENT

Thanks to Faculty Teaching and Education Sciences and the Biology Education study program at the Muhammadiyah University of Surakarta which has given permission and facilitation implementation study. This as well as support to activity study hydroponics, as well to participating colleagues contribute during study going on.

7. REFERENCES

Agustono, B., Lamid, M., Ma'ruf, A., & Purnama, Mte (2018). Identification Of Agricultural And Plantation Wastes As Unconventional Feed Materials In Banyuwangi. *Journal Of Veterinary Medicine , 1* (1), 12.

Aksa, M., Jamaluddin P, Jp, & Yanto, S. (2018). Planting Media Engineering In Hydroponic Planting Systems To Increase Vegetable Plant Growth. *Journal Of Agricultural Technology Education , 2* (2), 163.

Chairani, Efendi, E., & Hasiddiq, Ia (2017). Growth Response And Production Of Red Lettuce (Red Lettuce) Plants To Giving Water Hyacinth Bokashi And Sugarcane Dregs Bokashi. *Bernas Agricultural Research Journal , 13* (2), 37–43.

Gustia, H. (2013). Planting Media On Growth And Production Of Mustard Plants. *Widya Health And Environment E-Journal , 1* (1), 12–17.

Hidayanti, L., & Kartika, T. (2019). The Effect Of Ab Mix Nutrition On The Growth Of Red Spinach (Amaranthus Tricolor L.) Hydroponically. *Science: Scientific Journal Of Mathematics And Natural Sciences , 16* (2), 166.

Irawan, A. (2015). *Utilization Of Cocopeat And Rice Husk Charcoal As Planting Media For Cempaka Wasian (Elmerrilia Ovalis) Seedlings . 1* , 805–808.

Irianto, K. (2015). Agricultural Waste Management. *Warmadewa , 24* (2), 91.

Izzuddin, A. (2016). Santri Entrepreneurs Based On Hydroponic Plant Cultivation. *Dimas: Journal Of Religious Thought For Empowerment , 16* (2), 351.

Karyaningsih, S. (2012). Utilization Of Agricultural Waste To Support Increasing Land Quality And Paddy Paddy Productivity. *Buana Sanis , 12* (2), 8.

Mardhiana, M., Pradana, Ap, Adiwena, M., Kartina, K., Santoso, D., Wijaya, R., & Maliki, A. (2017). Effects Of Pruning On Growth And Yield Of Cucumber (Cucumis Sativus) Mercy Variety In The Acid Soil Of North Kalimantan, Indonesia. *Cell Biology And Development , 1* (1), 13–17.

Mosa, A., El-Banna, Mf, & Gao, B. (2016). Biochar Filters Reduce The Toxic Effects Of Nickel On Tomato (Lycopersicon Esculentum L.) Grown In The Nutrient Film Technique Hydroponic System. *Chemosphere , 149* , 254–262.

Muhammad Fuad Syah, Ardian, & Arnis En Yulia. (2021). Application Of Ab Mix Fertilizer To White Pakcoy (Brassica Rapa L.) With Floating Hydroponic System. *Agricultural Dynamics , 37* (1), 17–22.

Pebrianti, C., Ainurrasyid, Rb, & Purnamaningsih, L. (2015). Test Of Anthocyanin Content And Yield Of Six Varieties Of Red Spinach (Alternanthera Amoena Voss) In The Rainy Season Test Anthocyanin Content And

Yield Of Six Varieties Of Red Spinach (Alternanthera Amoena Voss) In The Rainy Season. *Journal Of Plant Production* , *3* (1), 27–33.

Roidah, Is (2014). *Land Utilization Using A Hydroponic System* . *1* (2), 43–50.

Sastro, Y. And N. (2016). *Vegetable Hydroponics In Urban Areas.*

Vanesaputri, A., Setiyono, S., & Arum, Ap (2022). The Effect Of Planting Media And Axes On The Growth And Yield Of Red Spinach (Amaranthus Tricolor L.) In Hydroponic Systems. *Agroscience : Journal Of Agronomy Research* , *24* (1), 20.

Wibowo, S., & Asriyanti, A. (2013). Nft Hydroponic Application On Pakcoy Cultivation (Brassica Rapa Chinensis). *Journal Of Applied Agricultural Research* , *13* (3), 159–167.

Wijaya, R., Hariono, B., & Saputra, Tw (2020). The Effect Of Nutrient Levels And Growing Media On The Growth Of Red Spinach (Alternanthera Amoena Voss) Hydroponic Systems. *Scientific*

Zamriyetti, Siregar, M., & Refnizuida. (2019). With The Application Of Some Ab Mix Nutrition Concentrations And Growth And Production Of Mustard Green (Brassica Juncea L.) By Application Of Ab Mix And Nutrition Contentrations. *Agrium Journal* , *22* (1), 56–61.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Oxygen Consumption and BB *Rattus novergicus* Obesity Sonde Treatment Glucomanan Porang Tubers and Moringa Leaf Extract

Mustika Arum Mayang Sari, Endang Setyaningsih*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: es211@ums.ac.id

KEYWORDS:
Wight
Moringa Leaves
Oxygen Consumption
White Rat
Porang Tubers
Obesity

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Obesity or overweight is a disorder of the amount of weight that results in excessive accumulation of body fat and can pose a risk to the health of the body. This results in metabolism in the body and ends up increasing oxygen consumption in the body. The purpose of the study was to determine the amount of oxygen consumption and body weight of obese white rats (*Rattus norvegicus*) in the treatment of glucomannan porang tubers (*Amorphopallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*). The research methods used are (1) Experimental methods prepared with Complete Random Design (RAL) in the form of Posttest Only Design using 8 treatment groups, (2) Documentation methods by documenting tools, research process materials and research results, (3) Literature methods by collecting data by looking for references to books, national and international journals and scientific papers. The results of this study stated the treatment of P2 with a body weight of 290 g with a volume of 9.93 x 10^{-4} ml / g.min. From this it can be concluded that the amount of oxygen 9.93 x 10^{-4} body weight 290 g results in increased oxygen consumption.

1. INTRODUCTION

Obesity is a condition where a person's weight exceeds a predetermined health standard. Obesity is a global problem, which every year experiences a very high increase per year. Not only in developed countries but also in developing countries in various countries. In 2016, the WHO stated that 39 % of adults aged 18 years and over were overweight and 13 % were obese. Most of the human population in the world is inhabited by humans who are overweight and obese. Obesity is a problem that causes more deaths compared to underweight people. In 2016, more than 340 million children and adolescents in the world aged 5-9 years were overweight or known as obesity. In Indonesia, according to Riskesdas 2018 data, it shows an increase in the prevalence of obesity in adolescents aged 16-18 years based on BMI / U in the last three periods, namely from 2010, 2013 and 2018 by 1.4 %, 1.6 % and 4 %. This shows that nationally obesity or overweight in children and adolescents and even adults is a health problem that is often experienced. Meanwhile, the prevalence of obesity in adolescents aged 16-18 years in South Sumantra Province based on the 2018 Riskedas is 2 % (Mardiana, 2022).

Obesity can be treated by going on a diet. A diet that is high in fiber is highly recommended to be one of the recommended diets for obese or overweight people. With the application of a high-fiber diet carried out, it is expected that someone who is obese can modify the nutritional arrangement and content in it and daily food portions by increasing high-fiber ingredients that are healthier also more than usual or exceed the recommended daily fiber intake. This high-fiber diet

aims to provide food intake according to the nutritional needs of the body that is high in fiber so as not to be excessive so that it can trigger intestinal peristalsis, so that the process of defecation becomes normal and does not experience problems. A high-fiber diet includes a diet that is good for health, easy to do, affordable and rich in benefits, especially for children and adolescents who are growing. This is because foods that contain high fiber are safer for the human body and most have a purchase price that is not too high so that anyone can buy and consume without an age limit (Zaki, 2021). Traditionally, dietary fiber is a part of the plant that can be consumed rich in benefits, composed of carbohydrates that are resistant to human digestive processes, can be absorbed in the small intestine and fermented partially or completely in the colon. For example, the fiber consumed is tubers that have a lot of glucomannan content such as porang tubers (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*). Glucomannan is 33 polysaccharides consisting of mannan groups such as monomers β-1,4 α-monnose and α-glucose. Glucomannan contained in porang tubers (*Amorphophallus muelleri* Blume) has benefits that can strengthen cells, improve texture, thicken, lower blood sugar levels, and reduce cholesterol levels in the blood (Almansyah, 2019).

Porang tuber (*Amorphophallus muelleri* Blume) is one of the natural alternative ingredients used to reduce obesity and overweight. Porang tubers are a very promising Indonesian export commodity that will be sent to various countries such as Japan, China, Vietnam, Australia and other developed and developing countries (Ministry of Agriculture, 2020). Indonesia exports porang tubers in raw and mature form, for example, one of which is porang chips or coarse porang flour. Actually, porang tubers are widely used glucomannan as cosmetics, glue and supplements. Proper processing of porang can be profitable in sales because the selling price is very high per year which can increase. Porang tubers cannot be consumed directly. This is because porang contains oxalate crystals that can cause allergic reactions or irritation of the mouth to damage to organs in the body. Therefore its processing is given great attention. Based on research (Saputro et al., 2014) glucomannan levels in porang tubers (*Amorphpphallus melleri* Blume) obtained after the purification process to remove oxalate crystals are greater ranging from 36.69 % - 64.22 % compared to porang flour before purification, which is worth 28.76 %.

Glucomannan is a water-soluble non-starch polysaccharide known as water-soluble fiber. Glucomannan has the ability to lower cholesterol levels in the blood and blood sugar levels, reduce weight, obesity, and affect intestinal activity and immune function in the human body (Nissa &; Masjid, 2016). High levels of glucomannan are found in tubers that have been processed into flour. As in porang tubers that are converted into flour, which produces high glucomannan. Glucomannan is processed and developed as a weight loss product and has been approved by the European Food Safety Authority (EFSA) to lose body weight in overweight or obese adults with consumption of 3 grams / day (Meiliana, 2022). Porang tubers or known as (*Amorphophallus muelleri* Blume) have a fairly high glucomannan content, which is 45-65%. The content of each type of porang varies, for example in the type of white porang flour which has a water content of 13.477 %, ash content of 4.612 %, starch content of 47.554 %, amylose content of 17.536 %. As for the content of the yellow porang type has a content of 12.326 %, ash content of 3.901 %, starch content of 5.598 %, amylose content of 16.948 %. For the extraction results from white porang flour with water solvents, glucomannan levels were obtained 73.70 % and for ethanol solvents glucomannan levels were obtained of 64.67 % (Aryanti &; Abidin, 2015). Meanwhile, according to (Nissa &; Madjid, 2016) the dose is 200 mg / kg. BB glucomannan of porang tubers (*Amorphophallus muelleri* Blume) in white rats induced with a high-fat diet was very effective in losing body weight and appetite of white rats (*Rattus novergicus*)

In addition to porang tubers (*Amorphophallus muelleri* Blume), natural ingredients that can be used in the diet to deal with obesity and overweight are Moringa leaves (*Moringa oleifera*). Moringa leaves (*Moringa oleifera*) is one of the superfood ingredients because it has high nutritional levels in meeting the nutritional needs in the body. Moringa leaves also contain several antioxidants that are very beneficial for the body such as flavonoids, vitamin C, polyphenols, and β-sitosterol which are useful for reducing lipid peroxidase levels and LDL concentrations in plasma and inhibiting reabsorption in cholesterol from endogenous sources (Tjong et al., 2021). Based on research (Nahar et al., 2016) Moringa oleifera powder is very useful as an anti-obesity and overweight that can manage weight gain. Giving a single dose of Moringa leaf powder 50 mg / day / rat can reduce food intake and body mass index in white rats treated by the obesity control group, while treatment dose 50 mg / day / rat for a day twice can result in a significant decrease in body mass index of white rats treated by the obesity control group.

High metabolic rate can be measured by calculating the amount of oxygen consumption in unity of time. This allows because oxidation in food ingredients requires oxygen to create a recognizable amount (Melisa, 2020). Respiration that occurs plays an important role in maintaining the continuity of cellular metabolism in the body so that a very strong respiration function is needed. So that cells contained in the body can metabolize properly so that they can produce energy. Cells need an adequate supply of oxygen and nutrients into the body. Nutrients are obtained from the intake of food and fluids that enter the body. The effects of overweight and obesity on the respiratory mechanism and lung volume with an increase in the amount of fat in the chest wall and abdomen, have an effect on the mechanical properties of the chest and diaphragm and indicate changes in respiratory function in the body. This decreases lung volume and changes in the picture with each respiration. Furthermore, an increase in the amount of fat mass indicates a widespread decrease in the respiratory system where the respiratory system decreases more than it should. Changes in respiratory volume per unit, pressure changes and greater reductions can be seen in the chest wall of the lungs. The total decrease occurs when overweight sufferers sleep flat due to the pressure of fat tissue pressing against their chest wall, this state of activity is observed also at normal body weight. This accumulation of fat mass increases the elasticity and ability of the respiratory system in the body, thus increasing the work of the respiratory muscles, increasing the speed of metabolism in obesity or overweight will increase oxygen consumption, carbon dioxide production and this change results in increased ventilation where air exchange in the lungs increases. So in both obese and overweight marked, chest wall compliance decreases, respiratory work increases and residual respiratory volume and vital capacity decrease. Overweight and obesity can lead to hypoventilation, due to increased carbon dioxide retention. Mechanical respiratory work increases by up to 30 % in mild overweight. So that oxygen consumption in the body has increased high.

Cholesterol tests at the laboratory level usually use white rats (*Rattus novergicus*). White rats (*Rattus norvegicus*) are experimental animals that are often used in obesity reduction research because white rats have more advantages compared to other test animals such as easy to handle, can be obtained in large quantities but the price is not too expensive, and has valid repeat results (Lahamendu et al., 2019). White rats (*Rattus norvegicus*) are often used as food trials and food substance deficiencies in all types of animals including humans (Rejeki et al., 2018).

2. MATERIALS AND METHODS

2.1. Time and Place of Research

This research was conducted from September 2022 to May 2023 from taking the title to drawing conclusions. This research was carried out at the Veterinary Laboratory of Sebelas Maret University as a place for keeping, perpetrators, and taking test animals. Research was also conducted at the Biological Education Laboratory, Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta as a place for examination and large analysis of oxygen consumption in white rats.

2.2. Tools dan Materials.

The tools used in this study include: (1) One cake scale, (2) A pair of glove, (3) One connecting hose, (4) One open manometer, (5) One 10 ml measuring cup, (6) One 100 ml glass beker, (7) one petri dish, (8) One syringe, (9) One tray, (10) One small bowl, (11) One dropper, (12) One rat cage. The ingredients used include: (1) Eight white rat samples, (2) One piece of tissue, (3) 1.6 ml brudy solution, (4) KOH to taste, (5) Silica gel to taste, (6) Vaseline to taste.

2.3. Sample Determination (Sampling Method)

Samples were taken at the UNS Test Animal Laboratory by preparing rat cages and taking one white rat in each treatment such as: P1, P2, P3, P4, P5, P6, P7, and P8. Then brought to the UMS Biological Laboratory to measure the amount of oxygen consumption of white rats.

2.4. Measurement Method

The measurement methods used in this study are (1). Experimental method with *Posttes Only Control Design*, (2). Documentation method, this method is an aid in taking research images used in documenting tools, materials, research processes and research results, (3). Literature method, Literature collection techniques, are carried out by looking for references to national and international journal books, scientific papers, and existing theses and studying the same scope. This method is used to support the creation of literature reviews and discussions on research.

2.5. Research Design

This study used a true experimental method prepared with a Complete Randomized Design (RAL) in the form of *Posttest Only Control Design* using 8 treatment groups. Details are as follows:

1) Treatment 1 (positive control): Control group with normal feed (P1).
2) Treatment 2 (negative control): Control group with high-fat diet feed (P2).
3) Treatment 3: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 100 mg / kg BB : 100 mg / kg BB (P3).
4) Treatment 4: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 120 mg / kg BB : 80 mg / KgBB (P4).
5) Treatment 5: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract, 80 mg / kg BB: 120 mg / kg BB (P5).

6) Treatment 6: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 50 mg/kgBB (Nugraheni et al., 2014): 50 mg/kgBB (Nahar et al., 2016modified) (P6).
7) Treatment 7: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 60 mg / kg BB : 40 mg / kg BB (P7).
8) Treatment 8: Treatment group of high-fat diet feed + glucomannan and Moringa leaf extract 40 mg / kg BB : 60 mg / kg BB (P8).

2.6. Aktivity Stage

The stages of activities in this study include: (1). Maintenance Stage, (2). Treatment Stage, (3) Measurement Stage of oxygen consumption by selecting 8 rats to be tested with oxygen consumption treatment. Prepare the tools and materials to be used.. The desiccator or breathing chamber is filled with silica gel and KOH to taste, then install a divider. Weigh the weight of the experimental animal, then put it into the breathing chamber. After the circuit is ready, the system in the circuit is closed, sealed with enough vaseline smear. Insert Brody's lar as much as 1.6 ml into the manometer pipe (until balanced), Then observed the scale on the manometer (its strip change) in the first 10 minutes and the second 10 minutes. Then input it into the oxygen consumption calculation formula

2.7. Data Calculation and Analysis

The results of the calculation of the amount of oxygen consumption of white rats will continue to be calculated using the following formula:

Formula 1	**Information :**
	v = Oxygen Consumption (to 1,2,….etc)
$v = \frac{x}{y} . \int$	x = Scale / large solution (ml)
	y = Scale / large manometer resipirometer (ml)
	$\int$ = Change of scale / strip on respirator manometer (ml)
Formula 2	**Information :**
	Oxygen consumption time 1 and time 2
$v_1 + v_2$	
Formula 3	**Information :**
	t = Required time (hours)
$\sum t = t1 + t2$	$\sum KO$ = Total oxygen consumption (ml/min.g)
	$\sum v$ = Total oxygen consumption (ml)
$\sum KO = \frac{\sum v}{\sum t . BB}$	BB = Aminal body weight (g)

Then the results of the study were analyzed in a quantitative statistical discriptive manner to determine the average between treatment groups.

3. RESULTS AND DISCUSSION

3.1. Body Weight

This study used experimental animals of white rats (*Rattus norvegicus*) male wistar strain aged 8 weeks with an average before acclimatization was 162 kg., healthy state and has never been

used for research. The experimental animals were divided into 8 groups consisting of 8 white rats *(Rattus norvegicus*). The treatment was carried out for 2 weeks of high-fat feed treatment or a combination of glucomannan porang tubers (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*). Data on 8 treatment groups, namely P1 (normal), P2 (high-fat diet), P3 (100:100 mg/KgBB), P4 (120:80 mg/KgBB), P5 (80:120 mg/KgBB), P6 (50:50 mg/KgBB), P7 (60:40 mg/KgBB) and P8 (40:60 mg/KgBB).

The average body weight of white rats (*Rattus norvegicus*) before and after receiving high-fat feed treatment or giving a combination of glucomannan porang tubers (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*) can be seen in figure 3.1

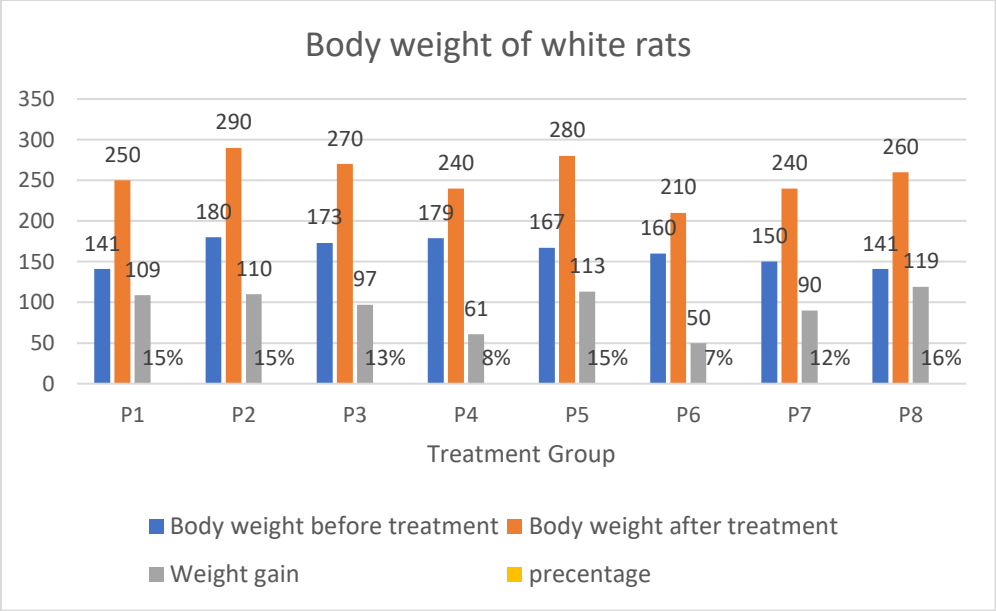


Figure 3.1 Bar chart of body weight of white rats before and after treatmen

Based on the diagram table above, it shows an increase in white rats (*Rattus norvegigus*), sonde glucomannan treatment, porang tubers (*Amorphollus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*). In the P1, P2, and P5 treatment groups experienced a gain of 15 % of body weight before being treated. In the P3 treatment, there was an increase of 13 %. In P4 experienced an increase of 8 %. In P7 it experienced an increase of 12 %. The lowest weight gain was in the P6 treatment group, which was 7 %. While in the P8 treatment, the increase was 18 %, which is the highest weight gain. If averaged all the increases that occurred in experimental animals, white rats (*Rattus norvegicus*), sonde glucomannan treatment, porang tubers (*Amorphollus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*) were 13 %, which means white rats are obese. Obesity that occurs.due to the treatment of sonde glucomannan porang tubers (*Amorphollus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*).

Overall, during the high-fat feed treatment and dosing of glucomannan treatment combination of porang tubers (*Amorphophallus muelleri* Blumen) and Moringa leaf extract (*Moringa olifera*) there was an increase in body weight of white rats as experimental animals.

3.2. Oxygen Consumption

The results of large measurements of oxygen consumption of obese white rats (*Rattus norvegicus*) in the treatment of sonde glucomannan porang tubers (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*) from experimental animals were carried out by calculating oxygen consumption in units (minutes / grams. BB). The serving value in figure 3.2 is the result of research that shows that the value of oxygen consumption is getting higher with time and increasing weight. The increased level of oxygen consumption shows an increased metabolic rate in white rats (*Rattus norvegicus*). The highest level of oxygen consumption is found in P4 treatment (120:80 mg/KgBB) which is 10.6 x 10^{-4} ml/gr.min. . This is thought to be because the more weight you gain will increase oxygen consumption. According to Wiraatnaja (2016), the rate of respiration in the body can be influenced by several factors including, weight: the heavier an organism is, the more oxygen consumption is needed. Body size: the larger the body size, the more oxygen consumption is required. Oxygen levels: if oxygen consumption is low the frequency of respiration increases to increase O_2 uptake. Activity: the more activity performed, the higher the oxygen consumption required.

The increased level of oxygen consumption and body weight of white rats showed an increased respiration process. This increased respiration process will increase the metabolic rate of white mice. According to Putra (2015), basal metabolism includes the processes of respiration, blood circulation, and peristatics.

No	OXYGEN CONSUMPTION RATE (MIN / Gr . BB)						
	EXPERIMENTAL GROUP	BODY WEIGHT	TIME			OXYGEN CONSUMPTION	ROUNDING OF OXYGEN CONSUMPTION
			10^1	10^2	Total		
1	P1	250 g	+7	+5	+12	7,68 x 10^{-4} ml/gr.min	8 ml/gr.min
2	P2	290 g	+9	+9	+18	9,93 x 10^{-4} ml/gr.min	10 ml/gr.min
3	P3	270 g	+8	+4	+12	7,11 x 10^{-4} ml/gr.min	8 ml/gr.min
4	P4	240 g	+10	+6	+16	10,6 x 10^{-4} ml/gr.min	11 ml/gr.min
5	P5	280 g	+7	+10	+17	9,71 x 10^{-4} ml/gr.min	10 ml/gr.min
6	P6	210 g	+6	+7	+13	9,90 x 10^{-4} ml/gr.min	10 ml/gr.min
7	P7	240 g	+9	+3	+12	8 x 10^{-3} ml/gr.min	8 ml/gr.min
8	P8	260 g	+8	+8	+16	9,85 x 10^{-4} ml/gr.min	10 ml/gr.min

Figure 3.2 Large oxygen consumption of white rats (*Rattus norvegicus*)

Description:

- The amount of oxygen consumption shows that there is not too much difference between P1-P8 treatment.
- 10^1 = first 10 minutes.
- 10^2 = first 10 minutes
- Total = first 10 minutes + second 10 minutes

While the results of the bar chart show the results of no significant far difference between P1-P8 which can be seen in figure 4.3 below:

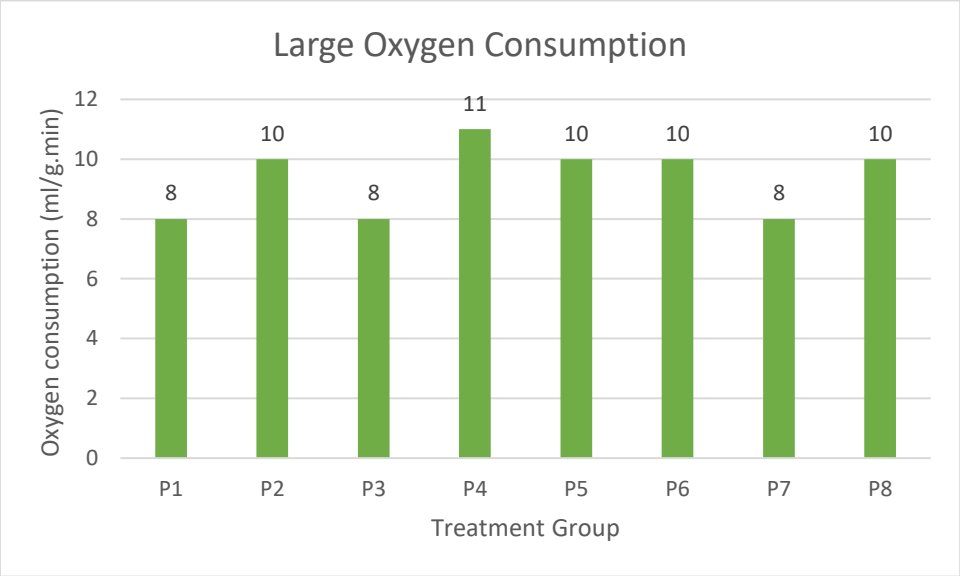


Figure 4.3 Large bar chart of oxygen consumption of obese white rats that have been treated with a combination of glujomanan porang tuber and moringa leaf extract.

Based on figure 4.3 above, it can be seen that there is not much difference in the amount of oxygen consumption between treatment groups. The P1, P3, and P7 treatment groups showed a total oxygen consumption of 8 ml/min. While the treatment of P2, P5, P6, and P8 shows the amount of oxygen consumption of 10 ml / minute. Then the P4 treatment showed oxygen consumption of 11 ml / minute.

Metabolic activity in the body is very important in our body. Metabolic activities are closely related to breathing, because breathing is the process of making energy from environmental food molecules that depend on the presence of oxygen, the metabolic rate in the body can be calculated and measured by measuring the amount of oxygen consumption in the unity of time. This is allowed because the oxidation of the material requires oxygen to create a known amount of energy (Suharso, 2018)

Oxygen consumption in white rats (*Rattus novergicus*) can be calculated by the formula: Final scale - initial scale of manometer (ml) Body weight (g) x time (mt) (Haris, 1985). The data obtained is processed by discriptive methods and analyzed manually. The white rat (*Rattus novergicus*) used was weighed using a digital scale, then prepared a petri dish, poured KOH and silica gel and put it into the desiccator tube. Then put 1.6 ml of brudy solution into the manometer pipe. Next, attach the manometer pipe to the desiccator tube using a connecting hose and then insert the white mouse. Apply Vaseline around the respirometer tube cap hole so that the air outside does not enter and the air inside does not come out when it will be used. It further records the treatment name data, body weight and oxygen consumption required in minutes. Recorded the development of oxygen consumption of white rats at oxygen consumption of the first ten minutes and the second ten minutes. After each recording and calculation one eosin organism is cleaned, then put it in the basket and mark it according to treatment. Then it is repeated until each repetition and treatment is completed, finally cleaning the laboratory and tools used when doing work and documenting the results and research activities (Melesi, 2020).

The test animals used in this study were white mice that were obese after being given a dose of feed. The feed doses given were 8 treatment groups dose P1 (positive control), P2 (negative

control), P3 (100 mg / kg.BB : 100 mg / kg.BB), P4 (120 mg / kg.BB : 80 mg / kg.BB), P5 (80 mg / kg.BB : 120 mg / kg.BB) , P6 (50 mg / kg.BB : 50 mg / kg.BB), P7 (60 mg / kg.BB : 40 mg / kg.BB and 40 mg / kg.BB).

The results of the study obtained the highest value in white rats in P2 treatment weighing 290 g with a volume of 9.93 x 10-4 ml / gr. min and the lowest value in P1 treatment weighing 250 g with a volume of 7.68 x 10-4 ml / gr.min. Ersawati (2018) stated that Moringa leaf extract can increase the body weight of white rat pups by 0.1 grams and increase the body length of white rats (*Rattus novergicus*) by 0.2 cm. In the cultivation of Moringa leaf flour (*Moringa oleifera*) as a natural protein in reinforcement feed has been widely applied. Moringa contains a lot of complete nutrients ranging from carbohydrates, proteins, fats, vitamins and minerals that are good for the body. In a dose of 100 grams of Moringa leaf powder contains 28.2 iron and 17.3 vitamin C in it. Iron is indispensable for the material of hemoglobin formation. Hemoglobin in the body serves to transport oxygen throughout the cells. The availability of hemoglobin in the body is sufficient to make the metabolic system in our body can run well and increase the weight of an organ, while vitamin C can make the iron in Moringa leaves absorbed by the body properly and maximally when consumed. According to Ologhobo and Affiku (2014), flour derived from Moringa leaves is one type of traditional herbal feed known as a substitute for the use of antibiotics for weight boosters. Antibiotics have properties that can stop the growth or kill other trace bodies that are panthogen which results in soaring bacterial populations in the body found in the digestive tract. From the above results it can be concluded that the body weight of white rats (*Rattus novergicus*) greatly affects oxygen consumption. . Where the heavier the weight of the animal tested, the higher and greater the oxygen consumption in the animal, and by giving sonde glucomannan treatment of porang tubers (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*).

In the treatment also using sonde glucomannan tuber porang (*Amorphophallus muelleri* Blume). Giving glucomannan has a role in reducing obesity because glucomannan in porang tubers (*Amorphophallus muelleri* Blume) contains dietary fiber can help provide a satiating effect so that it can reduce excess food consumption intake and raise HDL cholesterol levels through the process of binding fat in the intestine and binding bile salts in the digestive tract, thereby increasing the excretion of cholesterol in the faeces and can reduce cholesterol levels that go to the liver and stimulates the synthesis of HDL cholesterol levels in the liver (Nurdiantini, I., Prastiwi, S., &; Nurmaningsari et al., 2017). Glucomannan imbi porang (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*) were factors used to reduce obesity in this study and the most effective treatment in providing an obesity-reducing effect in obese mice. Nissa (2016) stated, both normal and obese groups who were given porang tuber flour containing glucomannan were proven to lose weight who were obese compared to groups that were not given porang tuber flour. Research conducted in the United States in 2007 and 2008 proved that glucomannan was able to lose weight in subjects suffering from obesity or overweight. Weight loss in obese people is thought to be due to the physical properties of glucomannan which can form gels and increase the viscosity of the gastrointestinal tract thereby decreasing the absorption of food by the intestine. Another study conducted in Spain in 2010 stated that consumption of high-fiber protein increases viscosity through the formation of a gel layer and is impermiable in the gastrointestinal tract, that is, the channel that extends from the mouth to the anus. The formation of the gel by fiber is able to block the contact of food with the walls of the gastrointestinal tract. Thus, to consume glucomannan fiber must be in accordance with the needs of the body, if consumed in too much amount it is feared that it can cause excessive weight loss. Therefore, to avoid excessive weight loss in normal individuals, it is recommended to consume fiber according to the needs in the body, while for someone who is obese can be done a slightly higher fiber consumption above the needs.

The results of the treatment of sonde glucomannan porang tubers (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*) affect the oxygen consumption of

the white rats, where the treatment causes white rats to be obese and affects their oxygen consumption. In accordance with Wiraatnaja's statement (2016) that respiration can be influenced by several factors including, weight: the heavier an organism is, the more oxygen consumption is needed. Body size: the larger the body size, the more oxygen consumption is required. Oxygen levels: if oxygen consumption is low the frequency of respiration increases to increase O_2 uptake. Activity: the more activity performed, the higher the oxygen consumption required. So that it is the same as the results of this study that in oxygen consumption P2 treatment with a body weight of 290 g experienced an increase in oxygen consumption with a volume result of 9.93×10^{-4} ml / gr.

4. CONCLUSIONS

Based on the results of the research obtained, it can be concluded that body weight in test animals of this study greatly affects the rate of respiration of these animals, the greater the body weight of an organism, the more oxygen consumption needed and the faster the respiration process and the need for oxygen consumption increases. The combination of glucomannan porang tuber (*Amorphophallus muelleri* Blume) and Moringa leaf extract (*Moringa oleifera*) at a dose of P2 (high-fat diet feed) weighing 290 g affected the oxygen consumption of white rats (*Rattus novergicus*) because it resulted in increased body weight of white rats resulting in a large amount of oxygen consumption needed.

This study can be continued to calculate the large differential of oxygen consumption and see the effect of glucomannan porang tuber and Moringa leaf extract that is effective against antibodies.

5. ACKNOWLEDGMENTS

Thank you to the Faculty of Teacher Training and Education and the Biology Education study program, University of Muhammadiyah Surakarta for granting permission and facilitating the implementation of this research and supporting white rat research activities, as well as to colleagues who contributed during the research.

6. REFERENCES

Alamsyah, M.A.B.O. (2019)." Pengaruh Glukomanan Terhadap Penurunan Risiko Penyakit Stroke Iskemik". *Jurnal Ilmiah Kesehatan Sandi Husada.* 10(2):292-289

Aryanti, Nita., & Abidin, Kharis. Yohan. (2015). Ekstrasi Glukomanan dari Porang Lokal (Amorphophallus oncophyllus dan Amorphophallus muerelli blume). *METANA, 11*(1), 21-30.

Ersawati, Neti. Susari, Ni Nyoman Werdi. Setiqsih, Ni Luh Eka. 2018. Berat Organ Usus Tikus Putih (*Rattus Norvegicus*) Pasca Penambahan Tepung Daun Kelor (*Moringa Oleifera*) pada Pakan. *Indonesia Medicus Veterinus*. 7(3).

Lahamendu, B., Bodhi, W., & Siampa, J. P. (2019). Uji Efek Analgentik Ekstrak Etanol Rimpang Jahe Putih (Zingiber officinale Rosc. var Amarum) pada tikus putih Jantan Galur Wistar (Rattus norvegicus). *PHARMACON, 8*(4), 928–935. .

Mardiana., Yusuf, A., & Sriwiyanti. (2022). The Relationship of Some Factors With the Event of Adolescent Obesity At Palembang. *(JPP) Jurnal Kesehatan Poltekkes Palembang, 17*(2), 163-170.

Meiliana, Sherin. Isna., & Muhtadi. (2022). Antiobesity Activity of Porang Tuber Flour (Amorphophallus muelleri) in Obesity Rat Model. *Seri MIPA dan Kesehatan,* 359-369.

Melisa, Putri., dkk. (2020). Perbedaan Laju Respirasi pada Belalang (Oxya Serville) dan Jangkrik (Archeta Domesticus) Setelah Penambahan Insektisida. *Jurnal Jeumpa, 7*(2), 450-457.

Nahar, S., Faisal, F. M., & Iqbal, J. (2016). Antiobesity activity of Moringa oleifera leaves against high fat diet-induced obesity in rats. *International Journal of Basic and Clinical Pharmacology, 5*(4), 1263–1268. https://doi.org/10.18203/2319-2003.ijbcp20162427

Nissa, C., & Madjid, I. J. (2016). Potensi glukomanan pada tepung porang sebagai agen anti-obesitas pada tikus dengan induksi diet tinggi lemak. *Jurnal Gizi Klinik Indonesia*, *13*(1), 1. https://doi.org/10.22146/ijcn.22751

Nugraheni, Bekti., Setyopuspito, Anastasia. P., & Advistasari, Yustisia. Dinda.(2018).Indetifikasi dan Analisis Kandungan Mkronutrium Glukomanan Umbi Porang (Amorphophallus onchophyllus).*Jurnal Ilmu Farmasi dan Farmasi Klinik (JIFFK)*.15(2),77-82.

Nurdiantini, I., Prastiwi, S., & Nurmaningsari, T. et al. (2017) 'Pengaruh pemberian tepung porang (*Amorphophallus muelleri* Blume) terhadap kadar HDL pada tikus (*Rattus novergicus*) Strain Wistar DM Tipe 2', *Jurnal Keperawatan Soedirman*, 2(2), pp. 31–37. doi:10.20884/1.jks.2017.12.1.717.

Ologhobo AO, Affiku JP. 2014. Effect of Polyherbal Aqueous Extract (*Moringa oleifera*, Arabic Gum, and wild *Ganoderma lucidum*) in Comparison with Antibiotic on Growth Performance and Haematological Parameters of Broilers Chickens. *Res. J. Recent Sci*. 1(7):10-18.

Pertanian Kementerian. (2020). Porang (Amorphophallus muelleri) dan Cara Budidaya. *Warta Penelitian dan Pengembangan Tanaman Industri*, *26*(1), 1–6.

Putra, Achmad. Noerkhaerin. (2015). Laju Metabolisme pada Ikan Nila Berdasarkan Pengukuran Tingkat Konsumsi Oksigen. *Jurnal Perikanan dan Kelautan*, *5*(1), 13-18.

Rejeki, P. S., Putri, E. A. C., & Prasetya, R. E. (2018). *Ovariektomi pada Tikus dan Mencit.* Pusat Penerbitan dan Percetakan Universitas Airlangga.

Saputro, E. A., Lefiyanti, O., & Mastuti, I. E. (2014). Permurnian Tepung Glukomanan dari Umbi Porang (Amorphophallus muelleri Blume) menggunakan Proses Ekstraksi/Leaching dengan Larutan Ethanol. *Simposium Nasional RAPI XIII*, 1–13.

Suharso. L, Badriah. D, Ramdan. 2018. Perbedaan Jumlah Konsumsi Oksigen (O2) Pada Respirasi Berbagai Hewan Invertebrata kelas Insekta. *Jurnal Kesehatan Bakti Tunas Husada*. 18(2).

Tjong, A., Assa, Y. A., & Purwanto, D. S. (2021). Kandungan Antioksidan Pada Daun Kelor (Moringa Oleifera) dan Potensi Sebagai Penurun Kadar Kolesterol Darah. *eBiomedik*, *9*(2), 248–254.

Wiraatnaja, I Wayan. 2016. Respirasi dan Fotorespirasi. Fakultas Pertanian. Universitas Udayana. Denpasar Bali

Zaki, Ibnu. dkk. (2021). "Diet Tinggi Serat Menurunkan Berat Badan Pada Obesitas". *Journal of Nutrition and Culinary*. 2(2):1-9

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Effect of Kepok Banana Skin Liquid Organic Fertilizer (*Musa paradisiaca*) on the Growth of Mustard Plants (*Brasicca juncea* L.)

Isherdini, Berliana Putri Athena, Suparti *
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. e-mail address: sup168@ums.ac.id

KEYWORDS:
Mustard greens
POC

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Green mustard (*Brassica Juncea* L.) is a vegetable that contains a lot of vitamins and high nutrients, so mustard greens have high commercial value and marketing prospects. Mustard greens are also much liked by the public for consumption, therefore the level of market demand for mustard lants is very high. The production of mustard greens in Indonesia is still not optimal to meet market demand, therefore a research is being carried out on applying Liquid Organic Fertilizer (POC) t mustard greens. There were 4 different experimental treatments in this study. This study used an experimental method, namely by using a Completely Ranomized Design (CRD) using 2 treatment factors. The first treatment factor is the volume of Liquid Organic Fertilizer (POC) watering and the second treatment factor is the time of Liquid Organic Fertilizer (POC) administration. P0 = control, P1 = 10 ml POC, P2 = 15 ml POC, P3 = 20 ml POC and P4 = 25 ml POC. The results of the study stated that the best for P4 treatment.

1. INTRODUCTION

Plant growth and development is strongly influenced by various factors such as light, temperature, humidity, soil, nutrients and others. Soil conditions and nutrients that do not support plant growth can be pursued by providing fertilizer according to plant needs. Fertilizers are materials that contain one or more plant nutrients which, if given to plants, can increase plant growth and yield (Salfina, 2017).

Fertilizers consist of two types, namely inorganic fertilizers and organic fertilizers. Organic fertilizers can be solid and liquid. Liquid organic fertilizer contains micro and macro elements needed by plants for the process of plant growth and development. Organic fertilizers are fertilizers composed of animal, human and plant wastes. One of the plant wastes that can be used is banana peels. The advantages of using fertilizers that contain complete nutrients, both macro nutrients and micro nutrients. This condition is not owned by artificial fertilizers (Susetya, 2012).

Banana plants are community cultivation plants that thrive in Indonesia. Banana plants are a separate business opportunity for the community, resulting in a lot of banana peel waste being produced. The banana peel itself is about 1/3 of the banana fruit. So far the utilization of banana peel waste is still lacking, only some people use it as animal feed (Risky, 2015).

Banana peel waste can be used as fertilizer, because banana peels have a lot of ingredients such as protein and phosphorus, besides that they also contain micronutrients such as Ca, Mg, N, Na, and Zn. The application of liquid organic fertilizer from banana peel waste has a significant effect on plant growth including plant height and number of plant leaves. Banana peels have good potential to be used as organic fertilizer which is watered on the planting medium (Risky, 2015)

Increasing vegetable production needs to be supported by various efforts, one of which can be done through fertilization. So far, farmers are still using chemical fertilizers in cultivating mustard greens. This is because chemical fertilizers are easier to obtain in the market but are relatively expensive and less environmentally friendly. The use of chemical fertilizers in a relatively long period of time has proven to cause serious problems, including soil contamination and economic and social dependence on bananas (Sedayu, 2014).

One of the solutions to increase the production of mustard plants is to use liquid organic fertilizers. Liquid Organic Fertilizer is fertilizer whose basic ingredients come from animals or plants that have undergone fermentation. One of the liquid organic fertilizers that can be used to fertilize mustard plants. The large number of home industry businesses made from bananas results in a large amount of banana peel waste. One-third part of the banana is the skin so that the thickness of the banana skin can cause fertilization of banana peel waste in large quantities (Susetya, 2012).

Banana peels can be used as liquid fertilizer because banana peels contain the elements N, P, K, Ca, Mg, Na, Zn, each of which functions for plant growth and development which has an impact on increasing plant productivity. Banana peel organic fertilizer has a significant effect on plant growth parameters. The need for different nutrients according to the growth phases of the plant. During the vegetative phase, different nutrients will be needed from when the plant reaches the generative phase. Mustard plants are plants that require N, P, and K nutrients in the vegetative phase.

Indonesian people, especially the middle class now, especially vegetable farmers, are increasingly concerned about the importance of fertilizer for plants. One solution to overcome the limitations of fertilizers that are cheap and easy to obtain is to use organic fertilizers in the utilization of organic waste such as banana peels. To reduce the problem of waste that pollutes the environment, it can be overcome by utilizing banana peel organic waste as liquid organic fertilizer which can increase the availability of nutrients in plants. The advantages obtained in making liquid fertilizer are that the manufacturing process is relatively easy, it is more practical to use, and the manufacturing costs incurred are also not too large.

2. MATERIALS AND METHODS

2.1 *Tools and materials*

The tools and materials used in this study included cellphone cameras, plastic jars, knives, measuring cups, and stationery. While the materials used are banana skin waste, eggshell waste, rice washing water waste and EM4.

2.2 Procedures

Research on the growth of mustard plants with the addition of POC to be able to determine the growth rate of mustard plants was carried out in Tuko Village, Pulokulon District, Grobogan Regency. The method used in this studywas a Completely Randomized Design (CRD) with one factor, consisting of 5 treatments: P0 : Without giving POC (control) P1: Watering volume with 10 ml POC P2: Watering volume with15 ml POC P3: Watering volume with 20 ml POC P4: Watering volume with 25 ml POC. Data analysis used Completely Randomized Design (CRD), namely byusing 2 treatment factors. Formulas used in data calculations are written using an equation editor or other standard applications. Formulas cannot be in the form of images or screen capture results from other sources. Formulas are written byincluding reference sources.

3. RESULTS AND DISCUSSION

2.3 Plant height

The increase in plant height is one of the parameters that can be used to determine growth in mustard plants. Based on the results of the research that has been done, the highestplant height results were found in the treatment P4 = Watering volume with 25 ml of POC, which was 12 cm plant height.

2.4 Number of Leaves

Based on the observation data, it shows that the number of leaves on mustard plants in growing media with different fertilizer concentrations and time intervals for applying fertilizers has a varying number of leaves. The research that has been carried out obtained the results of observing the number of leaves for each treatment on mustard plants. Observation of this research takes 4 weeks. And the results obtained were that the highest number of leaves wasfound in treatment P4 = Volume of watering with POC as much as 25 ml which contained 6 leaves. In addition, the results obtained were the least number of leaves, namely in the treatment P0 = without giving POC (control) which contained 5 leaves.

Table 1. Data on Plant Growth Results

Treatment (P)	First Week (H1)		Fourth Week (H2)	
	Plant height Quantity(cm)	Leaf	Plant height Quantity(cm)	Leaf
P0 = Without Giving POC (control)	2.5	2	7	5
P1 = Watering volume with POC as much as 10 ml	3	4	8	5
P2 = Watering volume with POC as much as 15 ml	3	4	9	6
P3 = Watering volume with POC as much as 20 ml	3	4	10	6
P4 = Watering volume with POC as much as 25 ml	3.5	4	12	6

Notes:
P : The first factor is the volume of watering liquid organic fertilizer (POC)
H : Time of application of Liquid Organic Fertilizer (POC)

(A) **(B)**

Figure 1. The Best (A) and the worst (B) of the green mustard growth

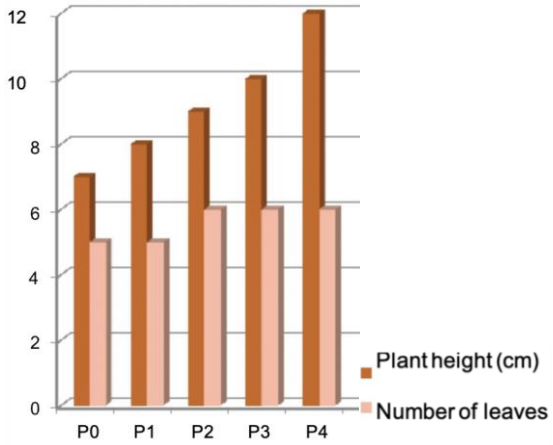


Figure 2. Mustard Plant Growth Chart

3. 3 Plant Height

Plant height growth is one of the parameters that can be used to determine plant growth. Based on the data obtained, it can be seen that the mustard plants that were given liquid organic fertilizer from kepok banana peels had the highest plant height increase in the P4 treatment (25 ml POC concentration), with a height increase of 12 cm. While the lowest plant height gain was in the P0 treatment (0 ml POC concentration), with a height value of 7 cm. This is because the P0 treatment did not use fertilizer so that plant growth was slow. Providing nutrients in the vegetative phase with sufficient concentrations can provide optimal results for plant growth.

3.4 Number of Leaves

The number of plant leaves is one of the important parameters to observe plant growth. Leaves are important organs to support plant growth because leaves are the main organ for food supply through the process of photosynthesis. To support leaf growth, it is necessary to have a supply of nutrients from fertilizer. in each treatment has a different leaf growth. The average increase in the number of leaves was highest in treatment P4 (25 ml POC concentration) with 6 leaves. The lowest average number of leaves in treatment P0 (POC concentration 0) with 5 leaves means that the higher the concentration of fertilizer, the higher the number of plant leaves. This is because the application of liquid organic fertilizer from kepok banana peels can affect the number of leaves on mustard plants.

4. CONCLUSIONS

Based on the results of the research that has been done, it can be concluded that there is an increase in the growth of mustard plants planted such as plant height and number of leaves on mustard plants and there is an increase in calcium content in mustard plants due to the treatment of banana peel Liquid Organic Fertilizer (POC). From the results of research and observations it can be concluded that the best plant growth occurred in treatment P4 = Watering volume with 25 ml of POC because at P4 mustard plants had a plant height of 12 cm and had 6 leaves. Whereas the worst or less optimal plant growth occurred in the P0 = treatment without POC(control) because at P0 the mustard plant only had a plant height of 7 cm and had 5 leaves.

5. ACKNOWLEDGMENTS

The author expresses his gratitude to Universitas Muhammadiyah Surakarta

6. REFERENCES

Ambar Pratiwi and Rana Ashma 2019. The Effect of Liquid Organic Fertilizer on Banana Peel (Musa paradisiaca L. var. balbisina colla.) on the Growth of Spinach Plants (Amaranthus gracilis Desf). Proceedings of the Symbion (Symposium on Biology Education). Faculty of Applied Science and Technology, Ahmad Dahlan University. Yogyakarta

Eka Febriana Saragih. 2016. The Effect of Kepok Banana Skin Liquid Organic Fertilizer (M. Paradisiaca forma typica) on the Growth of Mustard Greens (Brassinca Juncea L.) Thesis. Sanata Dharma University. Yogyakarta.

Fadma Juwita Nasution, Lisa Mawarni, Meiriani. 2014. Application of Solid and Liquid Organic Fertilizers from Kepok Banana Peels for the Growth and Reproduction of Mustard Greens (*Brassica juncea* L.). Journal of Agroecotechnology Online. 2(3) : 1029-1037.

Hasibuan, Saberina, et al 2021. Utilization of Eggshell Waste as Liquid Organic Fertilizer in Rumbai Bukit District. Journal of Community Empowering and Services. 5(2) : 154-155.

Jasim. 2016. Effect of Potassium Fertilization on Stomata Behavior and Drought Resistance. Journal of Sustainable Agrotek, 2 (2) : 47-54.

Lailiya, Limatul., 2016. Understanding Macro and Micro Nutrients in Plants, http://bp4k.blitarkab.go.id/ wp-content/uploads/2016/09/MEHAMI UNSUR-HARA-MAKRO-DAN-MIKRO-PADA -TANAMAN.pdf, accessed December 8, 2016

Machrodonia, Yulieni, and Evie, R. 2015. Utilization of Liquid Organic Fertilizer Made from Banana Peels, Eggshells and Gracillaria gigas on the Growth of Soybean Plants var Anjasmoro. LenteraBio Journal. 4(3):1-2.

Nasution, FJ, Lisa, M, and Meiriani. 2014. Application of Solid and Liquid Organic Fertilizers from Kepok Banana Peels for Growth and Production of Mustard Greens (Brassinca Juncea L.) Journal of Agroecotechnology. 2(1) :1.

Nuryana A. 2012. Study of Composition of Planting Media and Length of Cuttings on the Growth of Dragon Fruit Plant Seeds (Hylocereus costaricenis). Thesis. Agrotechnology Department. Faculty of Agriculture, University of Riau. Riau.

Rambitan, VMM and Mirna Sari P., 2013. The Effect of Kepok Banana Peel Compost (Musa paradisiaca L.) on the Growth and Yield of Peanut Plants (Arachis hypogea L.) as a Support for Plant Physiology Practicum. Journal of Tropical EduBio, 1 (1) : 14-24.

Risky Ayu. 2015. The Effect of Liquid Organic Fertilizer from Kepok Banana Peel on the Growth of Mustard Greens, Thesis, (Lampung: Faculty and Teacher Training of Education, University of Lampung).

Rofikah, 2013. Utilization of Kepok Banana Peel Pectin (Musa paradisiaca forma typica) for Edible Film Growth. Thesis. Semarang State University. Semarang.

Safitri, Mareta, et al. 2015. The Effect of Liquid Organic Fertilizer on Kepok Banana Peel on the Growth and Production of Cayenne Pepper Plants. Biopendix Journal. Vol.1. No. 1.

Salfina, Lina Rahmawati and Elita Agustina. 2017. The Effect of Banana Peel Liquid Organic Fertilizer on the Growth of Lettuce (Lactuca sativa). Proceedings of the National Seminar on Biotics. Biology Education Study Program, Faculty of Tarbiyah and Teacher Training. UIN Ar-Raniry. Banda Aceh.

Sriningsih, Endang. 2014. Utilization of Banana Peel (Musa paradisiaca forma typica) with the Addition of Bamboo Leaves (EMB) and EM4 as Liquid Fertilizer Thesis. Muhammadiyah Surakarta university. Surakarta.

Sulham and Retno Wulandari. 2019. The Effect of Lamatoro Leaf Compost (Leucaena leucocephala) on the Growth of Yellow Cempaka Seedlings (Michelia champaca L). Jungle News Journal. Tadulako University. Hammer. 7(3) : 2579- 6287.

Wahyuningsih and Edy Supriyo. 2013. Liquid Organic Fertilizer Production Technology from Household Garbage in Lempongsari Village, Semarang Municipality with Composer EM-4. METHANE, 9 (1) : 23-27.

Wardiah, Linda and Hafnati Rahmatan. 2014. Potential of Rice Washing Water Waste as Liquid Organic Fertilizer on Pakchoy (Brassica rapa L.) Growth. *Journal of Educational biology* 34-38. Edition 12. 6(1).

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Effect of PBL Learning Model Combined with Rewards and Punishment on Science Learning Outcomes

Annisa' Tri Yudhatami*, Djumadi
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. e-mail address: a420190081@student.ums.ac.id

KEYWORDS:
Learning Outcomes
PBL
Rewards and Punishment

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

This study aims to determine the effect of PBL learning model combined with rewards and punishments on the science learning outcomes of class VII students at SMP Muhammadiyah Sinar Fajar Cawas. This study used an experimental method with a pretest-posttest control group design. This study used a control class (VII As-Syifa) totaling 14 students and an experimental class (VII Al-Qolam) totaling 15 students. The research instrument was in the form of questions and observation sheets. Analysis of learning outcomes data using independent t-test with normality test and homogeneity test. The results of the research show that the three aspects of learning outcomes have an influence on this research. The results of the calculation of cognitive aspects using the independent t-test obtained Sig.(2-tiles) 0.001<with a significance level of 5% so that Ho was rejected and Ha was accepted. The results of the calculation of the affective aspect using the independent t-test obtained Sig.(2-tiles) 0.030<with a significance level of 5% so that Ho is rejected and Ha is accepted. The results of the calculation of the psychomotor aspect using the independent t-test obtained Sig.(2-tiles) 0.000<with a significance level of 5% so that Ho was rejected and Ha was accepted. This means that there is an influence of PBL learning model combined with rewards and punishments on the science learning outcomes of class VII students at SMP Muhammadiyah Sinar Fajar Cawas.

1. INTRODUCTION

Natural Science is a science related to systematically studying the universe (Simanjorang 2018). Science material is applied to all levels of education, one of which is the SMP/MTs education level which is developed and implemented in an integrated manner (Linda et al. 2021) Integrated science is a combination of three basic science fields, namely physics, chemistry and biology (Wibowo et al. 2021). Natural Science occupies a prime position in creating a holistic and general scientific picture of the world (Jumanov 2022) because natural science is not only a collection of natural knowledge that contains facts, concepts, principles, but also contains a process of discovery (Purwanti et al. 2019). So that science requires students to develop knowledge, understanding, experimenting skills, and scientific attitudes such as being honest, this requires interaction between the components of teachers, students, materials to manage learning well (Tegeh et al. 2019).

Based on the results of observations and interviews, SMP Muhammadiyah Sinar Fajar Cawas is one of the private Islamic schools that implements Islamic boarding school-based education with all school activities inseparable from Islamic values (diniyah). This school has problems in the learning process, based on the results of interviews with the VII grade science teacher, the Mathematics subject teacher is used as a temporary substitute teacher as a tutor for

VII grade science subjects. In the learning process the teacher often focuses on the teacher (teacher center) by focusing students on listening, taking notes, memorizing this is done by the teacher because he wants students to understand more about the material being taught, this has proven to result in students becoming bored, lazy, and less active . In the opinion Mabsutsah and Yushardi (2022) the above problems are due to the lack of implementation of science learning in everyday life. The teacher also explained that science subjects are quite difficult material because they require an argument or answer based on facts and processes so that they understand the material. In the opinion Umami (2021) that science subjects are quite difficult subjects because there is a lot of material that requires reasoning and understanding.

Learning is a series of activities, both physical and psychological, that result in changes in behavior so that it requires good learning by providing motivation (Chusin et al. 2021). After receiving the learning experience students will gain the abilities that are given in the form of learning outcomes (Rapiadi 2022). Learning outcomes are related to changes in behavior (Wijayanti and Fauziah 2021). Changes in behavior can be seen through changes in knowledge, attitudes and skills besides that it can be measured by written tests, oral tests, and action tests (Amrah 2019). To obtain more complete information about the pros and cons of developing students' knowledge, an evaluation process by the teacher is needed (Hotimah 2020). Furthermore, these developments can be used as an increase in good development.

Actually, when the learning process takes place the teacher will be faced with a variety of student characteristics, there are students who are able to understand the material well, there are also students who experience problems (Harahap and Nasution 2018). Learning difficulty is a condition where students are hampered in understanding the material, learning difficulties are a condition that occurs a lot in class (Nuraeni and Syihabuddin 2020). So the role of the teacher as a student facilitator is needed in getting to know the character of students (Hakimah 2020). Because knowing and understanding students proves how much teacher competence is in improving the learning process (Riadi 2017). There is a solution in improving the learning process according to Rusmalina and Putra (2015) if in learning students have deficiencies in understanding the material, passive student activities and students have learning difficulties then improving education can be through improving the learning process. These efforts require teachers to play an active, creative and innovative role in conditioning the learning atmosphere so that the learning process can be carried out optimally. Basically the innovations made by the teacher are carried out according to their own technique when educating in the classroom, but the teacher should try innovation so that students' attention is not reduced, concentrated and focused (Abdurazakov and Sohibidavron 2022).

The innovation that can be used is the PBL model combined with the provision of rewards and punishment methods. The PBL model is a learning model that uses authentic problem solving or problems aimed at emphasizing students so that they are able to actively form knowledge or information independently, improve higher-order thinking skills, become independent individuals, and have self-confidence (Rusmalina and Putra 2015). In addition, the PBL learning model itself is a learning model that is able to make problems as material to motivate students to collaborate in groups or individually to solve problems and develop skills to become independent and confident learners (Rosyidah et al. 2019). However, additional ways are needed to motivate students to improve learning outcomes, one of which is to provide a combination of using the reward and punishment method, based on the results of interviews with science teachers and class VII students while teaching science, they have never applied this method, so there is a need for new innovations for the class.

Providing this method will stimulate students to increase motivation so that it affects learning outcomes because students feel cared for so they are motivated to take good actions so they don't get punished (Haris et al. 2021). The combination of the PBL model and the reward and punishment method can influence student learning outcomes to be even better. Based on the problems in this background, the researcher is motivated to conduct research by focusing on the effect of the PBL learning model combined with rewards and punishments on science learning outcomes for class VII students at SMP Muhammadiyah Sinar Fajar Cawas.

2. MATERIALS AND METHODS

This study used an experimental method in the form of true experimental research which is a research design that has the most accurate final results in its application. This design can be carried out with or without a pretest with experiment class research subjects and controls selected randomly (Rapingah et al. 2022). Taking the pretest-posttest control group design classification as said by Yani (2021) this design is similar to the non-equivalent control group design, except that in this study the experimental and control groups were selected randomly or randomly.

The subject of this study took class VII students located at SMP Muhammadiyah Sinar Fajar Cawas. The pretest-posttest control group research design involved two classes, namely class VII As-Syifa as the control class and class VII Al-Qolam as the experimental class.

Table 1. Research Implementation Techniques

Class Category	Pretest	Treatment	Posttest
Control (K1)	O1	P1	O2
Eksperimen (K2)	O1	P2	O2

Information:
K_1 : Control Class (VII As-Syifa)
K_2 : Experiment Class (VII Al-Qolam)
O_1 : Pretest results before treatment
O_2 : Posttest results after treatment
P_1 : Application with conventional learning
P_2 : The application of the PBL learning model is combined with reward and punishment methods **(Tabel 1).**

The sample used for class VII As-Syifa is 14 students and class VII Al-Qolam is 15 students. Both classes were given the same material but different treatment. The control class was given conventional learning treatment and the experimental class was given learning treatment with the PBL learning model combined with the reward and punishment method. The pre-test test is given before the learning takes place and the post-test test is given after the learning given to the two classes ends.

The learning outcomes instrument consists of psychomotor aspects, affective aspects, and cognitive aspects. Affective aspect indicators include mutual cooperation, self-confidence, discipline, and honesty. Psychomotor domain indicators include student preparation, completeness of answers, presentation skills, and skills in making presentation media. The cognitive aspects of students refer to the taxonomic bloom indicators in the form of category questions (C1)

remembering, (C2) understanding, (C3) applying, (C4) analyzing, (C5) evaluating, (C6) creating. The assessment criteria uses a Rubik's Cube with a minimum score of 1 and a maximum score of 4. Score details are (1) score 1 = if the student only has 1 aspect of all the aspects mentioned. (2) score 2 = if the student only has 2 aspects of all the aspects mentioned, (3) score 3 = if the student only has 3 aspects of all the aspects mentioned, (4) score 4 = if the student only has all the aspects mentioned . Trial Test This multiple choice instrument uses a validity test and a reliability test.

Based on the validity test of 30 multiple choice items with 19 respondents, 13 items were declared valid. Then tested the reliability of the multiple choice questions obtained by Cronbach's Alpha of 0.671. So it can be concluded that the multiple choice questions have been declared valid and reliable to be used as a research instrument to find data. The data analysis technique used an independent sample T-test which had previously been subjected to the requirements test, namely the normality and homogeneity tests. The normality test is a test that is applied to find out whether the usage variable data has a normal distribution (Pratama and Permatasari 2021). Homogeneity test is a statistical test requirement to show that sample data from the population have the same variation or data characteristics or not (Nurhaswinda et al. 2023). Hypothesis testing is carried out to obtain logical conclusions from research results presented in the form of numbers. Hypothesis presentation is carried out by analysis of variation or ANOVA with a significance level of $\alpha = 0.05$ (Supriyanto et al. 2022).

3. RESULTS AND DISCUSSION

1.1. Results

This study contains student learning outcomes which include cognitive aspects, affective aspects, and psychomotor aspects. This research was conducted at Muhammadiyah Sinar Fajar Cawas Middle School in the 2023/2024 academic year in class VII even semester in March 2023. This research is a true experimental research by taking a pretest-posttest control group. The purpose of this study was to examine the influence of the PBL learning model combined with rewards and punishments on the science learning outcomes of class VII students. The material used in this study is the Earth and the Solar System. The following research results are obtained:

Tabel 2. Data Description Pretest and Posttest Results as a Cognitive Aspect Students.

Descriptive Statistics					
	N	**Min**	**Max**	**Mean**	**Std. Deviation**
Experimental Class Pretest Value	15	17	63	38.13	13.876
Experimental Class Posttest Value	15	60	87	71.07	7.056
Control Class Pretest Value	14	0	53	34.71	12.893
Control Class Posttest Value	14	40	73	57.43	11.099

Based on (**Table 2**), Statistical description data from the pretest and posttest results as a cognitive aspect in the experimental class and control class obtained the average value of the experimental class higher than the control class in the science subject on Earth and the Solar System. In the experimental class, the PBL learning model combined with the reward and punishment method produced an average pre-test score of 38.13 and a post-test average score of 71.07. whereas in the control class the conventional learning model treatment produced an average pretest score of 34.71 and an average posttest score of 57.34. based on this average value, the

experimental class experienced an increase of 32.94 and the control class experienced an increase of 22.71

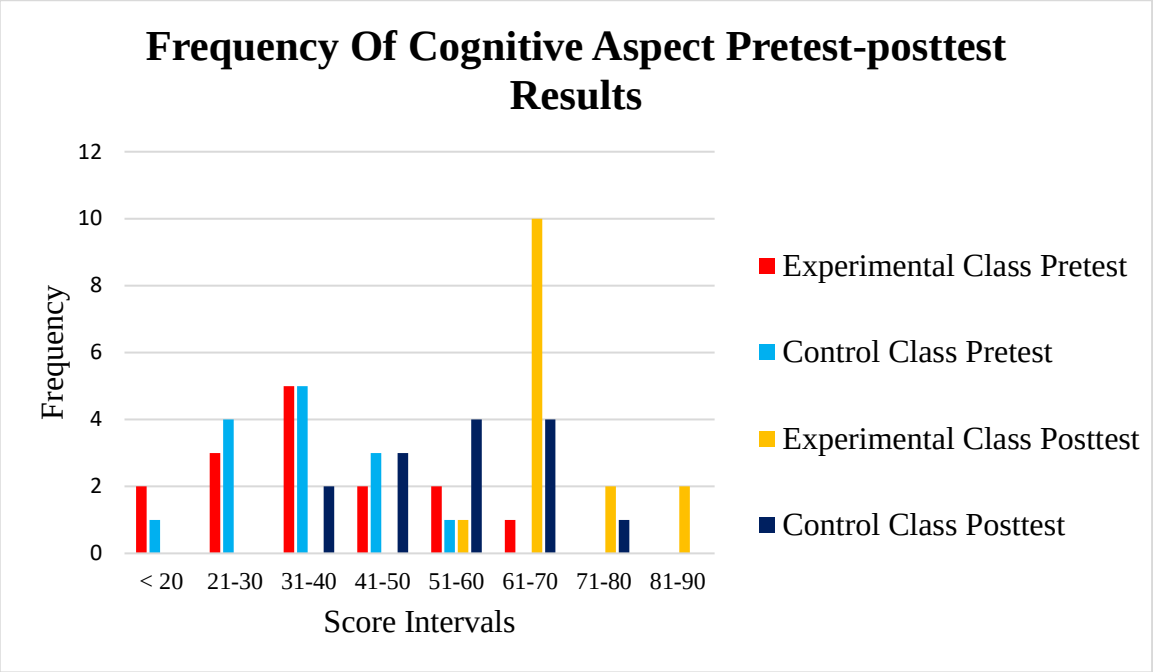


Figure 1. Histogram of Pretest and Posttest Results as Cognitive Aspects of Students.

Based on (**Figure.1)** From the histogram above, it can be seen that the experimental class and the control class at the time of the pretest, there were many students who scored in the less good category with a score of less than 60. However, during the posttest, the results of the students' cognitive aspects increased. However, there are differences in the frequency (number of students) who get the highest score among the existing score intervals. In the experimental class, the treatment of the PBL learning model combined with the reward and punishment method on the posttest results resulted in 10 students obtaining score intervals of 61-70 and there were 2 students obtaining the highest score intervals of 81-90. Whereas in the control class that was given treatment with conventional learning models the highest post-test results were found in the score intervals between 51-60 and 61-70 obtained by 4 students in each score interval.

Table 3. Test Independent Sample Test Cognitive Aspects

No.	Class VII	Sig. (2-tailed)	Decision
1.	Experiment Class-Control Class	0.001	H_0 is rejected and H_a is accepted

Based on (**Table** 3), the Independent Sample Test, which is a statistical test that tests the truth or falsity of two random samples, is capable of producing two interpretations through the Sig value. (2-tailed) of 0.001 <0.005 then according to the basis of decision making in the Independent Sample Test it can be concluded that H_0 is rejected and H_a is accepted which shows that there is a large influence on differences in learning outcomes in the cognitive aspect of the experimental class which is significant by giving the PBL learning model combined with reward and punishment.

Table 4. Description Data Science Learning Outcomes on Students Affective Aspects.

No.	Class VII	N	Min	Max	Mean	Std.Deviation
1.	Experiment Class	15	75	100	95	7.434
2.	Control Class	14	75	94	87	7.670

Based on (**Table 4**), Statistical description data from the affective aspect learning outcomes in the experimental class and control class obtained the average value of the experimental class higher than the control class in the Earth and Solar System science subjects. In the experimental class, the PBL learning model combined with the reward and punishment method from 15 students or respondents produced a minimum score of 75, a maximum score of 100 and an average affective aspect score of 95. Whereas in the control class the conventional learning model treatment of the number of students or 14 respondents produced a minimum score of 75, a maximum score of 94 and an average value of the affective aspect of 87.

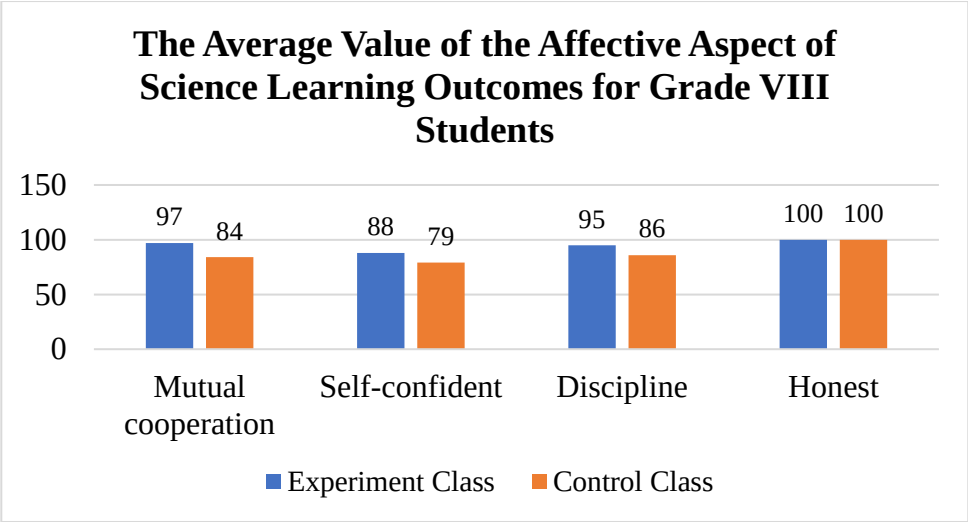


Figure 2. The Average Value of the Affective Aspect of Science Learning Outcomes for Class VIII Students

Based on (**Figure 2**), The histogram above shows the difference in the average science learning outcomes in the affective aspect per indicator which includes indicators (mutual cooperation, self-confidence, discipline and honesty). The experimental class treated with the PBL learning model combined with reward and punishment resulted in a relatively high value of the affective aspects of the indicator compared to the control class with the conventional learning model. However, there are similarities in the learning outcomes of the affective aspects of the honesty indicator which is worth 100.

Table 5. Independent Sample Test Affective Aspects

No.	Class VII	Sig. (2-tailed)	Decision
1.	Experiment Class-Control Class	0.031	H_0 is rejected and H_a is accepted

Based on (**Table 5**), the Independent Sample Test from two samples taken randomly is able to produce two interpretations through the Sig value. (2-tailed) of 0.031 <0.005, according to the basis for decision making in the Independent Sample Test it can be concluded that H_0 is rejected and H_a is accepted which shows that there is a large influence on differences in learning outcomes

in the affective aspect of the experimental class which is significant by giving the PBL learning model combined with reward and punishment.

Table 6. Description Data Science Learning Outcomes on Students Psychomotor Aspects.

No.	Class VII	N	Min	Max	Mean	Std.Deviation
1.	Experiment Class	15	94	100	98	2.928
2.	Control Class	14	81	94	88.14	5.376

Based on (**Table 6**), Statistical description data from the results of learning psychomotor aspects in the experimental class and control class obtained the average value of the experimental class higher than the control class in the Earth and Solar System science subjects. In the experimental class, the PBL learning model combined with the reward and punishment method from 15 students or respondents produced a minimum score of 94, a maximum score of 100 and an average value of the psychomotor aspects of 98. Whereas in the control class the conventional learning model treatment of the number of students or 14 respondents produced a minimum score of 81, a maximum score of 94 and an average value of the psychomotor aspect of 88.14..

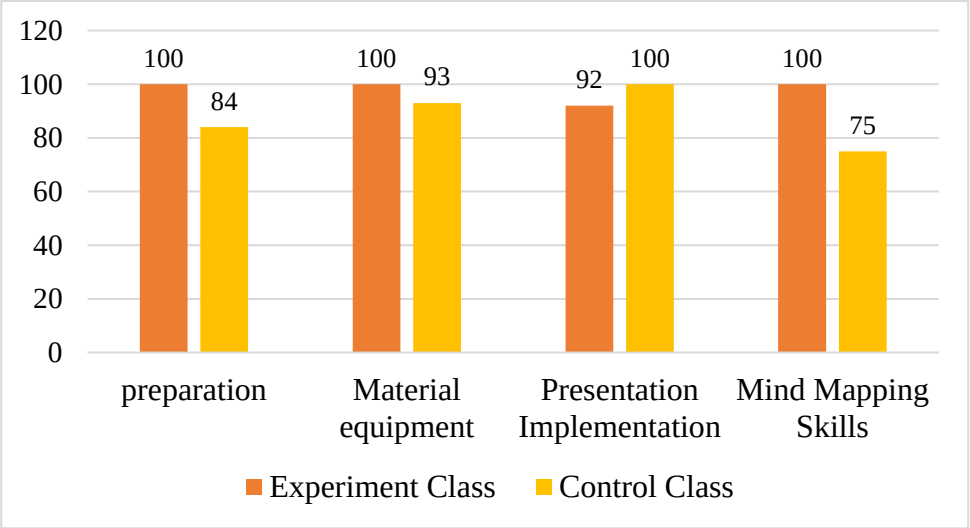


Figure 3. The Average Value of the Psychomotor Aspects of Science Learning Outcomes for Grade VIII Students

Based on (**Figure.3**) The histogram above shows the difference in the average science learning outcomes in the psychomotor aspect per indicator which includes indicators (preparation, completeness of material, implementation of presentations and skills in making Mind Maps). The experimental class treated with the PBL learning model combined with reward and punishment resulted in a relatively high indicator of psychomotor aspects compared to the control class with the conventional learning model.

Table 7. Independent Sample Test Psychomotor Aspects

No.	Class VII	Sig. (2-tailed)	Decision
1.	Experiment Class-Control Class	0.000	H_0 is rejected and H_a is accepted

Based on (**Table 5**), the Independent Sample Test from two samples taken randomly is able to produce two interpretations through the Sig value. (2-tailed) of 0.000> 0.005 then according to the basis of decision making in the Independent Sample Test it can be concluded that H0 is rejected and Ha is accepted which shows that there is a large influence on differences in learning outcomes in the psychomotor aspect of the experimental class which is significant by giving the PBL learning model combined with rewards and punishment.

1.2. Discussion

Science Learning Outcomes on Cognitive Aspect

The results showed that there were differences in learning outcomes from the cognitive aspect between the treatment class of the PBL learning model combined with rewards and punishment (Experimental Class) and the conventional treatment class (Control Class). Based on the analysis it is clear that the application of the PBL learning model and the combination with the reward and punishment method has an effect on cognitive aspects of learning outcomes. The results of this study are supported by previous research which showed the same results. Among them the research conducted by Ulfiana and Fitria (2022) states that the PBL learning model has a good impact on students with the PBL model students become accustomed to dealing with problems, fosters a sense of social cooperation between students and teachers, increases students' abilities to solve problems with such influence the PBL model on science cognitive learning outcomes in the experimental class is superior to the average score of 83.8 compared to the control class with conventional learning the average value is 74.44 and researchers Amirudin et al. (2020) stated that the reward and punishment method can improve student learning outcomes because students are more enthusiastic in learning so that their scores increase.

The effect of learning applied in the experimental class produced significant results as evidenced by the learning outcomes of the cognitive aspects of the experimental class students being higher than the control class. Differences in the average value of cognitive aspects in the control class which can be caused by differences in student learning activities that are less active and enthusiastic in participating in learning. In addition, control class students experience boredom because students feel often with conventional learning models that only listen to explanations from the teacher, take notes, discussion and presentation. Because of the low desire of students to learn so that it has a big effect on their learning outcomes. The low desire for student learning is one of the problems that often occurs in students and the teacher should provide direction to students so that they try to achieve learning in accordance with the specified results. Hidayati et al. (2022) in the learning process experimental class students were involved in the stages or syntax of the Problem Based Learning learning model starting with giving orientation to a problem to students, organizing students to research, assisting investigations, developing investigative results, identifying and evaluating (Junaidi 2020). In its implementation, the syntax of the PBL model is strived to be coherent so that it can help students find and solve problems that are presented in everyday life. The application of learning in the experimental class begins with the orientation stage of students being given a phenomenon or problem that aims to generate curiosity so that they are motivated to be involved in problem solving. In line with opinion Artinta and Fauziyah (2021)

the motivation that arises in students can influence student curiosity because when students are curious about something, students will focus on learning activities, seek deeper information and remember the expected messages, try to solve problems by asking questions. to the teacher and tend to do the task until it is finished.

Then the stage of organizing students to learn and the teacher as a facilitator helps by collaborating between students to look for or research problems jointly organize and determine tasks related to the problem. Followed by the independent and group investigation stages at the end of student learning will collect experimental results by making hypotheses and providing solutions. This presentation stage in the presentation process is carried out by explaining student learning outcomes which are carried out in turns either individually or in groups. The final phase of students by analyzing and evaluating student learning outcomes to harmonize the information obtained by students and teachers (Wati 2018).

In their learning, the experimental class also combines the PBL model with the reward and punishment method because during learning students experience many problems that support the successful application of the problem-based learning model, namely student enthusiasm, because the PBL model itself has weaknesses in its application which can occur if students feel lacking. interested, enthusiastic and motivated in the material presented so that students feel doubtful and reluctant to want to study the problems so that the material being taught is not resolved properly (Hayun and Syawaly 2019). To prevent this failure, the researcher presents this method to provide attraction or enthusiasm for students so that learning can run smoothly and the acquisition of learning outcomes increases.

In its application, when research in the experimental class begins with making an agreement between the teacher and students in which there are rules during learning students are asked to comply with these rules for students who are able to carry out these rules will get rewards and for students who violate there will be punishment. During the application of this method, students who are able to comply well with the rules that apply in class will get a compliment that builds student enthusiasm, for students who are brave or able to do assignments well can give prizes, this can increase student motivation and perceptions to get prizes for their behavior. The application of punishment in the experimental class is more aimed at strengthening in the form of motivation and examples of events that can stop negative actions.

Science Learning Outcomes on Affective Aspects

From the results of the study, it was shown that there were differences in learning outcomes from the affective aspects of students who used the PBL learning model combined with reward and punishment with those who only used conventional learning. This is evident from the hypothesis test that H0 is rejected and Ha is accepted, so it can be concluded that the application of the PBL learning model has an impact on improving student affective learning outcomes.

The use of the PBL model combined with the reward and punishment method helps students' affective learning outcomes. The problem-based learning model is a problem-oriented learning model that is used as a problem as student material for organizing students to study, guiding students to work in a group or individually, so that students are able to develop and present their work, analyze and evaluate at the end of problem solving so that students are indirectly active and have an impact on improving learning achievement (Fitria 2019). The results of this study are supported by several previous studies conducted by Ratnasari et al. (2022) which states that the PBL learning model plays an active role in increasing students' social activity, and self-confidence

in expressing opinions in class so that their research proves that learning outcomes in the affective aspect have increased by 76.61%.

From the picture above it can be seen that the average value of the affective aspect of science learning outcomes for class VIII students has not that much difference between the experimental class and the control class. However, the experimental class treated with the PBL learning model combined with reward and punishment on the affective aspect still had a high average result compared to the average results of the control class with conventional learning treatment. However, for the honest indicator, the control class has the same results as the experimental class, which is equal to 100. The indicators shown represent aspects of each individual's attitude, one of which is honesty, and act (Saeful 2021)

Based on the results of observations with the science subject teacher, the experimental class students had differences with the control class, the difference lies in the attitudes or affective aspects of students when learning takes place. The experimental class is a class that is difficult to control in class, so it requires extra effort so it needs help with the addition of the reward and punishment method. This is supported by researchers Nayla and Lestari (2021)who state that the reward and punishment method has a big impact on improving the affective component. the behavior and cognitive of students in the application of many teachers and volunteers who apply this method because of its ease of application and the magnitude of the impact on students.

The learning outcomes in the affective domain of the control class were lower than the experimental class because the control class only applied conventional learning models where previously many teachers often used this model so that students felt they needed a different learning model than usual. In addition, the conventional learning model does not provide a place for students to be active in learning. Students are only focused on taking notes, listening to explanations from the teacher and doing what is ordered by the teacher so that students feel bored and less interested in learning.

Science Learning Outcomes on Psychomotor Aspect

Based on the decision to test the hypothesis, it was found that H0 was rejected and Ha was accepted, so it can be concluded that the application of the PBL learning model has an impact on improving student psychomotor aspects of learning outcomes. The results of this study are also supported by Azizi (2019) that the PBL learning model shows an advantage over student learning outcomes, namely problem solving skills have a positive impact on students. Students who have succeeded in acquiring problem-solving skills will appear curious, try to identify, look for answers that are easy to understand, select relevant information, organize the workflow and evaluate work results (Elyani et al. 2019). The PBL model also influences students to develop students' psychomotor abilities related to communication, socializing, presenting and reasoning (Ardianti et al. 2021) this is obtained from the active and creative learning process contained in the PBL model where students are able to develop their own skills through the process ask questions, discuss, be able to reflect on the results obtained, so that learning outcomes can increase through real activities solving the cases presented (Gumuruh and Adinata 2020).

The control class psychomotor learning outcomes were lower than the experimental class because the control class only used conventional learning models. Based on the results of observations, this model has often been used by science subject teachers of class VII so that it is difficult for students to acquire skills in the learning process. According to Devita and Budiyanto (2022) the conventional model is a traditional learning model in which there are lecture, question and answer, discussion and assignment methods. The conventional model itself is a teacher-

centered learning model so that it is difficult for students to develop psychomotor skills because there are very few opportunities to be active in class. In line with Taqwan and Haji (2019) based on his research, the results of the problem-solving abilities in the experimental class (outdorlerning) were higher than the control class (conventional). The average value was 78.79 with 73.89. This is because the conventional model is often applied during learning so that students learn as usual by listening to lectures, working on these questions makes students quickly get bored and unenthusiastic so that students are lazy to think and just wait for the teacher's instructions.

Even so, during the experimental class learning there were also problems in motivating students to learn because the application of the PBL model felt less motivating for students to learn so it needed a combination that was able to increase student motivation, namely the reward and reward method. The Rewards and Punishment methods are positive steps that can stimulate students to respond to teachers in learning this method which comes from behavioristic theory (Akhiruddin et al 2019). This method has been agreed by experts as the most effective method. (Wahyudin 2003). It is proven that the experimental class was able to complete the learning well and obtained higher psychomotor learning outcomes than the control class.

The Influence of the Problem Based Learning Learning Model Combined with the Reward and Punishment Method on Science Learning Outcomes.

From the analysis of the hypothesis, it shows that there is an influence of the problem-based learning model with the reward and punishment method on student learning outcomes (cognitive aspects, affective aspects, and psychomotor aspects). The decision making for this hypothesis uses SPSS version 23 with an independent sample t-test where the significant value is Sig. (2-tailed) < 0.05. This shows that there is an influence between the learning model combined with the method used on student learning outcomes.

According to (Qomarudin 2021) that learning activities cannot be separated from input, process and output systems which consist of components of objectives, materials, methods, media, and evaluation. This can be seen from the application of the problem-based learning model combined with the reward and punishment method which influences the learning objectives in increasing student learning outcomes in the cognitive, affective, and psychomotor domains. The application of the problem-based learning learning model is a learning model that invites students to get used to and be active in solving the problems they face because this learning model has a risk of learning success, so there is a need for other ways or additional ways by presenting reward and punishment methods. This method is an old way that is believed by researchers in maximizing the learning process such as being able to improve cognitive aspects, affective domains, and psychomotor domains. That way there is a good influence between the application of the problem-based learning model combined with the reward and punishment method on science learning outcomes in this study.

4. CONCLUSIONS

From the presentation of research data it can be concluded that there are differences in student learning outcomes given the treatment of the PBL learning model combined with higher rewards and punishments compared to learning outcomes using conventional learning models in natural science learning on earth and the solar system.

The difference can be seen from the average value of each aspect of learning outcomes after the implementation of learning in the experimental class and the control class. In addition, it can be seen from the results of the independent sample t-test which shows that the calculation of

cognitive aspects with the independent t-test obtained Sig.(2-tiled) 0.001 <with a significance level of 5% so that Ho is rejected and Ha is accepted. The results of the calculation of the affective aspect using the independent t-test obtained Sig.(2-tiled) 0.030<with a significance level of 5% so that Ho is rejected and Ha is accepted. The results of the calculation of the psychomotor aspect using the independent t-test obtained Sig.(2-tiled) 0.000<with a significance level of 5% so that Ho was rejected and Ha was accepted. This means that there is an influence of the PBL learning model combined with rewards and punishments on the science learning outcomes of class VII students of SMP Muhammadiyah Sinar Fajar Cawas.

5. ACKNOWLEDGMENTS

Thank you to SMP Muhammadiyah Sinar Fajar Cawas for giving permission and facilitating the implementation of this research and supporting research activities on the influence of the PBL learning model combined with rewards and punishments on science learning outcomes for class VII students at SMP Muhammadiyah Sinar Fajar Cawas, as well as to colleagues colleagues who contributed to the research.

6. REFERENCES

Abdurazakov, F. A., and Sohibidavron, K. M. 2022. Interactive Methods Used In The Formation Of Creative Activity (On The Example Of Primary School Students). *Galaxy international interdisciplinary research journal* 10(1): 257.

Akhiruddin, Sujarwo, Atmowardoyo, H., and Nurhikmah. 2019. *Belajar dan Pembelajaran*. CV.Cahaya Bintang Cemerlang, Gowa.

Amirudin, Nurlaeli, A., and Muzaki, I. A. 2020. Pengaruh Metode Reward and Punisment Terhadap Hasil Belajar Siswa Pada Bidang Studi Pendidikan Agama Islam (Studi Kasus di SDIT Tahfizh Qur'an Al-Jabar Karawang). *TARBAWY: Indonesian Journal of Islamic Education* 7(2): 148.

Amrah. 2019. Peningkatan Hasil Belajar Ipa Siswa Kelas V Tema 6 Panas Dan Perpindahannya Dengan Menggunakan Pendekatan Konstruktivisme. *Jurnal Pendidikan Tambusai* 3(1): 451.

Ardianti, R., Sujarwanto, E., and Surahman, E. 2021. Problem-based Learning: Apa dan Bagaimana. : *Journal for Physics Education and Applied Physics* 3(1): 31–33.

Artinta, S. V., and Fauziyah, H. N. 2021. Faktor yang Mempengaruhi Rasa Ingin Tahu dan Kemampuan Memecahkan Masalah Siswa pada Mata Pelajaran IPA SMP. *Jurnal Tadris IPA Indonesia* 1(2): 113.

Azizi, A. 2019. Implemetasi Problem Based Learning (PBL) dengan Bermain Peran (BP) Terhadap Kemampuan Memecahkan Masalah. *Jurnal Pendidikan Mandala* 4(5): 189–190.

Chusin, M. M., Ardrian, R., Satriyanto, B., Hanifah, D. P., Lubis, R., Wellyana, Fitriani, A., Noviyanto, T. S. H., Herlinam, M., Wardani, K. D. K. A., Parera, M. M. A. E., and Fahdian, R. 2021. *Strategi Belajar Inovatif*. Pradina Pustaka, Sukoharjo.

Devita, R., and Budiyanto, C. 2022. Pengaruh Metode Pembelajaran Konvensional Terhadap Kecerdasan Naturalis Siswa Pada Pembelajaran IPA di Kelas IV SDN 1 Mekarsari Saat Pandemi COVID-19. *Jurnal Pendidikan Sekolah Dasar* 3(1): 32.

Elyani, R., Izzati, N., and Perdana, S. A. 2019. Analisis Efektivitas Model Pembelajaran ARIAS Berbantu LKS Dalam Meningkatkan Kemampuan Pemecahan Masalah Matematis Siswa. *Jurnal Kiprah* 7(2): 50–51.

Fitria, Y. 2019. Mampukah Model Problem Based Learning meningkatkan Prestasi Belajar Sains Mahasiswa Calon Guru Sekolah Dasar. *Jurnal Inovasi Pendidikan dan Pembelajran Sekolah Dasar* 3(1): 87.

Gumuruh, A. R., and Adinata, T. P. 2020. Peningkatan Hasil Belajar PKN Melalui Model Pembelajaran Berbasis Masalah Siswa Kelas VII di SMP Negeri 3 Negara. *Jurnal Cendikia* 1(1): 49.

Hakimah, N. L. 2020. Pengaruh Gender Terhadap Hasil Belajar Siswa Kelas VII SMP Darul Ulum 5 Jombang Mata Pelajaran IPA Materi Pemanasan Gelobal Menggunakan Model Pembelajaran Discovery Learning. *Jurnal Ed-Humanistics* 5(1): 617.

Harahap, F. D. S., and Nasution, M. Y. 2018. Analisis Kesulitan Belajar Siswa Pada Materi Virus Di Kelas X Mipa Sma Negeri 1 Rantau Selatan Tahun Pembelajaran 2017/2018. *Jurnal Pelita Pendidikan* 6(2): 72.

Haris, N., Maryam, and Mukhlisa, N. 2021. Penerapan Metode Reward And Punishment Untuk Meningkatkan Hasil Belajar Siswa Sekolah Dasar Kelas Lima Di Kabupaten Baru. *Pinisi : Journal of Education* 1(2): 132–143.

Hayun, M., and Syawaly, A. M. 2019. Pengaruh Penerapan Model Pembelajaran Problem Based LearningTerhadap Kemampuan Representasi Matematis Siswa Sekolah Dasar. *J u r n a l I n s t r u k s i o n a l* , 2(1): 13.

Hidayati, R., Triyanto, M., Sulastri, A., and Muhammad, H. 2022. Faktor Penyebab Menurunnya Motivasi Belajar Siswa Kelas IV SDN 1 Peresak. *Jurnal Educatio* 8(3): 1154.

Hotimah, H. 2020. Penerapan Metode Pembelajaran Problem Based Learning Dalam Meningkatkan Kemampuan Bercerita Pada Siswa Sekolah Dasar 5. *Jurnal Edukasi* 7(3): 8.

Jumanov, M. 2022. Forming Ecological Thinking In Students On The Basis Of Interdisciplinary Relationships Akhmadjon. *International Scientific Reserch Journal* 3(8): 241.

Junaidi. 2020. Implementasi Modul Pembelajaran Problem Based Learning Dalam Meningkatkan Sikap Berfikir Kritis. *Jurnal Pendidikan dan Pembelajaran Ilmu Pengetahuan Sosia* 9(1): 30–31.

Linda, R., Zulfarina, Mas'ud, and Putra, T. P. 2021. Peningkatan Kemandirian dan Hasil Belajar Peserta Didik Melalui Implementasi E-Modul Interaktif IPA Terpadu Tipe Connected Pada Materi Energi SMP/MTS. *Jurnal Pendidikan Sains Indonesia* 9(2): 192.

Mabsutsah, N., and Yushardi. 2022. Analisis Kebutuhan Guru terhadap E Module Berbasis STEAM dan Kurikulum Merdeka pada Materi Pemanasan Global. *Jurnal Pendidikan MIPA* 12(2): 205.

Nayla, R., and Lestari, T. 2021. Pengaruh Metode Reward dan Punishment Terhadap Perkembangan Moral Siswa Sekolah Dasar. *Jurnal Pendidikan* 5(2): 3–6.

Nuraeni, and Syihabuddin, S. A. 2020. Mengatasi Kesulitan Belajar Siswa dengan Pendekatan Kognitif. *Jurnal Pembelajaran dan Inovasi Pendidikan* 1(1): 24.

Nurhaswinda, Cahya, I., Wirna, M., and Aulia, M. 2023. *Statistik Pendidikan (Teori dan Praktik dalam Pendidikan)*. Guepedia, Bogor.

Pratama, S. A., and Permatasari, R. I. 2021. Pengaruh Penerapan Standar Operasional Prosedur Kompetensi Terhadap Produktivitas Kerja Karyawan Divisi Eksopr PT.Dua Kuda Indonesia. *Journal Ilmiah M-Progress* 11(1): 43.

Purwanti, E., Nurrohman, E., and Pra, H. S. 2019. *Kajian IPA (Untuk Mahasiswa Pendidikan Guru Sekolah Dasar)*. Universitas Muhammadiyah Malang, Malang.

Qomarudin, A. 2021. Aktivitas Pembelajaran Sebagai Suatu Sistem. *Jurnal Pendidikan Agama Islam* 4(1): 29.

Rapiadi. 2022. *Monograf Pengaruh Kemandirian Belajar Siswa dan Motivasi Trhadap Hasil Belajar Pendidikan Agama Buddha*. Insan Cendikia Mandiri, Solok.

Rapingah, S., Sugiarto, M., Sabir, M., Haryanto, M. T., Nurmalasari, V., and Alfalisyado, M. I. G. 2022. *Buku Ajar Metode Penelitian*. CV. Feniks Muda Sejahtera, Palu.

Ratnasari, D., Santoso, J. T. B., and Kardoyo. 2022. Pengaruh Pembelajaran PBL Berbasis Mind Mapping Terhadap Hasil Belajar Mata Pelajaran Ekonomi. *Jurnal Sarya Widya* 38(2): 158.

Riadi, A. 2017. Kompetensi Guru Dalam Pelaksanaan Evaluasi Pembelajaran. *Ittihad Jurnal Kopertais Wilayah XI Kalimantan* 15(28): 53.

Rosyidah, N. D., Nagara, D. T., and Supriana, E. 2019. Model Problem Based Learning (Pbl) Dalam Meningkatkan Motivasi Belajar dan Pemahaman Konsep Siswa. *Seminar Nasional Pendidikan Fisika* 4(1): 46–47.

Rusmalina, and Putra, A. P. 2015. Meningkatkan Hasil Belajar dan Aktivitas Siswa pada Konsep Virus melalui Model Pembelajaran Berdasarkan Masalah Increasing the Learning Result and Student Activity on Virus Concept through Problem Based Learning. *Seminar Nasional XII Pendidikan Biologi FKIP UNS 2015* 508–512.

Saeful, A. 2021. Implementasi Nilai Kejujuran Dalam Pendidikan. *Jurnal Tarbawi* 4(2): 127.

Simanjorang, E. 2018. Meningkatkan Hasil Belajar dan Keaktifan Belajar IPA Melalui Metode Simulasi Berbasis Bioedutainment Pada Siswa SMP Negeri 1 Selesai Tahun Ajaran 2016/2017. *Jurnal Tabularasa PPS UNIMED* 15(1): 34.

Supriyanto, Fatirul, A. N., and Walujo, D. A. 2022. Pengaruh Sterategi Problem Based Learning dan Motivasi Berprestasi terhadap Keterampilan Berpikir Kritis. *Jurnal Kumparan Fisika* 5(1): 45.

Taqwan, B., and Haji, S. 2019. Pengaruh Pembelajaran Luar Kelas (Outdoor Learning) Terhadap Kemampuan Pemecahan Masalah Siswa Kelas VII SMP Negeri 05 Seluma. *Jurnal Pendidikan Matematika Raflesia* 4(1): 17.

Tegeh, I. M., Pratiwi, N. L. A., and Simamora, A. H. 2019. Hubungan Antara Motivasi Belajar Dan Keaktifan Belajar Dengan Hasil Belajar IPA Siswa Kelas V Sd. *Jurnal IKA* 17(2): 152–153.

Ulfiana, N., and Fitria, Y. 2022. Pengaruh Model Problem Based Learning terhadap Hasil Belajar Kognitif IPA pada Pembelajaran Tematik. *Journal of Basic Education Studies* 5(1): 2325.

Umami, R. 2021. Kesulitan Dalam Memhami Materi Pelajaran IPA Yang Dikaitkan Dengan Psikologi Pendidikan. *Psikologia (Jurnal Psikologi)* 6(1): 14.

Wahyudin, M. F. A. 2003. *Menuju Kreativitas*. Gema Press, Jakarta.

Wati, Y. I. 2018. Penerapan Model PBL (Problem Based Learning) Pada Pembelajaran IPA Kelas 4 MI Nurur Rohmah Tentang Energi Panas. *Universitas Muhammadiyah Sidoarjo* 11–12.

Wibowo, S., Hatibe, A., and Werdhiana, I. K. 2021. Pengembangan Perangkat Pembelajaran IPA Terpadu Tipe Connected Materi Konsep Cahaya. *Jurnal Ilmiah Pendidikan Fisika* 5(3): 339.

Wijayanti, R. M., and Fauziah, P. Y. 2021. Perspektif dan Peran Orangtua dalam Program PJJ Masa Pandemi Covid-19 di PAUD. *Jurnal Pendidikan Anak Usia Dini* 5(2): 1305.

Yani, A. 2021. *Model Project Based Learning Untuk Meningkatkan Motivasi Belajar Pendidikan Jasmani*. Ahlimedia Book, Malang.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Antioxidant Activity and Organoleptic Quality of Probiotic Tepache of Pineapple Peel Sugar Variation and Fermentation Duration

Fithrotul Haq Rabbani Abdurrahman, Titik Suryani*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. e-mail address: ts169@ums.ac.id

KEYWORDS:
Tepache
Pineapple peel
Antioxidant
Fermentation duration
Organoleptic

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Tepache is a probiotic beverage from fermented product beneficial to health, which can improve the balance of good bacteria and reduce the risk of gastrointestinal disease. The content of honey pineapple peel includes carbohydrates 17.53 %, protein 4.41 %, reducing sugar 13.65 % and vitamins C and E which act as antioxidant. This research was aimed to determine the antioxidant activity and organoleptic quality of probiotics tepache beverage of pineapple peel with variation of sugar and fermentation duration. This research method used experimental and Complete Random Design (CRD) with two factors. The factor I was the type of sugar is 80 g granulated sugar (G1) and 80 g palm sugar G2). Factor II was the fermentation duration in three days (F1) and five days (F2). The result showed that the highest antioxidant activity of pineapple peel tepache was 67.14 % in G2F1 (palm sugar + 3 days fermentation duration). The best organoleptic quality of pineapple peel tepache at G2F1 (palm sugar + 3 days fermentation duration) was brown color, sour taste, and slightly pineapple aroma.

1. INTRODUCTION

Functional beverage involves bacteria whose role is to increase nutritional content and is a probiotic (Masengi et al. 2020). Functional beverages are gaining popularity because they provide benefits in the form of essential nutrients for the health of the body. Probiotics are believed to be able to produce antimicrobial compounds that can compete with pathogenic bacteria to prevent infection, particularly in the digestive tract (Rizal et al. 2020b). Tepache is one of the probiotic beverages that are advantageous to health.

Tepache is a traditional beverage of ancient mexico consumed for centuries; different fruit peels can be used as substrates for tepache production (Ojeda-Linares et al. 2021). Tepache contains beneficial microorganisms that can produce anti-pathogen compounds such as lactic acid, hydrogen peroxide, and bacteriocins. *Honey pineapple peel* is a substrate that can be used to make tepache. Currently, tepache is beginning to be produced on a large scale for personal consumption or commercial purposes and can serve as an alternative for lactose-intolerant individuals (Oak and Jha 2019)

Honey pineapple peel has an uneven texture and small spines on its outer surface, including vitamins C and E, carotenoids, and flavonoids (Erukainure et al. 2018). According to (Kusuma et al. 2019) , pineapple peel contains 81.7 % water, 17.53 % carbohydrates, 4.4 % protein, 13.65 % reducing sugar, and 20.87 % crude fiber. The content of flavonoids, saponins, and tannins can form antibacterial aromatic hydroxyl groups (Tivani and Sari 2021). Due to its high sucrose and carbohydrate content, honey pineapple peel has the potential to be used as a fundamental ingredient in processed fermented probiotics (Rizal et al. 2020a).

Sugar serves an essential function in the production of tepache as a nutrient source for

bacterial activity during the fermentation process (Rochani et al. 2016). Granulated and palm sugar are readily available sugar varieties with distinct compositions and production processes. (Iskandar et al. n.d.) Palm sugar is produced from palm juice that is cooked to a liquid state and then chilled to form granules. Palm sugar contains 85 % sucrose, 0.53 % reducing sugar, 2.28 % protein, 1.37 % calcium, and 1.37 % phosphor (Fatimah et al. 2019).

Granulated sugar contains 72 % sucrose, 3.7 % reducing sugar, 0.06 % protein, 1.64 % calcium, and 0.06 % export (Fatimah et al. 2019). The water content of palm sugar and granulated sugar differs, with palm sugar containing 10 % water and granulated sugar containing 0.02 % (USDA 2019 in Food Data Central ID343930). The presence of sugar in the substrate influences the duration of the fermentation process, which continues until the substrate's sugar content is depleted (A'yuni et al. 2020). The greater the concentration of sugar compounds in the substrate, the more significant the proportion of disaccharide compounds transformed into monosaccharides and glucose.

There is no involvement of starter-shaped microorganisms in the spontaneous fermentation that occurs during the production of tepache. However, microorganisms can be active because environmental factors support their growth. At the same time, the presence of sucrose encourages the growth of lactic acid bacteria in tepache products (Setiarto 2020). As long as sugar is still present, the fermentation process will continue (Rochani et al. 2016), and the more fermentation duration influences the decrease in pH value in fermentation results due to the presence of volatile acidic compounds resulting from the conversion of sugars. The variation in fermentation duration between the samples led to different antioxidant activities.

Antioxidants are compounds found in all plant parts, including stems, leaves, flowers, and fruits, that aid in overcoming oxidative damage caused by free radicals or reactive oxygen compounds (Saefudin et al. 2013). Honey pineapple peel is an antioxidant-rich fruit because of vitamins C and E (Rizal et al. 2020a). During fermentation, the type of sugar and duration of fermentation influence the antioxidant activity. In the research (A'yuni et al. 2020), it was discovered that differences in fermentation duration in samples led to an increase in antioxidant activity. Due to the length of fermentation, the flavonoid components in the wine have a greater antioxidant capacity. In addition, (Choong et al. 2016) compared the antioxidant activity of palm sugar and granulated sugar and found that palm sugar has an antioxidant activity of 28.88 % while white sugar has only 0.16 %. According to research (Hujjatusnaini, 2022), sucrose increased total lactic acid bacteria and pH. However, it decreased overall taste favorability, color, and acceptance scores, but not fragrance, in probiotic beverages made with pineapple peel extract. This research obejective was to determine the antioxidant activity and organoleptic quality of probiotic beverages tepache of pineapple peel on variations of sugar and fermentation duration.

2. MATERIALS AND METHODS

1.1. Materials and Methods

The research involved is experimental. This research design used Complete Randomized Design with two treatment factors of sugar type (80 g of palm sugar and 80 g of granulated sugar) and fermentation durations (3 days and 5 days), with three sample repetitions/ treatment. Three hundred grams of pineapple peel, 80 g of sugar, and 350 ml of aquades used in this research. This experiment was conducted at the University of Muhammadiyah Surakarta's Biological Laboratory, Faculty of Teacher Training and Education, for making tepache and organoleptic quality. The antioxidant activity test was conducted at the Chem-Mix Pratama Bantul-Yogyakarta Laboratory.

2.1.1 Research Procedure

This research begun by sterilizing all instruments utilized during the tepache sample collection procedure. Then, the ingredients, including pineapple peel, sugar, and equivalents, were prepared. 80 g of palm sugar and 80 g of granulated sugar were dissolved in simmering water prior to creating tepache. The production of tepache begun by placing all ingredients in a glass container and preserving them at ambient temperature for between three and five days, depending on the fermentation duration. After harvesting, pH measurements, antioxidant activity testing with the DPPH (2,2-diphenyl-1-picrylhydrazyl) method, and organoleptic quality tests with 15 panelists were conducted.

2.1.1.1 Data analysis

The results of a research were presented in tabular format. Analysis of antioxidant quantitative descriptive methods with Kruskal wallis analysis test. Evaluation of antioxidant activity using DPPH reagents. The Radical Scavenging Activity (RSA) equation calculates a substance's free radical inhibiting activity:

$$\text{DPPH RSA (\%)} = \frac{OD_{working\ fluid} - OD_{sample}}{OD_{working\ fluid}} \times 100\%$$

The organoleptic test utilized quanlitative descriptive analysis based on questionnaires distributed to 15 panelists, which included color, flavor, aroma, and acceptability then analyzed using Microsoft excel.

3 Results and Discussion

3.1 Result

According to the pH test results and antioxidant activity of tepache with variations in sugar types and fermentation duration (Table 3.1).

Tabel 3.1. The Result of Antioxidant Activity of Honey Pineapple Peel Tepache with Variations in Sugar Types and Fermentation Duration

No.	Treatments	Antioxidant Activity	pH
1	G1F1 (80 g granulated sugar + 3 days fermentation)	54.42 %	3.2
2	G2F1 (80 g plam sugar + 3 days fermentation)	67.14 %*	3.4
3	G1F2 (80 g granulated sugar + 5 days fermentation)	51.87 %**	3.0
4	G2F2 (80 g plam sugar + 5 days fermentation)	61.90 %	3.2

Notes: *) Highest score
**) Lowest score

Tabel 3.1 showed the G2F1 treatment (80 g palm sugar with a 3-day fermentation duration) produced the highest antioxidant activity (67,14 %) while the G1F2 treatment (80 g granulated sugar with a 5-day fermentation duration) produced the lowest antioxidant activity (51,87 %).

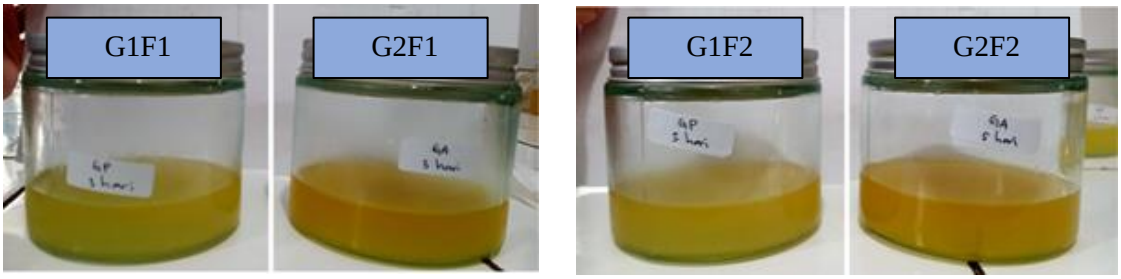


Figure 3.1 Organoleptic Quality of Honey Pineapple Peel Tepache with Variation of Sugar Types and Fermentation Duration.

Notes:
G1F1 : 80 g granulated sugar and 3- days fermentation duration
G2F1 : 80 g plam sugar and 3- days fermentation duration
G1F2 : 80 g granulated sugar and 5- days fermentation duration
G2F2 : 80 g plam sugar and 5- days fermentation duration

Tabel 3.2. Organoleptic Test Result of Honey Pineapple Peel Tepache at Variations of Sugar Types and Fermentation Duration.

No.	Treatments	Organoleptic			
		Color	**Flavor**	**Aroma**	**Acceptability**
1	G1F1	Slightly yellow	Much Sour	Slightly flavorful	Not like much
2	G2F1*	Brown	Sour	Slightly flavorful pineapple	Like
3	G1F2	Slightly yellow	Sour	Slightly flavorful pineapple	Not like much
4	G2F2	Brown	Sour	Slightly flavorful pineapple	Not like much

Notes: *) The highest organoleptic quality

Tabel 3.2 showed the G2F1 treatment (80 g of palm sugar and three days of fermentation) produced the highest organoleptic quality of pineapple peel tepache was brown color, sour flavor, and faint pineapple aroma).

3.1.1 Discussion

Tabel 3.1 shows that the antioxidant activity of tepache probiotic beverages with varying sugar types and fermentation durations based on the four treatments. The results of treating palm sugar varieties fermented for three days and five days, respectively, were 67.14 % and 61.94 %. In treating granulated sugar varieties fermented for three and five days, respectively, 54.42 % and 51.87 % yielded good results. Tepache treated with G2F1 (80g palm sugar fermented for three days) has the highest antioxidant activity of 67.14 %, whereas G1F2 (80g granulated sugar fermented for five days) had the lowest antioxidant activity of 51.87 %. The more fermentation durations, the lower antioxidant activity of tepache. Pineapple peel contains 38.95 mg/100 g of total antioxidants and 24.40 mg/100 g of bioactive components in vitamin C (Mardalena et al. 2015). As fermentation duration increases, vitamin C can be degraded, resulting in a decrease in antioxidant activity. This research, supported by (Sutedjo and Nisa 2015) explains that

microorganisms oxidize vitamin C (ascorbic acid) to L-dehydroascorbic acid, which then endures further changes to L-diketogulonate, which does not contain active vitamin C.

Adding palm sugar effect to result in more significant antioxidant activity than adding granulated sugar. Antioxidant activity with palm sugar type treatment and fermentation durations of 3 and 5 days yielded 67.14 % and 61.90 % results. In contrast, antioxidant activity with granulated sugar type treatment and fermentation durations of 3 and 5 days yielded 54.42 % and 51.82 % results because palm sugar has a more considerable antioxidant activity than granulated sugar, which has an activity of 0.16 %. In addition, palm sugar has a distinctively higher content than granulated sugar, with 85 % sucrose, 0.53 % reducing sugar, 2.28 % protein, 1.37 % calcium, and 1.37 % phosphor. In contrast, granulated sugar contains 72% sucrose, 3.7% reducing sugar, 0.06 % protein, 1.64 % calcium, and 0.06 % phosphor (Fatimah et al. 2019).

Based on the results of organoleptic quality, including color, aroma, flavor, and acceptability of probiotic beverages tepache pineapple peel with variations on sugar varieties and fermentation duration, as determined by 15 panelists, the following data was gathered:

1. Color

   The G2F1 treatment (80 g of palm sugar fermented for three days) yields the maximum color quality (brown color). Throughout the fermentation process, the tepache changes color. According to research (Puji Astuti et al. 2020), the pigment of the sample will change as the fermentation duration increases. The color of the epidermis of the pineapple, which was initially bright yellow, changed to a yellow-brown color. Adding palm sugar to the brown G2F1 treatment can also alter the color of the tepache, causing a change in color.

2. Flavor

   The G2F1 treatment (80 g of palm sugar fermented for three days) results in the highest flavor quality. Due to its high pH level, tepache possesses a sour flavor. According to research (Hujjatusnaini 2022) , the sour flavor of a product results from a decrease in pH value and an increase in lactic acid.

3. Aroma

   The G2F1 treatment (80 g of palm sugar fermented for three days) produces the finest aroma. According to (Hujjatusnaini 2022), adding sugar to tepache does not significantly alter its aroma. Due to the increase in alcohol content, however, a 5-day fermentation duration affects the aroma. According to the research (Puji Astuti et al., n.d.), panelists' interest was diminished due to the presence of compounds such as alcohol and acids during the fermentation process, which rendered the aroma objectionable.

4. Acceptability

   The G1F2 treatment (80 g palm sugar fermented for three days) yielded the highest acceptability, which has a good acceptability. According to (Hujjatusnaini 2022), organoleptic testing, including color, flavor, and aroma, is crucial for the primary characteristics of a product that determine the panelists' attraction to a product.

3. CONCLUSIONS

The highest antioxidant activity of pineapple peel tepache was 67.14 % in G2F1 (palm sugar + 3 days fermentation duration) and the best organoleptic quality of pineapple peel tepache in G2F1 (palm sugar+ 3 days fermentation) was brown color, sour taste, and slightly pineapple aroma.

4. ACKNOWLEGMENTS

The authors thank the Biology Education Department of Muhammadiyah Surakarta University for providing financial support for the INCOBEST conference.

5. REFERENCES

A'yuni, N. M., Hidaayah, N., and Pratiwi, V. N. 2020. Analisis Perbedaan Waktu Fermentasi terhadap Kadar Probiotik dan Aktivitas Antioksidan pada Minuman Probiotik Sari Buah Stroberi (Fragaria Anannassa). *Sport and Nutrition Journal* 2(2): 49–55. DOI: 10.15294/spnj.v2i2.39914

Choong, C. C., Anzian, A., Che Wan Sapawi, C. W. N. S., and Meor Hussin, A. S. 2016. Characterization of Sugar from Arenga pinnata and Saccharum officinarum sugars. *International Food Research Journal* 23(4): 1642–1652.

Erukainure, O. L., Sanni, O., and Islam, M. S. 2018. Chapter 6 - Clerodendrum volubile: Phenolics and Applications to Health. R. R. Watson, V. R. Preedy, and S. B. T.-P. M. of A. in H. H. and D. (Second E. Zibadi, eds. Academic Press 53–68. DOI: https://doi.org/10.1016/B978-0-12-813006-3.00006-4

Fatimah, F., Hairiyah, N., and Rahayu, R. Y. 2019. Pengaruh Konsentrasi Gula pasir dan Gula Aren pada Pembuatan Nata De Coco. *Jurnal Teknologi Agro-Industri* 6(2): 141–146. DOI: 10.34128/jtai.v6i2.97

Hujjatusnaini, N. 2022. INOVASI MINUMAN TEPACHE BERBAHAN BAKU KULIT NANAS (Ananas comosus (L.) Merr.) TERSUPLEMENTASI PROBIOTIK Lactobacillus casei. *Jurnal Teknologi Pangan dan Gizi* 21(1): 47–54. DOI: 10.33508/jtpg.v21i1.3568

Iskandar, A., Yuliasih, I., and Haryanto, B. (n.d.). *KARAKTERISTIK SIFAT FISIKO KIMIA, STRUKTUR DAN MORFOLOGI GULA AREN CETAK CHARACTERISTICS OF PHYSICOCHEMICAL, STRUCTURAL AND MORPHOLOGICAL PROPERTIES OF ARENGA PALM SUGAR BLOCKS*. *J Tek Ind Pert*.

Kusuma, A. P., Chuzaemi, S., and Mashudi, M. 2019. Pengaruh Lama Waktu Fermentasi Limbah Buah Nanas (Ananas comosus L. Merr) Terhadap Kualitas Fisik dan Kandungan Nutrien Menggunakan Aspergillus niger. *Jurnal Nutrisi Ternak Tropis* 2(1): 1–9. DOI: 10.21776/ub.jnt.2019.002.01.1

Mardalena, M., Warly, L., Nurdin, E., Rusmana, W. S. N., and Farizal, F. 2015. Milk quality of dairy goat by giving feed supplement as antioxidant source. *Journal of the Indonesian Tropical Animal Agriculture* 36(3): 205–212. DOI: 10.14710/jitaa.36.3.205-212

Masengi, K. I. E. G., Siampa, J. P., and Tallei, T. E. 2020. Penyalutan Bakteri Asam Laktat Hasil dari Fermentasi Kulit Buah Nanas (Ananas comosus) dengan Pewarna Bunga Telang (Clitoria ternatea). *JURNAL BIOS LOGOS* Universitas Sam Ratulangi 10(2): 86. DOI: 10.35799/jbl.10.2.2020.29047

Oak, S. J., and Jha, R. 2019. The effects of probiotics in lactose intolerance: A systematic review. *Critical Reviews in Food Science and Nutrition* Taylor & Francis. DOI: 10.1080/10408398.2018.1425977

Ojeda-Linares, C., Álvarez-Ríos, G. D., Figueredo-Urbina, C. J., Islas, L. A., Lappe-Oliveras, P., Nabhan, G. P., Torres-García, I., Vallejo, M., and Casas, A. 2021. Traditional fermented beverages of Mexico: A biocultural unseen foodscape. *Foods* 10(10): 1–31. DOI: 10.3390/foods10102390

Puji Astuti, F., Syenni Datu, O., and Ekawati Tallei, T. 2020. *EFFECTS OF ADDITION BENZOIC ACID ON YEAST GROWTH AND ALCOHOL CONTENT ON THE FERMENTATION OF LOCAL PINEAPPLE (Ananas comosus L.) SKIN*.

Rizal, S., Nurainy, F., Program Studi Teknologi Hasil Pertanian, M., and Pertanian Universitas Lampung, F. 2020a. Minuman Probiotik Kulit Nanas Madu Samsul Rizal et al PENGARUH GLUKOSA DAN JAHE MERAH TERHADAP KARAKTERISTIK MINUMAN PROBIOTIK DARI KULIT NANAS MADU [The Influence of Glucose and Red Ginger on the Probiotic Beverages Characteristics of Honey Pineapple Skin]. *Jurnal Teknologi & Industri Hasil Pertanian* 25(2): 110. DOI: 10.23960/jtihp.v25i2.%25p

Rizal, S., Udayana Nurdin, S., Teknologi Hasil Pertanian, J., Pertanian Universitas Lampung Jl Sumantri Brojonegoro No, F., Lampung, B., Teknologi Pertanian, J., Pertanian, F., Bengkulu Jl Supratman, U. W., Limun, K., and Bengkulu, K. 2020b. KAJIAN POTENSI SARI KULIT BUAH NANAS YANG DIFERMENTASI DENGAN Lactobacillus casei SEBAGAI MINUMAN PROBIOTIK SECARA IN VIVO STUDY ON POTENTIALS OF PINEAPPLE SKIN EXTRACT FERMENTED WITH Lactobacillus casei AS A PROBIOTIC BEVERAGE BY IN VIVO. | *Jurnal Agroindustri* 10(1): 12–20. DOI: 10.31186/j.agroind.10.1.12-20

Rochani, A., Yuniningsih, S., and Ma'sum, Z. 2016. PENGARUH KONSENTRASI GULA LARUTAN MOLASES TERHADAP KADAR ETANOL PADA PROSES FERMENTASI.

Saefudin, Marusin, S., and Chairul. 2013. Aktivitas Antioksidan pada Enam Jenis Tumbuhan Sterculiaceae (Antioxidan Activity on Six Species of Plants) Sterculiaceae. *Jurnal Penelitian Hasil Hutan* 31(2): 103–109.

Setiarto, H. B. 2020. *Teknologi_Fermentasi_Pangan_Tradisional*. (Guepedia, ed.) Guepedia, Jakarta.

Sutedjo, K. S. D., and Nisa, F. C. 2015. KONSENTRASI SARI BELIMBING (Averrhoa carambola L) DAN LAMA FERMENTASI TERHADAP KARAKTERISTIK FISIKO-KIMIA DAN MIKROBIOLOGI YOGHURT Star Fruit (Averrhoa carambola L) Concentrate and Fermentation Period in Physic-Chemical Microbiology Properties of Yogh. *Jurnal Pangan dan Agroindustri* 3(2): 582–593.

Tivani, I., and Sari, M. P. 2021. Uji Efektivitas Antibakteri Ekstrak Kulit Buah Nanas Madu dan Kulit Buah Pepaya terhadap Staphylococcus aureus. *PHARMACY: Jurnal Farmasi Indonesia (Pharmaceutical Journal of Indonesia)* 18(1): 45. DOI: 10.30595/pharmacy.v18i1.8030

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Analysis of Plant Vegetation in Sekipan Forest Tawangmangu District, Karanganyar District

Ima Aryani*, Shal Syabela Riskawati
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: ia122@ums.ac.id

KEYWORDS:
Diversity index
Skipan forest
Vegetation analysis

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The purpose of this study was to determine the structure and composition of Vegetation structure and composition in Sekipan forest, Tawangmangu subdistrict, Karanganyar regency and to determine the tree species that dominate in the structure and composition of plant vegetation species in sekipan forest, Tawangmangu subdistrict, Karanganyar regency. This research is quantitative descriptive research. The population in this study was the vegetation in the skipan forest, Tawangmangu District, Karanganyar Regency, Central Java Province. The sample in this study is part of the area in the skipan forest, Tawangmangu District, Karanganyar Regency, Central Java Province. Method for sampling location using exploration. Data analisys using purpossive sampling. Sampling data collection for each observation using the plot sampling method. Data analysis techniques are calculated by calculating density, frequency, dominance, important value index, and diversity index. The results showed that the composition of plants in the Tawangmangu Karanganyar Sekipan Forest consisted of 52 plant species. *Leucaena leucocephala* has the highest density value with 110 trees/ha. The highest frequency was owned by the species *Pinus Mercusii* with 1.5%. The highest dominance is owned by *Pinus mercusii*, which is 70.95% and INP is 128.70%. A diversity index of 2.38617 indicates that diversity in sekipan forests is medium category.

1. INTRODUCTION

Biodiversity is the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystem (Dickson, 2019). Biodiversity in the country of Indonesia is very high, which is found in forest and water resources, therefore Indonesia can be said to be a Mega Biodiversity Country. Biodiversity in Indonesia has been widely studied by experts. The results of various studies show that biodiversity in Indonesia consists of: lower plants commonly called herbs, shrubs, shrubs, saplings and trees. These types of plants are found in hilly areas and forests. These plants grow well with biotic and abiotic environmental factors that are suitable for these plants.

Plant diversity is spread throughout Indonesia. One of them is in the forest which forms a vegetation. Vegetation is a plant community that is included in the biotic component. Plants can occupy space in certain habitats according to the factors needed to grow and develop. These habitats are forests, hills, shrubs, grasslands, and so on. Vegetation in an area has a structure and composition that can be influenced by components in an ecosystem that interact with each other. Vegetation that can interact with various environments can grow well naturally in that area. Vegetation can also undergo drastic changes due to anthropogenic influences.

Vegetation is the aggregate of all the plants growing in an area and, as such, is the most conspicuous feature of most landscapes, already recognized by the early Greeks as a way of distinguishing one region from another. Vegetation involves populations of species of the local fl ora, which in turn involve different genetic, migration, historical or ecological elements. Vegetation is also composed of various plant forms and ecological plant types, reflecting various sizes, shapes and combinations. (Elgene, 2013). Vegetation is a collection of various types of plants that can live together in a certain area. In this togetherness of life, there are interactions that occur both among individual plants that make up the vegetation itself and with other organisms that live in the vegetation, so that vegetation is a living system that grows dynamically somewhere.

Vegetation analysis is a method for studying the composition of plant species in an area. In addition, it is also to study the form (structure) of vegetation and plant groups found. Large forest areas with diverse vegetation composition require detailed analysis, therefore the vegetation analysis activities are closely related to the sample. Detailed analysis of the relationship between vegetation and environment requires a detailed understanding of the environmental processes that influence vegetation, for example, knowledge of the processes the link rainfall to the availability of water to plants and of the physiological processes that govern its use by different species is essential (M.P. Austin, 2014). Vegetation analysis activities are carried out by determining various sample areas with a certain plot area (sample plot). Several selected sample plots can be used to represent the vegetation area. The selected sample plots must pay attention to three aspects, namely; the amount to be used, how to place the sample plots, and techniques for observing and analyzing data from the sample plots.

The purpose of this study was to determine the structure and composition of Vegetation structure and composition in Sekipan forest, Tawangmangu subdistrict, Karanganyar regency and to determine the tree species that dominate in the structure and composition of plant vegetation species in sekipan forest, Tawangmangu subdistrict, Karanganyar regency. A plant vegetation type describes the condition of the distribution of plant species in a certain area. Skipan forest vegetation consists of various kinds of plants. To find out the plants that make up the skipan forest vegetation, a study was carried out with the title "Analysis of Plant Vegetation in the Skipan Forest, Tawangmangu District, Karanganyar Regency".

2. MATERIALS AND METHODS

2.1. Method

This research is a type of exploratory research. The data is presented in a qualitative descriptive manner. Data collection techniques using exploration and inventory methods. Data is documented and identified by searching the literature review. The research was conducted in the area of the Skipan hill camp, Tawangmangu, Karanganyar, Central Java.

The population used in this study is the vegetation in the forest which is the skipan camping hill, Tawangmangu District, Karanganyar, Central Java. The sample used in this study is part of the skipan forest. Tawang Manggu District, Karanganyar Regency, Central Java Province. The areas used as samples are 8 plots divided by altitude as follows:

a. front area right and left (most west) near the entrance to the sikpan forest
b. forest center area left and right (north and south)
c. the central area of the forest on the left and right (north and south) with a slightly higher plain from the location b
d. the end of the forest with the highest plains of the skipan forest (easternmost) left and right (northern and southern parts.

2.2. Data analysis

Data analysis techniques can use parameters that are analyzed according to:

a. Density of a type (K)
K = Σ individual type/Area of example tile

b. Relative density of a type (KR)
KR = K of a type/K All types x 100 %

c. Frequency of a type (F)
F = Σ Sub− tile found of type/Σ All sub−example tiles

d. Relative frequency of a type (FR)
FR = F of a type/ F of all types x 100%

The plant frequency classes are:
Class A : 0 -20%
Class B : 21 - 40%
Class C : 41 - 60%
Class D : 61 - 80%
Class E : 81 – 100 %

e. Dominance of a type (D)
D = Base field area of a type/Example tile area
Base Area = π x (rod diameter/2)2

f. Relative dominance of a type (DR)
DR = D of a type/D of all types x 100%

g. Important Value Index (INP)
INP = KR + FR + DR

Information:
FR = Relative Frequency,
KR = Relative Density,
DR = Relative Domination

h. Diversity Index

$$H' = -\sum \left(\boldsymbol{ni}/\boldsymbol{N} \right) \mathbf{ln}\left(\boldsymbol{ni}/\boldsymbol{N} \right)$$

Information:
H' : Shannon-Wienner Diversity Index
Ni : the number of an individual type
N : total number of individuals of all species found

The definition of the formula above is as follows:
a. If the value of H'> 3 means that the diversity of species is high
b. b. If the value of H' 1 H' 3 means that the diversity of species is moderate
c. c. If the value of H',1 means that species diversity is low.

3. RESULTS AND DISCUSSION

3.1. Research result

From research activities that have been carried out in the Skipan Tawangmangu forest, Karanganyar regarding vegetation analysis, the results obtained are:

3.1.1. Plant data from the 10 plots used for analysis are presented in the following table

Table 1. Plant data with measurements of its diameter and area

Plot	Plant species	Tree diameter (m)	Tree diameter (m)	Radius (r) (meters)	Base Area (m)
1	*Pinus mercusii*	5.92	5.93	2.96	27.60
	Pinus mercusii	2.05	2.06	1.03	3.33
	Pinus mercusii	4.21	4.21	2.11	13.91
	Pinus mercusii	4.73	4.74	2.370	17.63
	Pinus mercusii	3.67	3.68	1.840	10.63
2	*Cyantheaceae*	7.22	7.23	3.615	41.03
	Leucaena leucocephala	3.7	3.7	1.850	10.75
	Dracaena angustifolia	0.95	0.95	0.475	0.71
	Dracaena angustifolia	0.95	0.95	0.475	0.71
	Dracaena angustifolia	0.85	0.85	.425	0.57
	Dracaena angustifolia	0.70	0.70	0.350	0.39
	Cajanus cajan	1.22	1.23	0.615	1.19
	Leucaena leucoephala	1.34	1.34	0.670	1.41
3	*Pinus mercusii*	6.20	6.20	3.100	30.18
	Pinus mercusii	5.85	5.85	2.925	26.86
	Pinus mercusii	8.40	8.40	4.200	55.39
	Pinus mercusii	5.35	5.35	2.675	22.47
	Coffea L.	2.75	2.75	1.375	5.94
	Coffea L.	1.42	1.41	0.705	1.56
	Coffea L.	1.20	1.20	0.600	1.13
4	*Acer neugunda L.*	1.45	1.45	0.73	1.65
	Leucaena leucocephala	3.85	3.85	1.93	11.63
	Leucaena	3.10	3.10	1.55	7.54

Plot	Plant species	Tree diameter (m)	Tree diameter (m)	Radius (r) (meters)	Base Area (m)
	leucocephala				
	Leucaena leucocephala	1.45	1.45	0.73	1.65
	Leucaena leucocephala	1.60	1.60	0.80	2.01
	Leucaena leucocephala	1.67	1.68	0.84	2.22
	Leucaena leucocephala	1.30	1.30	0.65	1.33
	Leucaena leucocephala	2.45	2.45	1.23	4.71
	Leucaena leucocephala	2.45	2.45	1.23	4.71
	Gnetum gnemon	4	4	2.00	12.56
5	*Pinus mercusii*	6.15	6.15	3.07	29.69
	Pinus mercusii	6.70	6.70	3.35	35.24
	Gnetum gnemon	6.80	6.80	3.40	36.29
6	*Pinus mercusii*	1.25	12.5	6.25	122.66
	Pinus mercusii	11.50	11.50	5.75	103.82
	Ruellia simplex	68.5	0.69	0.35	0.37
	Moringa oleifera	60.5	0.6	0.30	0.28
	Crassocepha lum crepidiodes	0.40	0.4	0.20	0.13
	Ageratum conyzoides	0.51	0.5	0.25	0.20
7	*Camellia sinensis*	1.39	1.39	0.69	1.52
	Camelia sinensis	3.9	3.9	1.95	11.94
	Schima walichii	1.66	1.67	0.84	2.19
8	*Pinus mercusii*	2.71	2.71	1.36	5.77
	Laucaena leucephala	6.20	6.21	3.10	30.27
	Pinus mercusii	3.91	3.92	1.96	12.06
9	*Citrus sp*	1.14	1.14	0.57	1.02
	Citrus sp	1.3	1.3	0.65	1.33
	Teotona grandis	1.2	1.2	0.60	1.13
10	*Terminalia catappa*	0.15	0.15	0.08	0.02
	Corydline fruticosa	0.32	0.32	0.16	0.08
	Corydline fructicosa	0.33	0.33	0.17	0.09
	Dypsis litescens	1.00	1.03	0.52	0.83

3.1.2. Data from analysis (important value index)

The results of the data on plant species in the research that have been obtained, then calculated the relative density and density, relative frequency and frequency, relative dominance and dominance as well as the IVI. The results of the calculation analysis are presented in table 2 below:

Table 2. Data from the analysis of density and relative density, relative frequency and frequency, relative dominance and dominance as well as plant important value index.

No	Spesies	K (ind/ha)	KR %	F	FR %	D (m2/ha)	DR %	INP %	H'
1	*Pinus mercusii*	15.00	28.85	1.5	28.85	0.4884	70.95	128.64	0.35861
2	*Cyantheaceae*	1.00	1.92	0.1	1.92	0.04103	5.97	9.87	0.07599
3	*Leucaena leucocephala*	11.00	21.15	1.1	21.15	0.07654	11.12	53.43	0.32859
4	*Dracaena angustifolia*	4.00	7.69	0.4	7.70	0.00226	0.33	15.71	0.1973
5	*Cajanus cajan*	1.00	1.92	0.1	1.92	0.00119	0.17	4.02	0.07599
6	*Coffea L.*	3.00	5.77	0.3	5.77	0.0085	1.23	12.77	0.16457
7	*Acer neugunda L.*	1.00	1.92	0.1	1.92	0.0016	0.23	4.08	0.07599
8	*Gnetum gnemon*	2.00	3.85	0.2	3.85	0.04885	7.10	14.79	0.12531
9	*Ruellia simplex*	1.00	1.92	0.1	1.92	0.00037	0.05	3.90	0.07599
10	*Moringa oleifera*	1.00	1.92	0.1	1.92	0.0002	0.03	3.88	0.07599
11	*Crassocephalum crepidiodes*	1.00	1.92	0.1	1.92	0.00012	0.02	3.86	0.07599
12	*Ageratum conyzoides*	1.00	1.92	0.1	1.92	0.00019	0.03	3.87	0.07599
13	*Camellia sinensis*	2.00	3.85	0.2	3.85	0.0134	1.95	9.64	0.12531
14	*Schima walichii*	1.00	1.92	0.1	1.92	0.00128	0.19	4.03	0.07599
15	*Citrus sp*	2.00	3.85	0.1	1.92	0.00234	0.34	6.11	0.12531
16	*Tecotona grandis*	1.00	1.92	0.2	3.85	0.00113	0.16	5.93	0.07599
17	*Terminalia catappa*	1.00	1.92	0.1	1.92	0.00001	0.00145	3.85	0.07599
18	*Corydline fruticosa*	2.00	3.85	0.2	3.85	0.00008	0.01	7.70	0.12531
19	*Dypsis litescens*	1.00	1.92	0.1	1.92	0.00091	0.13	3.98	0.07599
	Total	**52**	**100**	**5.2**	**100**	**0.69**	**100**	**300**	**2.38617**

3.1.3. Data of Coordinate Points from Plot 1-10

Table 3. The coordinate points of each plot

PLOT	COORDINATE POINT
plot 1	S07°40.364'E 111°08.842
plot 2	S07°40.344'E 111°08.834
plot 3	S07°40.363'E 111°08.853
plot 4	S07°40.124'E 111°08.631
plot 5	S07°40.404'E 111°08.879
plot 6	S07°40.438'E 111°08.734
plot 7	S07°40.477'E 111°08.884
plot 8	S07°40.368'E 111°08.795
plot 9	S07°40.385'E 111°08.790
plot 10	S07°40.366'E 111°08.775

3.2. Discussion

Vegetation is a group of plant communities that live in a particular area. the existence of plant vegetation in an area can have a positive effect on the balance of the ecosystem in a wider scope. Conversely, the absence of plant vegetation will have an impact on ecosystem imbalances so that it can be used as an illustration of ecosystem damage, including forest ecosystems (Latuhima, 2019). The plant vegetation is so wide and the variety of plant species makes it possible for researchers to carry out analysis.

The vegetation structure is divided into several groups. This grouping is based on growth form, size, crown shape, leaf function, and leaf texture and size. Based on the size, in plain view the vegetation can be seen from the height of the vegetation in question. Likewise, if it is based on the shape and size of the leaves, vegetation can be seen from the size, width, small, like needles, grass, and a combination of these forms. By feeling the sensation, you can immediately feel the structure of the leaves, whether they are hard, papery, or succulent. Finally, based on their covering capacity, vegetation has very diverse covering abilities. Very tall plants have a variable coverage area. However, even very tall plants have a horizontal cover with a large area. The closure can relatively be used as a cover, some are made to connect, and some are separated (Khambali, 2017).

Vegetation analysis is a method used to determine the distribution of various types of plant species found in a certain area. Vegetation analysis can facilitate information related to interactions between plants and also interactions with environmental factors. Vegetation analysis activities can be carried out by direct observation by making sample plots in the form of plots. This activity must be continued by observing the morphology, describing and identifying the vegetation found. In large forest conditions, vegetation analysis activities can be carried out by making sampling. The sampling was made to place the sample plots that we have provided as representative areas within the plant's habitat. The number of sample plots, the method of placing the sample plots and the vegetation analysis technique used need to be considered carefully so that the results are maximized. To carry out an analysis of a plant vegetation, the data that must be present is the type of plant, the diameter of the plant stem and the height of the plant. All of this data is needed to calculate the important value index of the forest community, which is then analyzed quantitatively and qualitatively to determine the distribution of biodiversity in an ecosystem.

In this research about Vegetation Analysis on Sekipan Hill, Tawangmangu. This vegetation analysis uses the plot method with a size of 10 m x 10 m. 10 plots were made with different altitudes. From the ten plots, 19 different plant species were found. Of the 19 species, the basal area was calculated as shown in table 4.1. Based on these calculations, the widest basal area is Pinus mercusii. This is because the number of Pinus mercusii is the most among other plants. So it seems to dominate the skipan forest vegetation.

Based on the entire plot size of 10 m x 10 m there are 52 species. The species Leucaena leucocephala has the highest density with 110 trees/ha. For the highest frequency belongs to the species Pinus mercusii with 1.5 %. This frequency is used as a parameter in plant vegetation which is used as the basis for the distribution of plant species at the species level in a studied habitat. This is in line with the statement in the Natural Resources and Environment Management Book (Damanik, 2018) which states the importance of analyzing vegetation in a habitat, namely to be able to find out the structure, abundance of species, distribution of vegetation in an ecosystem, and the relationship between the presence of plants and environmental factors environment.

Based on table 4.2, the species of each plant has been calculated, relative frequency and frequency, relative density and density, relative dominance and dominance as well as Important Value Index (INP). From the calculation results, the results are as shown in table 4.2, which shows that the most commonly found species is *Pinus mercusii* with a value of 70.95% and the least species found is *Terminalia catappa* with a value of 0.001%.

The highest Important Value Index or IVI in all plots measuring 10m x 10m was owned by Pinus mercusii with 128.639877% and the lowest Important Value Index or IVI was *Terminalia catappa*, which was 3.85%. So it can be seen that *Pinus mercusii* dominates the Tawangmangu Karanganyar sekipan forest. This is because the environmental conditions are very suitable for growth and development. The growth and development of a plant can be influenced by factors from within the plant itself and external factors, namely the habitat environment where the plant is located. Environmental factors that can be measured in the Skipan area at the time of the study were an altitude of 1244 masl, an air pressure of 872.3 hPa, and temperature of 25.7°C, and a humidity of 77%. The coordinate points in table 4.3 also affect the presence of species, causing one plant species to become dominant in a certain area according to the appropriate height.

4. CONCLUSIONS

The plant composition in the Tawangmangu Karanganyar Skipan Forest consists of 52 plant species. *Leucaena leucocephala* has the highest density value with 110 trees/ha. The highest frequency was owned by the species *Pinus Mercusii* with 1.5%. The highest dominance was owned by Pinus mercusii, namely 70.95% and the highest Importance Value Index or IVI was owned by the species *Pinus mercusii*, namely 128.70%.

The dominant plant species in the Tawangmangu Karanganyar Sekipan Forest is *Pinus mercusii*, which is 70.95% and INP is 128.70%. A diversity index of 2.38617 indicates that diversity in sekipan forests is medium category.

5. REFERENCES

Agustina, D.K. (2008). *Studi Vegetasi di Hutan Lindung RPH Donomulyo BK PH Sengguruh KPH Malang*. Skripsi tidak diterbitkan. Malang: Jurusan Biologi Fakultas Saintek UIN Mau-lana Malik Ibrahim Malang.

Baiquni, H. 2007. *Pengelolaan Keanekaragaman Hayati*. Australia: Social Economic Environmental.

Damanik, Sarintan Efratani. 2019. *Pengelolaan Sumber Daya Alam dan Lingkungan*. Ponorogo : Uwais Inspirasi Indonesia. Hal : 112.

Diah Permata Sari , Kornelia Webliana B , Maiser Syaputra. 2019. Analisis Vegetasi di Kawasan Sempadan Embung Bual, Desa Aik Bual Kecamatan Kopang Kabupaten Lombok Tengah. *Jurnal Belantara. Vol. 2 No. 2*

Dickson, A., dkk. 2019. The Concept of Biodiversity and its Relevance to Mankind: A Short Review. *Journal of Agriculture and Sustainability ISSN 2201-4357 Volume 12, Number 2, 2019, 219-231*

Elgene O. Box and Kazue Fujiwara. 2013. *Vegetation Types and Their Broad-Scale Distribution*. DOI:10.1002/9781118452592.ch15.

Elkordy, Ahmed; Elshikh, Omer; and Abdallah, Naglaa. 2019. "Floristic diversity and vegetation analysis of riparian and aquatic plants of the canals in the Sohag Governorate, Egypt". *Phytologia Balcanica*. Vol 25. Numb 1. Page 81-95.

Fachrul, M. F. 2012. *Metode Sampling Bioekologi*. Jakarta: Bumi Aksara.

Heddy, Suwarsono.2012. *Metode Analisis Vegetasi Dan Komunitas* .Jakarta : Rajawali Press.

Indrawan Mochamad. Richard B. Premack. Jatna Supriatna. 2007. Biologi Konservasi. Edisi Revisi. Jakarta: Yayasan Obor Indonesia.

Kartawinata, Kuswata. 2013. *Divertasi Ekosistem Alami Indonesia : Ungkapan Singkat dengan Sajian Foto dan Gambar*. Jakarta : LIPI Press. Hal : 1

Khambali, I. 2017. *Model Perencanaan Vegetasi Hutan Kota*. Yogyakarta : Andi. Hal 135-136.

Latumahina, Fransina; Mardiatmoko, Gun; dan Sahusilawane, Jhon. 2019. *Respon Semut Terhadap Kerusakan Ekosistem Hutan di Pulau Kecil.* Bandung : MediaAkselerasi. Hal : 32-33

Maridi, Alanindra Saputra, Putri Agustina. 2015. Analisis Struktur Vegetasi di Kecamatan Ampel Kabupaten Boyolali. *Jurnal BIOEDUKASI Volume 8, Nomor 1 Halaman 28-42*

M.P. Austin. 2014. *Vegetation and Environment: Discontinuities and Continuities*. CSIRO Ecosystem Sciences, Canberra ACT, Australia

Narisa, C. 2010. *Konsep Keanekaragaman Hayati*. http://www.scribd.com/ doc/9680540/Konsep-Keanekaragaman-Hayati.

Putri Nur Azizah. 2017. Analisis Vegetasi di Kawasan Sekitar Mata Air Ngembel, Kecamatan Pajangan, Kabupaten Bantul. *Jurnal riset daerah Vol. XVI, No.1.*

Rendra, Tedy; Duryat; dan Bintoro, Alif. 2018. " Analisis Vegetasi di Blok Inti Hutan Lindung Register 21 Kesatuan Pengelolaan Hutan XI Kabupaten Pesawaran ". *Jurnal Biologi Eksperimen dan Keanekaragaman Hayati*. Vol 5. No 1. Hal 57- 66.

Rohman, Fatchur.dkk. 2001. *Petunjuk Praktikum Ekologi Tumbuhan Ekologi Tumbuhan*. Malang. JICA

Sambas, Edy Nasriadi; Kusmana, Cecep; Prasetyo, Lilik Budi; and Partomihardjo, Tukirin. 2018. " Vegetation Analysis and Population Structure of Plants at Mount Endut Forested Area, Gunung Halimun Salak National Park, Banten, Java, Indonesia ". *REINWARDITA*. Vol 17. Numb 1. Page : 39-55.

Sukistyanawati, Agustin; Sepiastini, Wiwin; Makmun, Sukro; dan Andriyono, Sapto. 2016. " Analisis Vegetasi Hutan Pantai, Hutan Tropis Daratan Rendah Dan Ekosistem Mangrove Di Cagar Alam Pulau Sempu ". *Journal of Marine and Coastal Science*. Vol 5. No 1. Hal : 22-35.

Susanto, A. 2012. *Struktur Komposisi Vegetasi Di Kawasan Cagar Alam Manggis Gadungan*. (Jurnal Agri-tek. Vol. 13 No. 2,)

Tania Serezova Augusta., 2015, "Identifikasi Jenis dan Analisa Vegetasi Tumbuhan Air di Danau Lutan Palangka Raya", Jurnal Ilmu Hewani Tropika, Vol 4. No. 1.

Tiwari, Umeshkumar L; and Ravikumar, L. 2018. "Floristic Diversity, Vegetation Analysis and Threat Status of Plants in Various Forest Types in Dharmapuri Forest Division, Tamilnadu, Southern India ". *Notulae Scientis Biologicae*. Vol 10. Numb 2. Page : 297-304.

Zulkarnain; Kasim, S; dan Hamid, H. 2015. "Analisis Vegetasi dan Visualisasi Struktur VegetasiHutan Kota Baruga, Kota Kendari". *Jurnal Hutan Tropis.* Vol 3. No 2. Hal : 99-109

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Health Examination of The Digestion of Proboscis Monkey (*Nasalis larvatus*) Through Bacteriological Tests on Feces

Camalia Maisya[1], Anni Nurliani[1*], Amalia Rezeki[2], Rusmiati[1]
[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Lambung Mangkurat University, South Kalimantan 70714, Indonesia
[2]Department of Biology Education, Faculty of Teacher Training and Education, Lambung Mangkurat University, South Kalimantan 70713, Indonesia
[*]Corresponding Author. E-mail address: anninurliani@ulm.ac.id

KEYWORDS:
Bacteria,
E. coli,
Feces,
Proboscis monkey

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

This study aims to identify bacteria and the prevalence value of bacteria found in probosci's monkey feces as a picture of proboscis monkey digestive health. Seventeen fecal samples from each proboscis monkey, namely Mimin, Chikita, and Pedro, were taken at the Bekantan Rescue Center, Sahabat Bekantan Indonesia Foundation (SBI). Feces were identified by making macroscopic and microscopic observations. Visible observations include consistency, color, mucus, and blood in the physical feces. Microscopic observations were made by culturing feces on Mac Conkey, blood agar, EMBA, DHL agar, and NA media, followed by gram staining and biochemical tests consisting of VP (*Voges-Proskaeur*) test, methyl red test, indole test, citrate test, and lactose test. The results of identifying 17 feces samples from each probosci's monkey found the presence of *E.coli* bacteria from microscopic testing. The prevalence of *E.coli* bacteria in Mimin, Chikita, and Pedro is 41.17%; 35.29%; 35.29%, so it is concluded that the presence of *E.coli* is a typical bacterium that is not harmful to the digestion of proboscis monkeys, supported by observations on the physical macroscopic feces of good probosci's monkeys.

1. INTRODUCTION

The Proboscis monkey (*Nasalis larvatus*) is a primate from the Cercopithecidae family (Klaus et al., 2018). Proboscis monkeys are endemic primates of Borneo which are spread across three regional countries, namely Indonesia (Kalimantan), Brunei Darussalam, and Malaysia (Sabah, Sarawak) (Meijaard & Nijman, 2000). Proboscis monkeys in their habitat are starting to decrease due to the conversion of forests to residential land (Srimulyaningsih & Syaputra, 2021). The decline in the probosci's monkey population by 50-80% in nature has resulted in the species being categorized as endangered by the IUCN (*International Union for Conservation of Nature and Natural Resources*) and included in Appendix I of CITES (*Convention on International Trade in Endangered Species of Wild Fauna and Flora*) (IUCN, 2023). The causes of the decline in the probosci's monkey population include land conversion, forest fires, and poaching. These factors must be balanced with fishing efforts (Kartono et al., 2008).

In the context of and supporting government programs in the field of probosci's monkey conservation, Sahabat Bekantan Indonesia Foundation (SBI) is a non-profit foundation that has several programs such as rescue & rehabilitation activities and rehabilitation of proboscis monkeys before being released into their natural habitat (Santoso et al., 2019). Monitoring animal health

during the rehabilitation period is necessary to evaluate the readiness of animals both physically and mentally before they are released into their natural habitat. Animals that have good digestive health will also have good physical health. Digestive health is an important indicator to assess animal health in general.

Gastrointestinal disorders are a problem that is often found in primates (Rahmi et al., 2014). Digestive health examination can be performed macroscopically using a stool sample, including observing the stool's color, consistency, amount, smell, mucus, and blood (Collison et al., 2010). Gastrointestinal disorders are usually caused by enteropathogenic bacteria (Wahyuni, 1999). Microscopic examination of probosci's monkey feces to determine the presence of bacteria can be used as a supporting examination in diagnosing digestive disorders. So far, tracing of bacteria focusing on enteric bacteria in probosci's monkey feces at the Indonesian Proboscis Monkey Foundation (SBI) Rehabilitation Center has never been carried out.

Research conducted by Pramono (2021) on the feces of proboscis monkeys (*Nasalis larvatus*) by examining bacteria, namely lactic acid bacteria (BAL), and the results of this study found three types of lactic acid bacteria, the *Lactobacillus* type. In addition, several researchers have examined enteric bacteria in other primates. The results of research by Rahmi et al. (2014) reported that two Sumatran orangutans (*Pongo abelii*) at the Jantho Orangutan Reintroduction Center identified nine fecal samples contaminated with bacteria from the genera *Salmonella* and *Shigella*. Research by Virgi (2016) also reported on cases of diarrhea of two Bornean orangutans (*Pongo pymaeus*), each of which came from captive orangutans at the Yogyakarta Nature Conservation Foundation in Kulon Progo and orangutans at the Borneo Orangutan Survival Foundation in Semboja, East Kalimantan, identified two swab samples feces contained *Providencia rustigianii* and *Enterobacter agglomerans*. In addition, research from Loe et al. (2021) regarding the prevalence of bacteria in the feces of long-tailed monkeys (*Macaca fascicularis*) who experience diarrhea at the Bogor Agricultural University Captive Facility, it is known that the results of isolation and bacterial assistance show that the fecal sample is contaminated with *E.coli* (100%), *Salmonella enteritidis* (97%), and *Shigella* sp. (60%).

Based on the bacterial background above, it is necessary to research tracing proboscis monkey feces. This study aims to describe the digestive health of proboscis monkeys at the Bekantan Rescue Center, Sahabat Bekantan Indonesia Foundation (SBI) by tracing bacteria in feces with the hope that this research will be helpful as basic information for reference in monitoring the health of probosci's monkeys before being released back to their natural habitat.

2. MATERIALS AND METHODS

This research was conducted for five months, from February to June 2023. Sampling was conducted at the Bekantan Rescue Center, Sahabat Bekantan Indonesia (SBI). The research samples were feces from 1 adult male proboscis monkey (Pedro) and two adult female proboscis monkeys (Mimin and Chikita). Sample examination was conducted at the Banjarbaru Regional V Veterinary Investigation and Testing Laboratory, Banjarbaru Veterinary Center, South Kalimantan Province.

The tools used for this study were ziplock packs, scoops, tongs, latex sheaths, trays, ice boxes, ice gel, Petri dishes, micropipette, cover slip, slide, loop needle, bunsen, microscope, test tube, pipette, incubator, freezer, digital scales, and camera. The materials used for this study were proboscis monkey feces, DHL agar, Blood agar, Mac Conkey agar, Nutrient agar, Eosin Methylene Blue agar (EMBA), VP Media, MR Media, trypticase broth, 0.9% NaCl, alpha-naphthol solution, 40% KOH, distilled water, crystal violet, Lugol's iodine, 96% alcohol, safranin, Koser's citrate medium, tryptone broth, brilliant green lactose broth, methyl red reagent, and Kovac's reagent.

Sampling was conducted in the morning at around 07.00 - 09.00 for each adult probosci's monkey at the Bekantan Rescue Center, Sahabat Bekantan Indonesia Foundation. The macroscopic examination is done immediately after the sample is placed in the tray. Stool samples were identified through macroscopic characteristics: consistency, color, mucus, and blood. The

macroscopic characteristics obtained from the observations were then recorded. Parameters of Proboscis monkey stool consistency are known using the Fecal Consistency Score (FCS), according to Moxham (2001). Meanwhile, Microscopic observation was carried out by culturing the feces by isolating bacteria on Mac Conkey media, blood agar, EMBA, DHL agar, and NA, followed by gram staining and biochemical tests consisting of the VP test (Voges-Proskaeur), methyl red test, indole test, citrate, and lactose tests.

The data were analyzed descriptively to explain the description by correlating the macroscopic results/physical characteristics of the stool, the microscopic results (type of bacteria), and the prevalence of bacteria. Determination of the prevalence of bacterial infection is based on the results of examining the presence or absence of bacteria on stool examination.

The data obtained is presented using the formula:

$$\text{Prevalence} = \frac{\sum positive\ sample\ of\ bacteria}{\sum observed\ samples} \times 100\% \quad \text{.....(1)}$$

(Safitri et al., 2019)

3. RESULTS AND DISCUSSION

3.1.Results

The results of macroscopic observations on the feces of proboscis monkeys can be seen in (**Table 1**).

Table 1. Results of macroscopic observations of the feces of proboscis monkey feces

No.	Nth Collection Sample	Individual Code	Macroscopic Observations			
			Color	Consistency	Presence of Mucus	Presence of Blood
1.	1	M	Greenish	Liquid, Shaped	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Liquid, shapeless	-	-
2.	2	M	Brownish yellow	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Brownish yellow	Liquid, shapeless	-	-
3.	3	M	Brownish yellow	Solid, Shaped	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Solid, Shaped	-	-
4.	4	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Solid, Shaped	-	-
5.	5	M	Greenish	Liquid, shapeless	-	-

No.	Nth Collection Sample	Individual Code	Macroscopic Observations			
			Color	Consistency	Presence of Mucus	Presence of Blood
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Fairly liquid, Shaped	-	-
6.	6	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Solid, Shaped	-	-
7.	7	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Solid, Shaped	-	-
8.	8	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Liquid, shapeless	-	-
9.	9	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Moderately dense, Shaped	-	-
10.	10	M	Greenish	Solid, Shaped	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Fairly dense, shapeless	-	-
11.	11	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Yellowish green	Moderately dense, Shaped	-	-
12.	12	M	Greenish	Moderately dense, Adequately shaped	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Liquid, shapeless	-	-
13.	13	M	Greenish	Fairly dense, shapeless	-	-

No.	Nth Collection Sample	Individual Code	Macroscopic Observations			
			Color	Consistency	Presence of Mucus	Presence of Blood
		C	Greenish	Fairly dense, shapeless	-	-
		P	Greenish	Liquid, shapeless	-	-
14.	14	M	Greenish	Solid, Shaped	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Liquid, shapeless	-	-
15.	15	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Liquid, shapeless	-	-
16.	16	M	Greenish	Liquid, shapeless	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Liquid, shapeless	-	-
17.	17	M	Greenish	Solid, Shaped	-	-
		C	Greenish	Solid, Shaped	-	-
		P	Greenish	Liquid, shapeless	-	-

Note: (-) = none

Each proboscis monkey's stool is tested microscopically, including bacterial culture, gram staining, and biochemical tests. The identified bacteria are *Escherichia coli* (*E.coli*). The results of bacterial identification from microscopic observations of proboscis monkey feces and the results of the tests are presented in (**Table 2**) and (**Table 3**).

Table 2. Results of Microscopic Observations on the Feces of Proboscis Monkeys

No.	Nth Collection Samples	Individual Code	Results of Identification of Bacteria in Proboscis Monkey Feces
1.	1	M	*E.coli*
		C	-
		P	-
2.	2	M	*E.coli*
		C	*E.coli*
		P	*E.coli*
3.	3	M	*E.coli*
		C	*E.coli*
		P	-
4.	4	M	*E.coli*
		C	-
		P	*E.coli*

No.	Nth Collection Samples	Individual Code	Results of Identification of Bacteria in Proboscis Monkey Feces
5.	5	M	-
		C	*E.coli*
		P	*E.coli*
6.	6	M	-
		C	-
		P	-
7.	7	M	-
		C	-
		P	-
8.	8	M	-
		C	-
		P	-
9.	9	M	*E.coli*
		C	*E.coli*
		P	*E.coli*
10.	10	M	-
		C	-
		P	-
11.	11	M	-
		C	-
		P	-
12.	12	M	*E.coli*
		C	*E.coli*
		P	*E.coli*
13.	13	M	-
		C	-
		P	-
14.	14	M	-
		C	-
		P	-
15.	15	M	*E.coli*
		C	*E.coli*
		P	*E.coli*
16.	16	M	-
		C	-
		P	-
17.	17	M	-
		C	-
		P	-

Note: (-) = none

Tabel 3. Microscopic Test Results

Type of Bacteria	Isolated culture					Staining Gram	Biochemical test				
	Mac Conkey Agar	Blood Agar	DHL Agar	EMBA	NA		VP	MR	Indole	Citrate	Lactose
E.coli	+	-	+	+	+	Gram Negatif	-	+	+	-	+

Note: (+) = reacts/ changes occur
(-) = no change

The prevalence of *E.coli* bacteria identified was then calculated from the total amount of feces for each proboscis monkey Mimin (M), Chikita (C), and Pedro (P). The results of calculating the percentage prevalence of bacteria found in the feces of proboscis monkeys are presented in (**Table 4**).

Tabel 4. Prevalence of *E.coli* in Proboscis Monkey Feces

Type of Bacteria	Percentage of Bacteria in Mimin (M)	Percentage of Bacteria in Chikta (C)	Percentage of Bacteria in Pedro (P)
E.coli	41.17%	35.29%	35.29%

3.2. Discussion

Macroscopic observations include the characteristics of consistency, color, presence of blood, and mucus. The existence of this observation is intended as preliminary research to support microscopic observations, which are then carried out. According to Kasırga (2019), finding out the presence of diseases that occur in the digestive tract can be obtained from stool examination with several options, namely macroscopic and microscopic. Stool consistency was observed based on the provisions of the Fecal Consistency Score (FCS), with a score range of 1 (dry and hard stools) to 5 (watery diarrhea) (Ridwan & Batan, 2021). From all observations, Chikita's (C) feces showed normal stool consistency at a score of 2-2.5 with an oval and dense shape but not too dry and hard or soft so that it only left a few marks when lifted.

The consistency of Mimin's (M) and Pedro's (P) stools had a consistency score of 2.5-3.5, with the observation that there were generally oval stools but not completely oval, and the surface was quite moist. In addition, Mimin and Pedro's feces were excreted at level 3, which had a slightly denser, almost liquid form with a very moist surface. According to research by Mirsageri et al. (2015), macroscopic observations of feces show that the consistency of orangutan feces is soft to hard. Hard stool consistency is often found in orangutan puppies with a blackish-brown to yellowish-green color, while relatively soft stool consistency is found in adults. This research is directly proportional to the results of stool macroscopic observations conducted in this study. Judging from the age of the proboscis monkey Chikita is included in the category of juvenile proboscis monkeys or still in the process of reaching adulthood, similar to Mirsageri's research, which found hard feces in baby orangutans, while Pedro and Mimin's proboscis monkeys are in the category of mature probosci's monkeys with a relatively soft faecal texture. (soft) corresponds to macroscopic observations of relatively soft faeces in orangutans.

In addition, differences in the texture of the feces excreted by individual proboscis monkeys cannot be separated from the feed consumption, digestive metabolism, and eating habits of each observed proboscis monkey. The main feed is fresh green vegetables, namely kelakai, cassava leaves, kale, raw corn, and cassava. The proboscis monkeys are also given fruits such as unripe papayas, bananas, and milk in the afternoon. Giving food in the form of fresh vegetables and fruit is an effort to fulfill the nutrition in the form of protein, fat, and vitamins needed by adjusting their natural needs (Alkatiri, 2020). Giving corn to proboscis monkeys is in line with the statement of Sharafina (2017) in her research, which stated that giving corn can be a source of energy and fat for primate feed.

Feeding green vegetables to each proboscis monkey is given at least three bunches of vegetables of each type at three meals interspersed with tubers and fruits. The provision of these green vegetables contributes fiber to the process of food metabolism in the proboscis monkey's body at the Proboscis Monkey Rehabilitation Center. The presence of dietary fiber in the stool causes the stool to absorb more water so that the stool volume becomes large and has a soft texture. A large

volume of feces will accelerate intestinal contractions to pass water faster, so food transit time will be quick (Faidruz & Nisa, 2015).

Research by Kusumorini et al. (2014) found a difference in the texture of the feces of slow lorises, where the texture of the feces tends to be denser because slow lorises eat bananas more. In contrast, those who prefer papaya tend to be softer. From the results of observing the texture of the proboscis monkey stools studied, Mimin and Pedro's stools were more liquid and slightly denser because Mimin and Pedro ate fewer green vegetables and preferred fruit to eat. Meanwhile, Chikita eats anything with gusto.

From the texture of the excreted feces, all observations confirmed that the three proboscis monkeys did not experience constipation or difficulty defecating. The overall condition or texture of the stool is in the range of 2-3.5, where the water and moisture content on the stool's surface is still visible. *Constipation* is a reduction, loss, or difficulty defecating (Garcia-Pertierra et al., 2017). Constipation can be caused by dehydration due to a lack of water intake that enters the body (Watrous, 1983).

The color of the feces of all three proboscis monkeys is greenish, in line with the research by Mirsageri et al. (2015), which states that orangutan feces are yellowish green to black. The ingested feed can cause the presence of a different color in the physical proboscis feces. According to Lisana et al. (2015), feed digestibility is influenced by the content of nutrients in feed, especially crude fiber and lignin. Various green vegetables are given to the proboscis monkeys. Kalakai has a yellowish-green leaf color, while cassava leaves have a darker green color. Kale gives the same green as cassava leaves. In addition, pieces of corn, unripe bananas, and papaya give it a yellow color.

Observations in the field provide clues about where the feces produced will be brighter in color, such as light green or brownish yellow, when proboscis monkeys prefer to eat light green vegetables and fruit such as kalakai, bananas, papaya, and corn. Meanwhile, the feces are greenish when the food consumed mainly contains dark green leaves such as cassava and kalakai. Green or yellow-green food contains lots of spinach and other green vegetables. The laxative comes from vegetables. Food passes through the intestines quickly so that bile pigments have no time to oxidize (Faidruz & Nisa, 2015).

Apart from the type of leaves or fruit that is given, the behavior that is carried out because of each proboscis monkey's appetite also affects the excreted physical feces. Proboscis monkey eating behavior is caused by feed stimulation (environmental stimulation) and a need or hunger (internal stimulation) because the energy has been used for metabolism during rest or sleep. This stimulation from inside and outside the proboscis monkey's body will respond to the body's action of digesting food (Alikodra, 1993). Chikita has a stable appetite, where he will eat the food given when the time comes until the food runs out (Picture 3), while Mimin does not immediately eat the food given.

Mimin will look for the position where she usually eats and carefully sorts out the parts of the vegetables to be eaten (Picture 4). Besides this picky nature, Mimin often ignores food to watch over her child, Hanny. Pedro has a great appetite when it is time to eat but will occasionally drop his food (Plate 5). The feed given is usually eaten immediately on the spot or near the place where the feed is placed (Alikodra, 1993). With its multi-chambered stomach, the proboscis monkey digests natural food from various proportions of leaves and mostly unripe fruits/seeds (Matsuda et al., 2010).

In macroscopic observation of the feces of the three proboscis monkeys, no blood or mucus was found during the observation. These observations' results stated that the excreted feces were normal feces without mucus and blood. According to Widman (1995), mucus indicates irritation or inflammation of the intestinal wall. Meanwhile, the presence of blood in the stool may indicate acute inflammatory diarrhea (Zein et al., 2004)

Furthermore, the results of microscopic observations on seventeen stool samples from each proboscis monkey identified the presence of *Escherichia coli* (*E.coli*) bacteria. In general, these

bacteria are in the feces of proboscis monkeys Mimin (M), Chikita (C), and Pedro (P). The feces of the three proboscis monkeys indicated *E. coli* in the 2nd, 9th, 12th, and 15th collection samples. In contrast, other collection samples found it in one or two individuals until they were indicated in the entire collection samples. Samples of the 6th, 7th, 8th, 10th, 11th, 13th, 14th, 16th, and 17th collections did not find *E. coli* in the three proboscis monkeys.

E.coli bacteria are sequentially examined through microscopic stages, from bacterial culture and gram staining to being tested through biochemical testing. Bacterial culture or purification as an isolation step by growing colonies on certain media. Purification occurs until a colony grows separately or singly from the bacteria (Putri & Kusdiyantini, 2018). Positive results on MCA media (Mac Conkey agar) are indicated by the growth of round colonies accompanied by changes in the color of the media. These results are consistent with the observations of Bakri et al. (2015) stated that *E.coli* colonies grew on Mac Conkey media to appear round in shape, with flat edges and smooth surfaces with colony color. Mac Conkey agar media is a selective medium for isolating gram-negative bacteria with a media composition containing bile salts which can inhibit the growth of gram-positive bacteria (Amri et al., 2017) and lactose as a source of carbohydrates (Jawetz et al., 2013).

According to Champoux et al. (2004) production of acid formed in MCA media as a form of discoloration of bacterial colonies, which were initially pink due to neutral red absorbance due to a decrease in pH. This product proves lactose fermenting bacteria's success on MCA media. In addition, these bacteria can also form gas from fermented lactose (Jawetz et al., 2013). Loey et al. (2021) used Mac Conkey media in the feces of long-tailed monkeys with a positive result for *E.coli* bacteria.

The isolation medium for the subsequent bacterial culture is eosin methylene blue agar (EMBA). The positive results of *E.coli* in the study were seen from bacterial growth on the EMBA media with a change in color to shiny green. According to Rashid et al. (2020), *E.coli* bacteria on EMBA media have a characteristic that is metallic green in color with a flat surface, and there is a black spot in the middle of the colony. *E.coli* were also found in EMBA media from a study conducted by Loey et al. (2021) as a culture medium from long-tailed monkey feces. The metallic green color change in the EMBA media is because *E.coli* can ferment lactose, which increases the media's acid levels (Lal & Cheeptam, 2007).

The EMBA media used, according to Antony et al. (2016), is a selective and differential medium for growing *E.coli* bacteria. EMBA effectively grows gram-negative enteric bacteria and inhibits the growth of gram-positive bacteria, including yeast growth. This media contains methylene blue dye, which is toxic to microorganisms except for enteric bacteria. Research conducted by Rasyid et al. (2020) showed that the *E.coli* on this media were metallic green. This feature distinguishes *E.coli* from other enteric bacteria that grow on EMBA media.

Negative results were found in Blood agar media in the absence of *E.coli* colony growth capable of lysing erythrocytes in the media. The same result was also found in a study by Tivani et al. (2019) that *E. coli* cannot carry out hemolysis, characterized by no color change in the area near the bacterial colony. Blood Agar Plate (BAP) is a culture medium enriched with 5-10% sheep blood for cultivating selective organisms such as *Streptococcus* spp. (Cappucino & Sherman, 2014; Krihariyani et al., 2016).

Addition of blood to BAP media to determine the ability of particular microorganisms, especially *Streptococcu*s spp., in lysing erythrocytes (hemolysis) and classified into three hemolytic activities, namely gamma, alpha, and beta hemolysis (Collins et al., 1989; Cappucino & Sherman, 2013). McKane & Kandel (1998) stated that bacteria that can completely lyse erythrocytes by forming a clear zone are classified into β-hemolysis. In contrast, if the hemolysis area is not clear, accompanied by a change in the color of the media from greenish to brownish, it is grouped as α-hemolysis, and the gamma hemolysis group indicates no hemolysis.

The presence of *E.coli* bacteria on DHL agar was indicated by the presence of red colonies, which was consistent with the results of a study by Sato et al. (2020) that the isolation of bacteria

suspected of being *E. coli* was found to be characterized by pink colonies after being incubated for 24 hours at 37°C. Sakazaki et al. (1960) described DHL agar, also known as Deoxycholate Sulfide Lactose Agar, which contains a rich nitrogenous base to allow the growth of enteric bacteria, especially *Salmonella* and *Shigella* strains. The result of the differentiation of enteric bacterial colonies depends on lactose fermentation. Lactose fermenting bacteria produce acid and form pink to red-colored colonies, whereas non-lactose fermenting bacteria form colorless colonies. Most normal gut bacteria ferment lactose with red colonies, whereas *Salmonella* spp. and *Shigella* spp. can not ferment lactose (colorless colonies) (Sakazaki et al., 1971).

Furthermore, positive results in NA media were indicated by the presence of colonies on the surface of the media by Putri & Kusdiyantini's opinion (2018) that NA media is a non-selective medium so that all bacteria can grow. Pelczar et al. (2008) stated that NA media contains nutrients that support bacterial growth. These nutrients come from a nitrogen source, so this medium is commonly used as a standard medium for the growth of microorganisms in laboratory bacteriological procedures (Amri et al., 2017; Putri & Kusdiyantini, 2018). NA media in this study is a comparison medium for the growth of bacteria growing on Mac Conkey, EMBA, Blood agar, and DHL agar media which refers to Putri & Kusdiyantini's research (2018) using NA media as a comparison medium for the growth of bacteria growing on MRSA media.

The gram staining results at the microscopic stage showed that the observed bacteria were gram-negative with a red color and short rod shape. The same is in line with Darmawan (2017) that the pink color at the time of staining shows the characteristics of gram-negative and rod-shaped bacteria in general, which shows the characteristics of enteric bacteria. Gram staining was performed to confirm the shape of the bacteria and classify bacteria based on differences in response to the gram reaction on the physical and chemical properties of the cell wall (Bisen, 2014; Wibowo et al., 2016; Katon et al., 2020).

Putri & Kusdiyantini (2018) explained that the principle of gram staining is that gram-positive bacteria will absorb the color from the crystal violet solution so that it turns purple. Meanwhile, gram-negative bacteria will release a crystal violet solution after washing with alcohol and then absorb safranin so that it is red. This explanation refers to the results of observations of gram staining showing red-colored bacteria because bacteria have a thin cell wall, so they cannot hold crystal violet solutions. The observation results are strengthened by the opinion of Amri et al. (2017) gram-negative bacteria have a thin peptidoglycan layer and high enough permeability to release crystal violet substances quickly, and bacteria only absorb safranin. Gram-negative bacteria cannot retain crystal violet because of their cell walls' high lipid and protein content (Marzuki et al., 2014).

The final stage is to carry out biochemical testing. Biochemical tests were carried out to confirm previously obtained examination results (Rasyid et al., 2020). The test results were declared hostile in the VP (Voges-Proskauer) test because there was no change or formation of a red color on the surface of the test tube. These results suggest that *E. coli* cannot decompose glucose into acetoin but produces glucose which is in line with the research of Gunawan et al. (2022) that the negative results of *E.coli* in the VP test were because *E.coli* is a fecal group that cannot produce acetoin so that when KOH and alpha-naphthol are dropped, there will be no color change.

Escherichia coli in the MR test tested positive, with a change in the surface of the media becoming red that same with is consistent with the research by Gunawan et al. (2022) that the positive test for *E. coli* on MR media is with the formation of red color in the media. Methyl red, as a reagent (indicator) that is reacted with MR media, can detect acid products from the fermentation of glucose so that it forms a red color and lowers the pH of the media in an acidic environment (Hemraj et al., 2013).

Positive test results for *E.coli* on indole media were indicated by the presence of a red ring on the surface of the media, with the explanation from Darmayanti et al. (2015) that *Escherichia coli* produces tryptophanase enzymes to decompose tryptophan amino acids into indole compounds and utilize tryptophan as a carbon source. According to Anggraini et al. (2016), some bacteria can

produce tryptophane enzymes to catalyze the macromolecules of the amino acid tryptophan into pyruvic acid, ammonia, and indole. The red ring formed on indole media indicates the ability of the bacteria to degrade tryptophan. The indole product formed will react with Kovac's reagent to form a red ring (Hemraj et al., 2013).

E.coli was declared hostile on the citrate test results with no color change in the citrate medium. According to Pastra et al. (2012), *Escherichia coli* does not utilize citrate as a carbon source. Citrate media is used to differentiate enteric bacteria as a carbon source, with the media composition containing bromothymol blue as an indicator of a green-to-blue color change in the media (Hemraj et al., 2013). In addition, the positive test results for *E. coli* on the glucose test are known by the presence of bubbles that appear in the test tube, which follows the statement of Hemraj et al. (2013) that the presence of air bubbles in the Durham tube is the result of carbohydrate fermentation. The lactose test was carried out in the same way as the glucose test where according to Nurhidayati et al. (2015), a glucose test was carried out to determine which bacteria are capable of fermenting glucose with a positive test result that will cause bubbles in the Durham tube which indicates the formation of gas while no bubbles indicate a negative result.

The characteristics of *E.coli* in the reference book stated positive results on Mac Conkey agar media, indol test, MR test, and lactose test, while negative results on the VP test and citrate test. The presence of these characteristics is consistent with existing microscopic tests. *Escherichia coli* is a bacterial species of the genus *Escherichia* and the family of Enterobacteriaceae (Cowan & Steel, 1993). Jawetz et al. (2008) stated that the Enterobacteriaceae family is a gram-negative rod that is short and has a distinctive morphology, but the morphology varies significantly in each species. The classification of E.coli is as follows.

Classification of *E.coli*, according to Songer & Post (2006), is as follows:

Kingdom : Bacteria
Phylum : Proteobacteria
Class : Gamma Proteobacteria
Order : Enterobacteriales
Family : Enterobacteriaceae
Genus : *Escherichia*
Species : *Escherichia coli* (*E.coli*)

The prevalence or level of presence of *E.coli* in each sample of proboscis monkey stools Mimin (M), Chikita (C), and Pedro (P) were sequentially 41.17%, 35.29%, and 35.29%. According to Isnawati (2012), the high percentage of presence is due to *Escherichia* bacteria, usually present in the digestive organs of humans and animals. The high *E. coli* bacteria can protect the proboscis monkey's digestion from pathogenic bacteria because pathogenic bacteria are unable to compete with normal bacteria in the digestive tract, such as the genus *Escherichia* and lactic acid bacteria (LAB) (Supardi & Sukanto, 1999).

Escherichia coli is a commensal bacteria or normal microflora in warm-blooded animals and humans' peritoneum or lower intestine (Elliot et al., 2013). The intestinal microflora is a term for microorganisms commonly found living in the digestive tract and beneficial to the host (Salminen & Wright, 1993). *E. coli* becomes a pathogen if the number increases beyond normal or is outside the intestine. These bacteria can be spread through water contaminated with feces or urine from animals suffering from digestive infections so that they can be transmitted to other animals (Amri et al., 2017).

Infections that arise in the digestive tract due to the attack of *E.coli* bacteria on the intestinal wall cause movement of intestinal fluids in the large intestine and can damage the electrolyte balance in the mucous membrane and then can cause reduced water absorption in the intestinal wall and diarrhea (Soeliongan et al., 2013). Some strains produce enterotoxins and virulence factors to invade tissues and can cause diarrhea (Bergey's Manual, 1994). Pathogenic *E.coli* pathogens in animals that can cause diarrhea include enterotoxigenic *E.coli* (ETEC),

enteropathogenic *E.coli* (EPEC), Shiga toxin (stx) producing *E.coli* (STEC), and extraintestinal pathogenic *E.coli* (EIEC). (Gyles & Fairbrother, 2010).

Several researchers have previously researched the presence of bacteria in primate feces. Wibowo et al. (2016) tested orangutan feces from the BOS Foundation and successfully identified a type of bacteria, *Escherichia coli.* In addition, Rahmi et al. (2014) also reported the results of monitoring the feces of releasing orangutans at the Pinus Jantho Nature Reserve, Aceh, and it was known from the monitoring results that *Salmonella* sp., *Shigella* sp., and *E.coli* bacteria were identified. Research on feces of long-tailed monkeys by Loe et al. (2021) at the Bogor Agricultural Institute Captive Facility in Dramaga succeeded in isolating and identifying 100% *E.coli* bacteria (30/30), *Salmonella* sp. 97% (29/30), and *Shigella* sp. 60% (18/30).

The feces examined macroscopically and microscopically are expected to illustrate the digestion of proboscis monkeys in rehabilitation centers that are in good condition. The existence of proboscis monkeys in rescue center is continuously maintained to avoid digestive diseases by paying attention to the cleanliness of the cage as a place to live and the quality of food provided as well as routine checks by veterinarians (Wibowo et al., 2016; Amri et al., 2017).

Rahmi et al. (2014) stated that orangutans in rehabilitation have difficulty finding food because, at the training level, it causes orangutans to pick up leftover food that has fallen and is contaminated with feces. Individual proboscis monkeys also carry out the activity of picking up leftover food at the Bekantan Rescue Center Sahabat Bekantan Indonesia Foundation. Hence, the keepers need to pay attention to the cage's cleanliness daily to minimize any leftover food the proboscis monkeys can take. Wibowo et al. (2016) suggested that washing the cage floor with disinfection is vital to reduce disease-causing pathogens. The analysis in this study is expected to be used as material for further evaluation in supporting the sustainability of proboscis monkey conservation.

4. CONCLUSIONS

The bacteria identified from 17 stool samples from each proboscis monkey Mimin, Chikita, and Pedro were *Escherichia coli*. The prevalence or level of presence of *E. coli* in the proboscis monkey stool samples Mimin, Chikita, and Pedro were sequentially 41.17%, 35.29%, and 35.29%.

5. ACKNOWLEDGMENTS

This study was financially supported by Grant from Lambung Mangkurat University, namely Program Dosen Wajib Meneliti (PDWM) 2022 No. 025.51/UN8.2/PL/2022. The authors are grateful to staff of Sahabat Bekantan Indonesia Foundation for the technical assistance during observation.

6. REFERENCES

Alikodra, H. S. 1993. *Pengelolaan Satwa Liar*. Yayasan Penerbit Fakultas Kehutanan. Institut Pertanian Bogor, Bogor.

Alkatiri, A. B. 2020. *Perilaku Makan dan Status Gizi Siamang (Symphalangus syndactylus* Raffles*, 1821) di Pusat Penyelamatan Satwa Tegal Alur, Jakarta.* Skripsi. Universitas Islam Negeri Syarif Hidayatullah, Jakarta.

Amri, F., Sayuti, A., & Darniati. 2017. Isolasi dan Identifikasi Bakteri Enterik pada Feses Gajah Sumatera (*Elephas maximus sumatranus*) di Pusat Konservasi Gajah (PKG) Saree Aceh Besar. *JIMVET* 1(3): 305-315.

Antony, A. C., Paul, M. K., Silvester, R., Aneesa, P. A., Suresh, K., Divya, P. S., Paul, S., Fathima, P. A., & Abdulla, M. H. 2016. Comparative Evaluation of EMB Agar and Hicrome *E.coli* Agar for Differentiation of Green Metallic Sheen Producing Non *E.coli* and Typical *E.coli* Colonies from Food and Enviromental Samples. *Journal of Pure and Aplied Microbiology* 10(4).

Bakri, Z., Hatta, M., & Massi, M. N. 2015. Deteksi Keberadaan Bakteri *Escherichia coli* O157:H7 pada Feses Penderita Diare dengan Metode Kultur dan PCR. *JST Kesehatan* 5(2): 184-192.

Bergey's Manual Determinative Bacteriology. 1994. *Facultatively Anaerobic Gram-Negative Rods.* 9th edition. Holt, J. G., et al., Williams & Wilkins, 423, East Preston Street, Baltomore, Maryland, USA.

Bisen, P. S. 2014. *Microbial Staining*. Jiwajy University, New Delhi.

Cappuccino, J. G., & Sherman, N. 2013. *Manual Laboratorium Biologi*. EGC, Jakarta.

Cappuccino, J. G., & Sherman, N. 2014. *Microbiology a Laboratory Manual*. 10th Ed. Pearson Education, Inc, San Fransisco.

Champoux, J. J., Neidhardt, F. C., Drew, W. L., & Ploride, J. J. 2004. *Enterobacteriaceae in Pathogenic Bacteria*. McDraw-Hill, New York.

Collins, C. H., Lyne, P. M., & Grange, J. M. 1989. *Collins and Lyne's Microbiological Methods.* Butterwotrhs, London.

Collison, K. S., Maqbool, Z. M., Inglis, A. L., Makhoul N. J., Saleh, S. M., & Bakheet, R. H. 2010. Effect of Dietary Monosodium Glutamate on HFC S-Induced Hepatic Steatosis: Expression Profile in the Liver and Visceral Fat. *Obesity (Silver Spring)* 18: 1122-1134.

Cowan, S. T., & Steel, K. J. 1993. *Manual for the Identification of Medical Bacteria*. 3rd Ed. Cambridge University Press, New York.

Darmawan, A. 2017. *Identifikasi Bakteri Salmonella sp. pada Daging Ayam yang Dijual di Pasar Tradisional Makassar*. Skripsi. Universitas Hasanuddin, Makassar.

Elliot, T., Worthington, T., Osman, H., & Gill, M. 2013. *Mikrobiologi Kedokteran dan Infeksi*. Edisi Ke-4. EGC, Jakarta.

Faidruz, A., & Nisa, K. 2015. Pengaruh Serat Pangan terhadap Kadar Kolesterol Penderita Overweight. *Majority* 4(8): 121-126.

Garcia-Pertierra, S., Gonzales-Gasch, E., Puyoi, C. C. P., & Boixeda, J. M. C. 2017. Dynamic Chronic Rectal Obstruction Causing a Severe Colonic Dilatation in a Cat. *Journal of Feline Medicine and Surgery Open Reports* 3(2): 1-5.

Gunawan, Kholik, & Agustin, A. L. D. 2022. Profil Uji Biokimia Hasil Isolasi *Escherichia coli* pada Feses, Air Minum, dan Air Saluran Buangan Kandang Sapi Bali di Kelompok Tani Ternak Menemeng (KT2M) Kabupaten Lombok Tengah. *Mandalika Veterinary Journal* 2(1): 26-36.

Gyles, C. L., & Fairbrother, J. M. 2010. *Escherichia coli*, dalam: Gyles C. L., Presscott, J. F., Songer, G., & Thoen, C.O. *Pathogenesis of Bacterial Infections in Animals*. Edisi ke-4. Blackwell Pub, Iowa.

Hemraj, V., Diksha, S., & Avneet, G. 2013. A Review on Commonly Used Biochemical Test for Bacteria. *Innovare Journal of Life Sciences* 1(1): 1-7.

Isnawati. 2012. Hubungan Higiene Sanitasi Keberadaan Bakteri *Coliform* dalam Es Jeruk di Warung Makan Kelurahan Tembalang Semarang. *J. Kesehatan Masyarakat* 1(2): 1005-1017.

IUCN. 2023. *The IUCN Red List of Threatened Species*. Version 2022-2. https://www.iucnredlist.org (diakses tanggal 3 Februari 2023).

Jawetz, Melnick., & Adelberg. 2008. *Mikrobiologi Kedokteran.* Edisi Ke-23. EGC, Jakarta.

Jawetz, Melnick., & Adelberg. 2013. *Normal Flora of the Intestinal Tract in Normal Microbial Flora of the Human Body*. McDraw-Hill, New York.

Kartono, A. P., Ginting, A., & Santoso, N. 2008. Karakteristik Habitat dan Wilayah Jelajah Bekantan di Hutan Mangrove Desa Nipah Panjang, Kecamatan Batu Ampar, Kabupaten Kubu Raya Provinsi Kalimantan Barat. *Media Konservasi* 13(3):1-6.

Katon, M. R., Solichin, A., & Jati, O. E. 2020. Analisis Pendugaan Bakteri *Escherichia coli* pada Kerang Hijau (*Perna viridis*) di Morosari, Demak. *Journal of Maquares* 9(1): 40-46.

Kasırga, E. 2019. The Importance of Stool Tests in Diagnosis and Follow-Up of Gastrointestinal Disorders in Children. *Turkish Archives of Pediatrics/Türk Pediatri Arşivi* 54(3): 141-148.

Klaus, A., Strube, C., Röper, K., Radespiel, U., Schaarschmidt, F., Goossens, B., & Zimmermann, E. 2018. Fecal Parasite Risk in the Endangered Proboscis Monkey is Higher in an Anthropogenically Managed Forest Environment Compared to a Riparian Rain Forest in Sabah, Borneo. *PLoS One* 13(4).

Krihariyani, D., Woelansari, D.E., & Kurniawan, E. 2016. Pola Pertumbuhan *Staphylococcus aureus* pada Media Agar Darah Manusia Golongan O, AB, dan Darah Domba sebagai Kontrol. *Jurnal Ilmu dan Teknologi Kesehatan* 3(2): 191-200.

Lal, A., & Cheeptham, N. 2007. *Eosin Methylene Blue Agar Plates Protocol*. American Society for Microbiology, Washington.

Loe, F. R., Tomongo, S., Saepuloh, U., Sajuthi, D., & Suparto. I. H. 2021. Prevalensi dan Kepekaan Bakteri Enteropatogen terhadap Antibiotik pada Monyet Ekor Panjang dengan Diare di Fasiltitas Penangkaran Institut Pertanian Bogor di Dramaga. *Jurnal Veteriner* 22(4): 523-530.

Lisana, S. A., Dhalika, T., & Hidayat, R. 2015. Pengaruh Umur Pemotongan Tanaman Rami (*Boehmeria nivea*) terhadap Kecernaan Bahan Kering dan Bahan Organik (*In Vitro*). *Prosiding Seminar Nasional Peternakan Berkelanjutan 7*, Sumedang Indonesia, 423-429.

Marzuki, I., Noor, A., Nafie, N. L., & Djide, M. N. 2014. Isolasi dan Identifikasi Bakteri Shimbion Spons Penghasil Enzim Amilase Asal Pantai Melawai Balikpapan. *Jurnal Ilmiah "dr. Aloei Saboe*" 1(2): 11-18.

Matsuda, I., Tuuga, A., & Higashi, S. 2010. Effects of Water Level on Sleeping-Site Selection and Inter-Group Association in Proboscis Monkeys: Why Do They Sleep Alone Inland on Flooded Days?. *Ecological Research* 25: 475-482.

McKane, L., & Kandel, J. 1998. *Microbiology, Essentials and Applications*. 2nd ed. McGraw-Hill, Philadelphia.

Meijaard, E., & Nijman, V. 2000. Distribution and Conservation of the Proboscis Monkey (*Nasalis larvatus)* in Kalimantan, Indonesia. *Biological Conservation* 92: 15-24.

Mirsageri, M., Umi, M. J. A., Risa, T. C., & Zulfiqri. 2015. Endoparasit Cacing pada Orangutan *Ex-Captive* di Suaka Margasatwa Sungai Lamandau Kalimantan Tengah Indonesia. *Jurnal Kedokteran Hewan* 9(1): 67-70.

Moxham, G. 2001. Waltham Feces Scoring System-a Tool for Veterinarians and Pet Owners: How does Your Pet Rate?. *Waltham Focus* 1: 24-25.

Nurhidayati, S., Faturahman, & Ghazali, M. 2015. Deteksi Bakteri Patogen yang Berasosiasi dengan *Kappaphycus alvarezii* (Doty) Bergejala Penyakit Ice-Ice. *Jurnal Sains Teknologi & Lingkungan* 1(2): 24-30.

Pastra, D. A., Melki, & Surbakti, H. 2012. Penapisan Bakteri yang Bersimbiosis dengan Spons Jenis *Aplysina* sp. sebagai Penghasil Antibakteri dari Perairan Pulau Tegal Lampung. *Maspari Journal* 4(1): 77-82.

[Pemerintah RI] Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia. 2018. P.20/MENLHK/SETJEN/KUM.1/6/2018 Tentang Jenis Tumbuhan dan Satwa yang Dilindungi.

Pramono, S. 2021. *Identifikasi Bakteri Fermentatif Asam Laktat Feses Bekantan (Nasalis larvatus), Primata Endemik Kalimantan.* Skripsi. Fakultas Kedokteran Hewan Institut Pertanian Bogor, Bogor.

Pelczar, M. C., Chan, E. C. S., & Krieg, N. R. 2008. *Microbiology Concepts and Applications*. McGraw-Hill, Inc., New York.

Putri, A. L. O., & Kusdiyantini, E. 2018. Isolasi dan Identifikasi Bakteri Asam Laktat dari Pangan Fermentasi Berbasis Ikan (Inasua) yang Diperjualbelikan di Maluku-Indonesia. *Jurnal Biologi Tropika* 1(2): 6-12.

Rahmi, E., Agustina, D., & Jamin, F. 2014. Isolasi dan Identifikasi Genus *Salmonella* dan *Shigella* dari Feses Orangutan Sumatera (*Pongo abelii*) di Pusat Reintroduksi Orangutan Jantho. *Jurnal Medika Veterinaria* 8: 5-8.

Rasyid, B., Karta, I. W., Sari, N. L. P. E. K., & Putra, I. G. N D. 2020. Identifikasi Gen Penyandi Protein Transport Sebagai Kandidat Vaksin Subunit terhadap Bakteri *Escherichia coli* Penyebab Diare Wisatawan. *Jurnal Sains dan Teknologi* 9(1): 47-57.

Ridwan, I. A., & Batan, I. W. 2021. Laporan Kasus: Keberhasilan Penanganan Kasus Konstipasi pada Kucing Lokal dengan Imbuhan Labu Kuning (*Cucurbita moschatta*) pada Pakannya. *Indonesia Medicus Veterinus* 10(4): 673-689.

Safitri, E., Hidayati, N.A., & Hertati, R. 2019. Prevalensi Bakteri *Salmonella* pada Ayam Potong yang Dijual di Pasar Tradisional Pangkal Pinang. *Ekotonia: Jurnal Penelitian Biologi, Botani, Zoologi dan Mikrobiologi* 4(1): 25-30.

Sakazaki, R., Namioka, S., Osada, A., & Yamada, C. A. 1960. A Problem on the Pathogenic Role of Citrobacter of Enteric Bacteria. *J. Ex. Med* 30: 13-22.

Sakazaki, R., Tamura, K., Prescott, L. M., Benzic, Z., Sanyal, S. C., & Sinha, R. 1971. Bacteriological Examination of Diarrheal Stools in Calcutta. *J. Med. Res* 59: 1025-1034.

Salminen, S., & Wright, A V. 1993. *Lactic Acid Bacteria.* Marcel Dekker, Inc., New York.

Santoso, H. B., Hidayaturrahmah, & Rizki, A. 2019. *Kecernaan Makanan Bekantan (Nasalis larvatus) di Wilayah Rehabilitasi dan Konservasi Eks-situ Yayasan Sahabat Bekantan Indonesia Banjarmasin.* Laporan Penelitian DIPA FMIPA ULM. Universitas Lambung Mangkurat, Banjarmasin.

Sato, W., Sukmawinata, E., Uemura, R., Kanda, T., Kusano, K., Kambayashi, Y., Sato, T., Ishikawa, Y., Toya, R., & Sueyoshi, M. 2020. Antimicrobial Resistance Profiles and Phylogenetic Groups of *Escherichia coli* Isolated from Healthy Throughbred Racehorses in Japan. *J. Equine Sci* 31(4): 85-91.

Sharafina D. 2017. *Manajemen Pakan dan Perilaku Siamang (Symphalangus syndactylus) di Taman Satwa Taru Jurug, Surakarta.* Skripsi. Institut Pertanian Bogor, Bogor.

Soeliongan, D., Rares, F., & Waworuntu, O. 2013. Identifikasi Bakteri Aerob Patogen yang Diisolasi dari Kue Siap Saji yang Dijual di Pasar Tradisional di Kota Manado. *Jurnal e-Biomedik (eBM)* 1(3): 1106-1108.

Songer, J. G., & Post, K. W. 2005. *Veterinary Microbiology: Bacterial and Fungal Agents of Animal Diseases*. Elsevier Saunders, Missouri, USA.

Srimulyaningsih, R., & Syaputra, M. 2021. Struktur Populasi Bekantan (*Nasalis larvatus*) di Rawa Gelam. *Jurnal Belantara* 4(1): 48-55.

Supardi, I., & Sukanto. 1999. *Mikrobiologi dalam Pengolahan dan Keamanan Pangan*. Yayasan Adikarya Ikapi, Bandung.

Tivani, I., Amananti, W., & Sunardi, A. 2019. Uji Identifikasi Bakteri *Escherichia coli* pada Jamu Gendong Kunyit Asem di Kabupaten Tegal. *Parapemikir: Jurnal Ilmiah Farmasi* 8(1):31-35.

Virgi, C. A. C. 2016. *Isolasi dan Identifikasi Bakteri pada Kasus Diare Dua Orangutan Kalimantan (Pongo pygmaeus) Asal Konservasi Alam Yogyakarta dan Asal Borneo Orangutan Survival dan Uji Sensitivitas Terhadap Beberapa Antibiotik.* Skripsi. Universitas Gadjah Mada, Yogyakarta.

Wahyuni, T. 1999. *Bakteri Enteropatogen pada Monyet Ekor Panjang (Macaca fascicularis): Tingkat Keterpaparan dan Pola Kepekaannya terhadap Antibiotik.* Tesis. Institut Pertanian Bogor, Bogor.

Watrous, B. J. 1983. *Esophageal Disease. in: Textbook of Veterinary Internal Medicine, Disease of the Dog and Cat*. W. B. Saunders, Philadelphia.

Wibowo, M. H., Rosetyadewi, A. W., Wijayanti, A. D., & Airin, C. M. 2016. Isolasi dan Identifikasi Bakteri dari Tinja Orangutan Penderita Gangguan Gastrointestinal. *Jurnal Veteriner* 17(1): 7-15.

Widman, F. K. 1995. *Tinjauan Klinis atas Hasil pemeriksaan Laboratorium*. Kedokteran EGC, Jakarta.

Zein, U., Sagala, K. H., & Ginting, J. 2004. Diare Akut Disebabkan Bakteri. *Jurnal e-USU Repository* 1-15.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Phylogeny of Parasitic Hemiptera Using *Multivariate Statistical Package* Cluster Analysis

Dwi Setyo Astuti*[1], Murwanto Setyo Nugroho[2]
[1]Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
[2]Darul Arqom Junior High School, Tulung Klaten, Jawa Tengah
*Corresponding Author, E-mail address: dsa122@ums.ac.id

KEYWORDS:
Hemiptera
Phylogeny
Cluster Analysis
MVSP

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Hemiptera is an Insecta with the characteristic of the forewing which has been modified as a "hemelitron", namely half of the part at the base is thickened, while the rest is structured like a membrane, and the hind wing is like a thin membrane. Most of Hemiptera are parasite that attack rice plants. The purpose of this study was to determine the kinship of Hemiptera parasite species in rice fields in the Tulung area, Klaten , Central Java. The data obtained in this study is the identification of Hemiptera based on 30 morphological characters. Data analysis carried out using cluster analysis with MVSP (Multivariate Statistical Package) software. The results showed that there were 9 species of Hemiptera as parasitic species namely Gerris lacusticus, Narvesus carolinensis, Dysdercus cingulatus, Leptoglossus clypealis, Triatoma sanguisuga, Arilus cristatus, Thyanta custator, Padops cinctipes and Boisea trivittata. The most closely related species is Narvesus carolinensis and Arilus cristatus, yes, with a similarity rate of 86.9%. While the species that have the most distant kinship are Narvesus carolinensis and Gerris lacusticus that is equal to 60.4%. The high degree of similarity indicates a close relationship between parasite species.

1. INTRODUCTION

Insect is object important thing to learn Because is destructive pests _ crops in agricultural areas and constitutes organism with amount the largest species that is about 91% of species arthropods or about 72% of whole species known animal. (Menta & Remelli, 2020) Frequent insects _ damage plant is group class Hexapods. Insect Hexapods have characteristic typical, that is own six legs. Type This own a number of order types , among others are : Diptera , Coleoptera , Lepidoptera , Orthoptera and Hemiptera (Li et al., 2019b).

Hey means " half " and pteron means " wing ". class insects included _ to in this order own wing experiencing future _ modification as a " hemelitron ", ie half part in the area base thick, meanwhile the rest structured like membranes, and wings behind similar thin membrane (membrane). That name given Because insect of this order own wing front that part the base hard like skin, however part the back is thin like membrane. Insect the Hemiptera group ever to invade the rice fields in the district Delanggu , Karanganom , Wonosari , Juwiring and Trucuk in 2011. Explosion _ Hemiptera pests are caused by several factors, factors main contributor _ to increasing several Hemiptera populations and attacks year final This is potency high biotic Hemiptera, factor abiotic and systems cultivation supporting paddy _ development Hemiptera population (Radhy, 2011).

There are several techniques that can used For know lift phylogeny between species among them is with count manually using _ formula index similarity Sorensen or also can done with use application *Multivariate Statistical Package*(Vidovic, n.d.). *The Multivariate Statistical Package* is an application that is often used by biologists, especially those who focus on taxonomy. MVSP is an analysis program strong multivariate _ For compatible with a PC that does various cluster and dendogram analysis. MVSP is used on hundreds of sites and more from 50 countries. Application This give the easy way For analyze data across a wide range field start from taxonomy, ecology, geology, sociology, genetics, and systematics MVSP fits perfectly used For know level density between species after species the identified especially formerly (Giribet & Edgecombe, 2019).

Characteristic typical main insect Hemiptera members are structure shaped mouth _ like needles. They use structure mouth This For stab network from eat it and then suck fluid in it. Hemiptera Alone is omnivore meaning _ they consume almost all type food start from fluid plants, seeds , insects else , until animals small like fish (Lytle, 2015). The process of morphological identification is to make observations details start from characteristic general until characteristic Specific Which owned every species. Activity identification can done with helpkey terminated nor without key terminated. Identification withthe help of the termination key will deliver the observed species to to taxon each, start taxon highest until Lowest,that is start *phyllum* until with species. As for identification withouthelp key determination still can done with objective For know percentage kinship between species in One level taxon, both class, order, family, or genus (Lee et al., 2019). Techniques to determine the level of kinship of species in an area taxon level, can done with various method, among them through tree phylogeny, cladogram, cladistic, And dendogram. Tree phylogeny, cladistic, and cladogram describe kinship relationships something species with grandma ancestor Which related with history evolution. As for dendogram is diagram which describes degree of closeness or kinship of the indicated species group with magnitude percentage (Edgecombe, 2020). Magnitude percentage Which obtained based on results calculation through comparison character morphology Which owned each species. There are several techniques that can used For know lift kinship between species among them is with count manually using _ formula index similarity Sorensen or also can done with use application *Multivariate Statistical Package*(Vidovic, n.d.).

The Multivariate Statistical Package is an application that is often used by biologists, especially those who focus on taxonomy. MVSP is an analysis program strong multivariate _ For compatible with a PC that does various cluster and dendogram analysis. MVSP is used on hundreds of sites and more from 50 countries. Analysis results using MVSP has published in various journals, including *Science, Nature, Ecology, Journal of Petroleum Geology,* and Journal *of Biogeography.* Application This give the easy way For analyze data across a wide range field start from taxonomy, ecology, geology, sociology, genetics, and systematics. MVSP fits perfectly used For know level density between species after species the identified especially formerly (Giribet & Edgecombe, 2019).Study about cluster analysis using MVSP yet Lots used, especially For know level Hemiptera kinship plays a role as pests on plants rice The purpose of this study is to determine the degree of kinship of the parasitic Hemiptera that attacks the rice fields in Majegan Distik, Tulung, Klaten..

2. MATERIALS AND METHODS

2.1. Ditermine Species

Determine species results catch Which will in count his kinship from the order Hemiptera as pest of plant, consisting from family Gerridae , Reduviidae , Pentatomidae , Coreidea , Rhopalidae , Rudiviidae , Pyrrhocoridae , Pentadomidae , Reduvidae , and Pyrhocoridae.

2.1.1. Determine the sampling point at the location

Sampling was carried out at 5 points covering the largest rice fields in 5 areas, including Klirong, Klalung, Daden, Sanggrahan, and Nandan.

2.1.1.1. Sub sub-chapters

The formulas used in the data calculation are written using the equation editor or other standard applications. Formulas shall may not be in the form of images or screen capture results from other sources. The formula is written by including the source of reference.

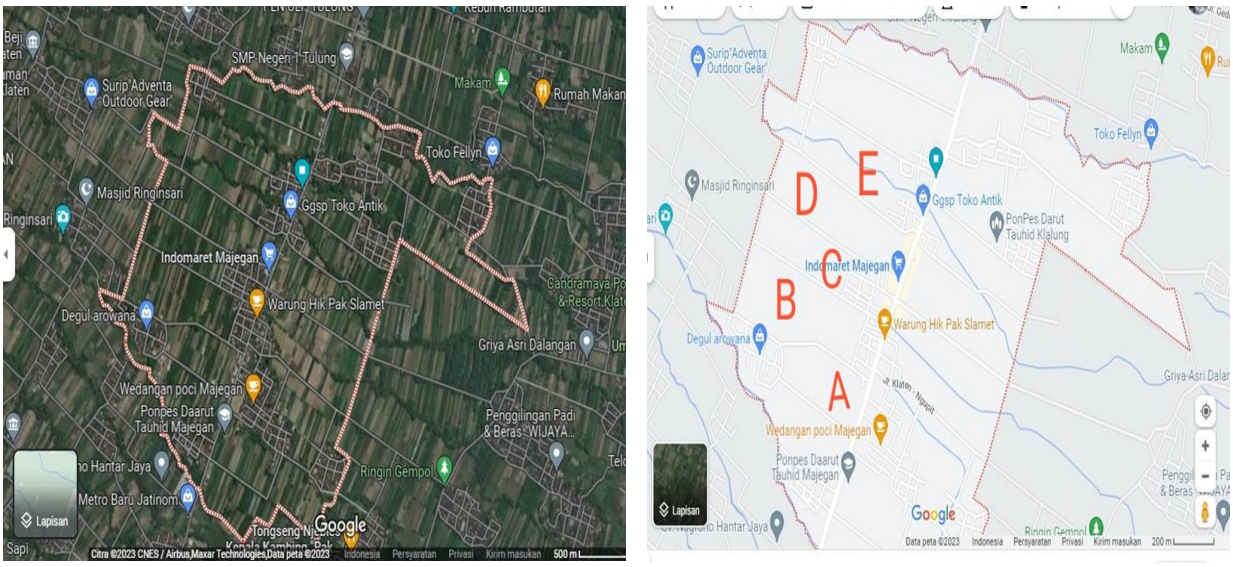


Figure 1. Hemiptera species sampling points

Description :

A = Rice field area of Klirong
B = Rice field area of Klalung
C = Rice field area of Daden
D = Rice field area of Sanggrahan
E = Paddy field area of Nadan

2.1.1.2. *Identifying Species*

After determine species Which will counted level kinship, Then determine character morphology Which will made base identification. Identification done withhelp insect determinant key and Boror

2.1.1.3. Kinship Analysis

Analysis kinship using MVSP (*Multivariate Statistical Package) software*. The data obtained through this application are the percentage of kinship levels between Hemiptera species and the dendogram which shows the kinship clusters between species.

3. RESULTS AND DISCUSSION

3.1. Identification of Species

Morphological identification was carried out based on 30 specific characters of Hemiptera. Some families of Hemiptera are parasitic, including Gerridae, Reduviidae, Pentatomidae,

Coreidea, Rhopalidae, Rudiviidae, Pyrrhocoridae, Pentadomidae, Reduvidae, and Pyrhocoridae. There are 9 species from this family that have been identified in table 1 below.

Table 1. Identified Species of Hemiptera

No	Species Code	Species Name	Family
1	A	*Gerris lacusticus*	Gerridae
2	B	*Leptoglossus clypealis*	Coreidea
3	C	*Dysdercus cingulatus*	Pyrrhocoridae
4	D	*Narvesus carolinensis*	Reduviidae
5	E	*Triatoma sanguisuga*	Reduvidae
6	F	*Arilus cristatus*	Rudiviidae
7	G	*Thyanta custator*	Pentatomidae
8	H	*Padops cinctipes*	Pyrhocoridae
9	I	*Boisea trivittata*	Rhopalidae

3.1.1. Cluster Analysis And Dendogram

MVSP (*Multi-Variate Statistical Package*) is Popular multivariate analysis *software* is a program that allows calculations from index kinship between species. MVSP is a statistical program for the best statistical analysis, not only for its analytical capabilities, but also for ease of use for presenting data and checking kinship assumptions in a biodiversity (Ogasawara & Kon, 2021). There are various methods of data analysis. One way is to use the Bray Curtis method. Bray Curtis distance, or commonly called Sorensen distance is a normalization method that is widely used in botany, ecology, taxonomy , and systematics to measure differences. In the Bray Curtis method, the number 0 indicates an identical similarity and the number 1 indicates a very absolute difference between the species being compared(Bhargava & Yablonovitch, 2015). Contrary to Bray Curtis, the Jaccard method is used to analyze the kinship between species based on their similarities. The inventor of this method is Paul Jaccard. The highest score in the Jaccard analysis is 1 which means the specimens being compared are identical and the lowest is 0 which means the specimens have nothing in common (Vidovic, n.d.).

Table 2. Cluster Analysis of Parasite Hemiptera

Node	Group 1	Group 2	Simil. (%)
1	D	F	86.957
2	C	E	86.364
3	Node 2	G	83.721
4	Node 1	H	79.545
5	Node 3	I	75.502
6	B	Node 5	70.826
7	A	Node 4	66.140
8	Node 7	Node 6	60.458

The results of the cluster analysis showed that the 9 species of Hemiptera were divided into 2 different groups. Species D and F show the highest similarity and it can be interpreted that the two are closely related. The lowest degree of similarity is between species at node 7 and node 8, which are independent of each cluster. Node 7 is represented by species B while node 8 is represented by species A. Thus the most distantly related species are species B and A. To draw

conclusions about phylogeny, systematicians must gather information on the morphology, genes, and biochemistry ofrelevant organisms. It's important to focus on traits which are the result of a common ancestor, because they are just traits here's what reflect connection evolutionary (Song et al., 2019)

Helden & Leather (2004), stated that stated that Partially big distribution kingdom animal most based on morphology, physiology, And pattern development. Symmetry, metamer, development caelom, and the type of cleavage in the egg is widely discussed as a basis determine kinship. Dendrograms is a tree-shaped diagram showing the degrees of equality in between members something group creature life (Vidovic, n.d., 2020). Clustering hierarchies build a cluster hierarchy or in other words a cluster tree, which is also known as a dendrogram. Each cluster node contain clusters child; clusters you Which share point Which covered by the parent they (Montgomery et al., 2020).

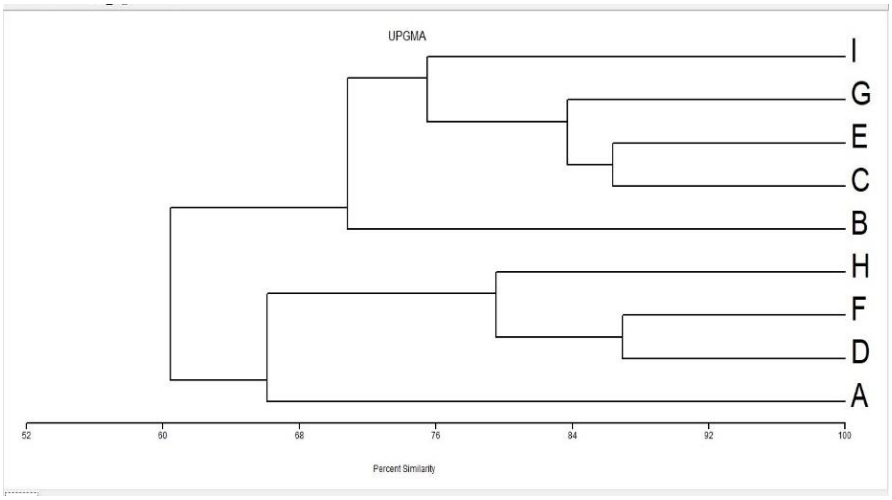


Figure 1. Dendogram

The closest relatives are *Narvesus carolinensis* and *Arilus cristatus*, with a similarity rate of 86.9%. The life cycle of *Narvesus* carolinensis is about 35-56 days. Usually these insects are active in the morning and evening. During the day they usually hide under plants or grass. What is unique about walang sangit is that when disturbed it will emit a distinctive odor ('scorching' smell). The population density of the stink bug will usually increase when the plants are in bloom, the weather is warm and drizzling (on the other hand, heavy rains can reduce the population). This insect usually attacks the milk-ripe rice by sucking the liquid of the rice seeds. The puncture mark will be a dark spot. Rice that is attacked by stink bugs will decrease in weight and even become empty. *Arilus cristatus* usually measures 1-1.25 inches. This species includes a powerful killer. It has long legs, antennae, a stubby beak with large eyes, a slender head.

Figure 2. *Narvesus carolinensis*

Figure 3. *Arilus cristatus*

While the species that have the most distant kinship are *Narvesus carolinensis* and *Gerris lacusticus* with 60.4%. *Gerris lacusticus* is a group of predatory insects which all belong to the Gerridae tribe. Its members, about 340 species, many of which are difficult to distinguish. In literature it is also known erroneously as the "water spider", although it is not a spider at all. The name "anggang-anggang" itself comes from its movement back and forth while floating.

Figure 5. *Gerris lacusticus*

This insect is very easy to recognize because of its habit of always walking/jumping on the surface of the water. Movement is fast, can reach 1.5 m/s. Most live in calm waters, but there are five species (from the genus Halobates) that are known to live on the surface of the ocean. From the surface of the water, the algae target prey (usually other insects) that are near the surface. This animal has become a model in biophysical research regarding the ability of surface pressure to support weight.

4. CONCLUSIONS

The results of morphological identification obtained 9 species of parasitic Hemiptera in the rice field area of Majegan village, Tulung, Klaten, Central Java, namely: *Gerris lacusticus,*

Leptoglossus clypealis, *Dysdercus cingulatus*, *Narvesus carolinensis*, *Triatoma sanguisuga*, *Arilus cristatus*, *Thyanta custator*, *Padops cinctipes* and *Boisea trivittata*. The most closely related species is *Narvesus carolinensis* and *Arilus cristatus*, with a similarity rate of 86.9%. While the species that have the most distant kinship are *Narvesus carolinensis* and *Gerris lacusticus* that is equal to 60.4%. The high degree of similarity indicates a close relationship between parasite species. Future research could focus on developing natural enemies for the Hemyptera parasite.

5. ACKNOWLEDGMENTS

Thanks to the head of the Majegan region who has given permission and support for the implementation of this research.

6. REFERENCES

Bhargava, S., & Yablonovitch, E. (2015). Lowering HAMR near-field transducer temperature via inverse electromagnetic design. IEEE Transactions on Magnetics, 51(4). https://doi.org/10.1109/TMAG.2014.2355215

Edgecombe, G. D. (2020). Arthropod Origins: Integrating Paleontological and Molecular Evidence. https://doi.org/10.1146/annurev-ecolsys-011720

Giribet, G., & Edgecombe, G. D. (2019). The Phylogeny and Evolutionary History of Arthropods. In Current Biology (Vol. 29, Issue 12, pp. R592–R602). Cell Press. https://doi.org/10.1016/j.cub.2019.04.057

Helden, A. J., & Leather, S. R. (2004). Biodiversity on urban roundabouts-Hemiptera, management and the species-area relationship. Basic and Applied Ecology, 5(4), 367–377. https://doi.org/10.1016/j.baae.2004.06.004

Hong, F., Han, H. L., Pu, P., Wei, D., Wang, J., & Liu, Y. (2019). Effects of five host plant species on the life history and population growth parameters of myzus persicae (Hemiptera: Aphididae). Journal of Insect Science, 19(5). https://doi.org/10.1093/jisesa/iez094

Høye, T. T. (2020). Arthropods and climate change – arctic challenges and opportunities. In Current Opinion in Insect Science (Vol. 41, pp. 40–45). Elsevier Inc. https://doi.org/10.1016/j.cois.2020.06.002

Jactel, H., Koricheva, J., & Castagneyrol, B. (2019). Responses of forest insect pests to climate change: not so simple. In Current Opinion in Insect Science (Vol. 35, pp. 103–108). Elsevier Inc. https://doi.org/10.1016/j.cois.2019.07.010

Lee, D. H., Park, Y. L., & Leskey, T. C. (2019). A review of biology and management of Lycorma delicatula (Hemiptera: Fulgoridae), an emerging global invasive species. In Journal of Asia-Pacific Entomology (Vol. 22, Issue 2, pp. 589–596). Elsevier B.V. https://doi.org/10.1016/j.aspen.2019.03.004

Li, F., Zhao, X., Li, M., He, K., Huang, C., Zhou, Y., Li, Z., & Walters, J. R. (2019a). Insect genomes: progress and challenges. In Insect Molecular Biology (Vol. 28, Issue 6, pp. 739–758). Blackwell Publishing Ltd. https://doi.org/10.1111/imb.12599

Li, F., Zhao, X., Li, M., He, K., Huang, C., Zhou, Y., Li, Z., & Walters, J. R. (2019b). Insect genomes: progress and challenges. In Insect Molecular Biology (Vol. 28, Issue 6, pp. 739–758). Blackwell Publishing Ltd. https://doi.org/10.1111/imb.12599

Lytle, D. A. (2015). Order Hemiptera. In Thorp and Covich's Freshwater Invertebrates: Ecology and General Biology: Fourth Edition (Vol. 1, pp. 951–963). Elsevier Inc. https://doi.org/10.1016/B978-0-12-385026-3.00037-1

Ma, C.-S., Ma, G., & Pincebourde, S. (2020). Survive a Warming Climate: Insect Responses to Extreme High Temperatures. Annual Review of Entomology Annu. Rev. Entomol. 2021, 66, 163–184. https://doi.org/10.1146/annurev-ento-041520

Menta, C., & Remelli, S. (2020). Soil health and arthropods: From complex system to worthwhile investigation. In Insects (Vol. 11, Issue 1). MDPI AG. https://doi.org/10.3390/insects11010054

Montgomery, G. A., Dunn, R. R., Fox, R., Jongejans, E., Leather, S. R., Saunders, M. E., Shortall, C. R., Tingley, M. W., & Wagner, D. L. (2020). Is the insect apocalypse upon us? How to find out. In Biological Conservation (Vol. 241). Elsevier Ltd. https://doi.org/10.1016/j.biocon.2019.108327

Moreira, F. F. F., Rodrigues, H. D. D., Sites, R. W., Silva Cordeiro, I. da R., & Magalhães, O. M. (2018). Order Hemiptera. In Thorp and Covich's Freshwater Invertebrates (pp. 175–216). Elsevier. https://doi.org/10.1016/b978-0-12-804223-6.00007-x

Ogasawara, Y., & Kon, M. (2021). Two clustering methods based on the Ward's method and dendrograms with interval-valued dissimilarities for interval-valued data. International Journal of Approximate Reasoning, 129, 103–121. https://doi.org/10.1016/j.ijar.2020.11.001

Song, N., Zhang, H., & Zhao, T. (2019). Insights into the phylogeny of Hemiptera from increased mitogenomic taxon sampling. Molecular Phylogenetics and Evolution, 137, 236–249. https://doi.org/10.1016/j.ympev.2019.05.009

Valdez, J. W. (2020). Arthropods as vertebrate predators: A review of global patterns. In Global Ecology and Biogeography (Vol. 29, Issue 10, pp. 1691–1703). Blackwell Publishing Ltd. https://doi.org/10.1111/geb.13157

Vidovic, S. U. (n.d.). Tree congruence: quantifying similarity between dendrogram topologies.

Wagner, D. L. (2019). Insect Declines in the Anthropocene. https://doi.org/10.1146/annurev-ento-011019

Wang, J., Wu, Y., Dai, R., & Yang, M. (2020). Comparative mitogenomes of six species in the subfamily Iassinae (Hemiptera: Cicadellidae) and phylogenetic analysis. International Journal of Biological Macromolecules, 149, 1294–1303. https://doi.org/10.1016/j.ijbiomac.2020.01.270

Wong, M. K. L., Guénard, B., & Lewis, O. T. (2019). Trait-based ecology of terrestrial arthropods. Biological Reviews, 94(3), 999–1022. https://doi.org/10.1111/brv.12488

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Identification of Intestine Parasite Worms Eggs in Feces Proboscis Monkey (*Nasalis larvatus*)

Fiqita Giulleta Irtifannisa Rahman[1], Anni Nurliani[1]*, Amalia Rezeki [2], Rusmiati[3]
[1] Department of Biology, Faculty of Mathematics and Natural Sciences, Lambung Mangkurat University, South Kalimantan 70714, Indonesia
[2] Department of Biology Education, Faculty of Teacher Training and Education, Lambung Mangkurat University, South Kalimantan 70123, Indonesia
[3] Department of Biology, Faculty of Mathematics and Natural Sciences, Lambung Mangkurat University, South Kalimantan 70714, Indonesia
* Corresponding Author. E -mail address: anninurliani@ulm.ac.id

KEYWORDS:
Feces
Proboscis Monkey
Nasalis larvatus
Worm

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The proboscis monkey (*Nasalis larvatus*) is one of the endemic primates on the island of Borneo which is protected in Indonesia. Rehabilitation efforts are important to prevent extinction of the proboscis monkey. Parasitic diseases are diseases that often infect primates in rehabilitation centers. Examination feces is one way to diagnose the presence of parasitic worms in the animal's body. This study aims to identify and know Prevalence of types of parasitic worms found in the feces of proboscis monkeys at the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI). Sampling of proboscis monkey feces was carried out for 20 days on three proboscis monkeys at SBI. Identification of endoparasites is carried out in the Parasitology Laboratory, Banjarbaru Veterinary Center, South Kalimantan, using the Whitlock sedimentation method. The results of this study indicate that there are types of worms *Trichuris trichiura*, *Trichostrongylus* sp. and *Oesophagostomum sp.* found in proboscis monkey feces samples. The highest prevalence was found in the type of worm *Trichuris trichiura* which was found in Mimin's proboscis monkey, which was 35%.

1. INTRODUCTION

The proboscis monkey (*Nasalis larvatus*) is one of the endemic primates on the island of Borneo, protected in Indonesia because of its declining population. Since 2014, the International Union for Conservation of Nature and Natural (IUCN) has categorized the proboscis monkey as an endangered species (IUCN, 2014), whereas CITES is categorized into Appendix I (CITES, 2010). The proboscis monkey population is declared endangered because it is caused by a very high level of habitat disturbance, such as the conversion of forest land, forest encroachment, forest fires, and forest logging (Rabiati *et al*., 2015). The impact of this habitat destruction makes the proboscis monkeys lose their homes and food sources, and many proboscis monkeys experience stress, get injured, die, and run to residential areas because they feel insecure in the forest. In addition, the decline in the proboscis monkey population is also caused by poaching and illegal trading activities that still occur frequently in some areas, generally poaching proboscis monkeys to be kept as pets (Bennett, 1988; Boonratana, 1993; Soendjoto, 2004). Proboscis monkeys who face these bad events will generally experience stress, fear, trauma, and even physical injuries. Therefore, there is a need for physical and psychological recovery by carrying out rehabilitation efforts for proboscis monkeys who experience this.

The institution engaged in animal rehabilitation, especially proboscis monkeys in South Kalimantan, is the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI). There are 3 adult proboscis monkeys and 1 baby proboscis monkey being rehabilitated at the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI), with various backgrounds, such as accident victims, conflicts with residents, or former residents' pets. Health monitoring during rehabilitation is necessary to assess the animal's readiness before being released into its natural habitat, one of which is by conducting tests for parasitic diseases. One of the parasitic diseases that often infect primates in rehabilitation centers is intestinal helminthiasis (Shepherd, 2008). Gastrointestinal worms belong to the class of endoparasites, which can be detrimental to the host because they compete for food, suck blood, damage the digestive tract epithelium, facilitate the entry of other pathogens, and cause mechanical blockages (Kuntum, 2020). This is very detrimental if it happens and can certainly disrupt rehabilitation programs for animals such as the proboscis monkey. One way to diagnose the presence of parasitic worms in an animal's body is to examine fresh feces to look for parasitic worm eggs released by the female worm after mating to continue its life cycle (Rahmah & Salmah, 2013). Therefore, it is necessary to examine feces samples with a sufficient number of samples and the right method so that the results obtained are more accurate so that the prevention and treatment of parasitic worm infections can be maximized.

2. MATERIALS AND METHODS

This research was conducted from February to June 2023. Fecal samples were collected from the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI), Banjarmasin, South Kalimantan. Examination and identification of proboscis monkey feces samples were carried out at the Parasitology Laboratory, Banjarbaru Veterinary Center, South Kalimantan.

2.1. Sample Collection

The proboscis monkey feces was sampled at the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI), Banjarmasin. Feces samples were collected every morning around 07.00-09.00 AM. Sampling was conducted for 20 days on 3 proboscis monkeys (Mimin, Chikita, Pedro), consisting of 1 adult male proboscis monkey and 2 adult female proboscis monkeys. The fecal samples are then put into zip lock plastic, weighed, labeled, put into an ice box, and taken to the Parasitology Laboratory, Banjarbaru Veterinary Center, to identify worm eggs.

2.2. Feces Sample Examination

Examination of proboscis monkey feces samples was carried out by the sedimentation method. The fecal sample was weighed as much as 3 grams and put into a conical tube, then added water until the volume reached 60 ml and stirred until homogeneous. The mixture is then filtered, and the filter results are put into another conical tube. Water is added until it is full in the conical tube containing the filter results and left for 3 minutes until the eggs settle to the bottom of the tube. Then the top liquid is removed, and the sediment or sediment results are left. Then water is added again until it is full and allowed to stand again for 3 minutes. After that, the top liquid was removed and left with approximately 15 ml of sediment. Then 2 drops of 1% methylene blue were added to the remaining sediment and stirred thoroughly, and the suspension was taken using a Pasteur pipette. The suspension was put into the Universal Whitlock Counting Chamber. The examination was conducted under a microscope with 4x or 10x magnification, whether worm eggs were found at the bottom of the glass under the counting chamber. Identification of worm eggs that have been found to determine their type is based on identification, namely egg morphology, after which they are matched using the Atlas of Medical Helminthology and Protozoology, Atlas of Medical Helminthology, and Textbooks of Medical Parasitology. Count each type of worm egg found with the formula:

Number of eggs per gram of feces = the number of eggs in one counting chamber x 10.

2.3. Prevalence Calculation

Determination of the prevalence of worm infection is based on examining the presence or absence of worm eggs in the proboscis monkey's feces sample. The prevalence of the types of worms found is calculated using the following formula (Murdayasa et al ., 2019):

$$\text{Prevalence} = \frac{\sum Infected\ sample}{\sum Examined\ sample} \text{ x } 100\ \%$$

3. RESULTS AND DISCUSSION

The Bekantan Rescue Center Sahabat Bekantan Foundation (SBI) has 3 adult proboscis monkeys being rehabilitated. There are 2 female proboscis monkeys named Mimin and Chikita and 1 male proboscis monkey named Pedro. The Bekantan Rescue Center Sahabat Bekantan Foundation (SBI) uses cages of proboscis monkeys made of iron, each with a separate cage.

The proboscis monkey feces samples examined are as many as 20 from each proboscis monkey named Mimin, Chikita, and Pedro using the Whitlock sedimentation method. Based on the identification results, in the feces sample of Mimin's proboscis monkey, 8 positive samples were found for worm eggs. The positive samples consisted of 7 samples found eggs of the worm type *Trichuris trichiura* and 1 sample found eggs of the worm type *Oesophagostomum* sp. The results on the Chikita proboscis monkey from the 20 samples examined obtained 4 samples that were found positive for worm eggs. The positive samples consisted of 1 sample found *Trichostrongylus* sp. worm eggs, 2 *Trichuris trichiura* worm eggs, and 1 *Trichostrongylus* sp worm eggs. and *Trichuris trichiura*. The results on the proboscis monkey Pedro from the 20 samples examined obtained 4 samples that were found positive for worm eggs. The positive sample consisted of 1 sample found worm eggs of *Trichostrongylus* sp. and 3 samples found *Trichuris trichiura* worm eggs. Identification results can be seen in Table 1.

Table 1 Results of Identification of the Type and Number of Worm Eggs in Proboscis Monkey Feces Samples with the Whitlock Sedimentation Method

No.	Collection Sample	Individual Name	Code	Types of Worm Eggs Found in Proboscis Monkey Feces	Number of Worm Eggs
1.	1	Mimin	M/15.08	*Trichuris trichiura*	250
		Chikita	C/15.08	*Trichostrongylus*	50
		Pedro	P/15.08	*Trichostrongylus*	50
2.	2	Mimin	M/16.08	*Oesophagostomum*	50
		Chikita	C/16.08	Negative	-
		Pedro	P/16.08	Negative	-
3.	3	Mimin	M/17.08	*Trichuris trichiura*	150
		Chikita	C/17.08	Negative	-
		Pedro	P/17.08	Negative	-
4.	4	Mimin	M/18.08	Negative	-
		Chikita	C/18.08	Negative	-
		Pedro	P/18.08	Negative	-
5.	5	Mimin	M/19.08	Negative	-
		Chikita	C/19.08	*Trichuris trichiura*	200

No.	Collection Sample	Individual Name	Code	Types of Worm Eggs Found in Proboscis Monkey Feces	Number of Worm Eggs
		Pedro	P/19.08	Negative	-
6.	6	Mimin	M/22.08	Negative	-
		Chikita	C/22.08	Negative	-
		Pedro	P/22.08	Negative	-
7.	7	Mimin	M/23.08	Negative	-
		Chikita	C/23.08	Negative	-
		Pedro	P/23.08	Negative	-
8.	8	Mimin	M/24.08	Negative	-
		Chikita	C/24.08	Negative	-
		Pedro	P/24.08	Negative	-
9.	9	Mimin	M/25.08	*Trichuris trichiura*	650
		Chikita	C/25.08	Negative	-
		Pedro	P/25.08	Negative	-
10.	10	Mimin	M/26.08	*Trichuris trichiura*	550
		Chikita	C/26.08	Negative	-
		Pedro	P/26.08	Negative	-
11.	11	Mimin	M/29.08	Negative	-
		Chikita	C/29.08	Negative	-
		Pedro	P/29.08	Negative	-
12.	12	Mimin	M/30.8	Negative	-
		Chikita	C/30.08	Negative	-
		Pedro	P/30.08	Negative	-
13.	13	Mimin	M/31.08	*Trichuris trichiura*	300
		Chikita	C/31.08	Negative	-
		Pedro	P/31.08	Negative	-
14.	14	Mimin	M/01.09	Negative	-
		Chikita	C/01.09	Negative	-
		Pedro	P/01.09	*Trichuris trichiura*	100
15.	15	Mimin	M/02.09	Negative	-
		Chikita	C/02.09	Negative	-
		Pedro	P/02.09	Negative	-
16.	16	Mimin	M/05.09	*Trichuris trichiura*	1450
		Chikita	C/05.09	*Trichuris trichiura*	250
		Pedro	P/05.09	*Trichuris trichiura*	150
17.	17	Mimin	M/06.09	Negative	-
		Chikita	C/06.09	Negative	-

No.	Collection Sample	Individual Name	Code	Types of Worm Eggs Found in Proboscis Monkey Feces	Number of Worm Eggs
		Pedro	P/06.09	*Trichuris trichiura*	750
18.	18	Mimin	M/07.09	*Trichuris trichiura*	850
		Chikita	C/07.09	*Trichuris trichiura* *Trichostrongylus*	250 50
		Pedro	P/07.09	Negative	-
19.	19	Mimin	M/08.09	Negative	-
		Chikita	C/08.09	Negative	-
		Pedro	P/08.09	Negative	-
20.	20	Mimin	M/09.09	Negative	-
		Chikita	C/09.09	Negative	-
		Pedro	P/09.09	Negative	-

Worm eggs identified and counted in each feces sample are the TTGT value category (number of worm eggs per gram of feces). The degree of parasitic worm infection is categorized into a mild infection if the number of eggs found is <500 eggs per gram of feces, and moderate infection is indicated if the worm eggs are found. Found to be 500 - 5000 eggs per gram of feces, while severe infection is indicated if the eggs produced are > 5000 eggs per gram of feces (Thienpont *et al.*, 1995; Nofyan *et al.*, 2010). Based on the data that has been obtained, the degree of *Trichuris trichiura worm infection* those found in the proboscis monkey feces samples Mimin on days 9, 10, 16, and 18 and the *Trichuris trichiura worm* in the proboscis monkey feces samples on day 17 were classified as moderate infections because the eggs found totaled more than 500 eggs, while for other types of worms, the degree of infection was still relatively mild because the number of eggs found was less than 500 eggs.

The prevalence of the type of worm that infects an individual proboscis monkey is calculated based on the number of feces samples that are positive for worm eggs divided by 20 samples and multiplied by 100% according to the prevalence formula. The results of calculating the prevalence of proboscis monkey Mimin for the prevalence of *Trichuris trichiura* worms is 35%, and for the prevalence of worms, *Oesophagostomum* sp. is 5%. The prevalence calculation in Chikita proboscis monkeys for the prevalence of *Trichuris trichiura* worms is 15%, and for the prevalence of *Trichostrongylus* sp. worms. that is equal to 10%. The prevalence calculation for the proboscis monkey Pedro for the worm type *Trichuris trichiura* is 15%, and for the prevalence for the worm, *Trichostrongylus* sp. is 5%. Based on the prevalence category, the *Trichuris trichiura* worm that infects Mimin's proboscis monkey is in a general category (49-30%), which illustrates that this worm usually infects proboscis monkeys Mimin and worms *Oesophagostomum* sp. into the category sometimes (9-1%), which illustrates that the worm sometimes infects proboscis monkeys Mimin. *Trichuris trichiura* and *Trichostrongylus* sp. those that infect the Chikita proboscis monkeys are in the frequent category (29-10%), which illustrates that these worms often infect the Chikita proboscis monkeys. The *Trichuris trichiura* worm that infects the proboscis monkey Pedro is included in the frequent category (29-10%), which illustrates that the worm often infects the proboscis monkey Pedro and the worm *Trichostrongylus* sp. into the occasional category (9-1%), which illustrates that the worm sometimes infects Pedro's proboscis monkey (Syukran et al., 2017).

3.1. Description of Found Worm Eggs

Worm eggs in the feces samples examined consisted of *Trichuris trichiura*, *Trichostrongylus* sp., and *Oesophagostomum* sp. The description of worm eggs found is as follows:

3.1.1. Trichuris trichiura

Trichuris trichiura worm eggs were the first eggs found on examination. *Trichuris trichiura* eggs obtained in the study showed the same characteristics as the literature: eggs shaped like a crock or wine barrel, with both poles or opercula protruding in clear color. The egg wall is thick, and an embryo is inside (Prianto et al., 2010). The wall has two layers, the inner layer is clear, and the outer layer is brown. *Trichuris trichiura* eggs are distinctive because they are shaped like a crock and have an operculum. The operculum is a cover at both poles and protrudes at both poles (Natadisastra & Agoes, 2009).

3.1.2. Trichostrongylus sp.

Trichostrongylus sp. worm eggs. Found on the first day of feces examination. The eggs obtained are oval with one sharp end. The characteristics obtained by El-Shazly et al. (2006) show that the eggs of *Trichostrongylus* sp. have an oval shape with rounded ends and thin walls, and there is a clear space between the embryo and eggshell, and a size of 56-75 microns x 36-40 microns.

3.1.3. Oesophagostomum sp.

Oesophagostomum sp. worm eggs. Found for the first time on the second day of feces examination. *Oesophagostomum* sp worm eggs. On observation, it shows an oval or elliptical shape, and this is what was stated by Purwanta et al. (2009) that the worm eggs of *Oesophagostomum* sp. have an elliptical shape and thin walls, and according to Puspitasari et al., (2019) the eggs of *Oesophagostomum* sp. generally measuring 70.74 x 41.09 µm.

3.2. Factors Causing Worm Infection

Several factors, such as the cleanliness of the cage, cleanliness of the feed, environmental conditions, and preventive and treatment measures, can cause the presence of parasitic worm eggs found in proboscis monkey feces samples. The results showed that during the observation of *Trichuris trichiura* worm eggs in the proboscis monkey feces sample, Mimin was the most commonly found, namely 4,200 eggs, followed by *Trichuris trichiura* worm eggs. In Pedro's proboscis monkey feces samples with 1000 eggs during observation. The worm type *Trichuris trichiura* had the highest prevalence in the feces of the proboscis monkey Mimin, which was 35%. The number of *Trichuris trichiura* worm eggs found in the fecal samples of Mimin and Pedro proboscis monkeys and the prevalence of Trichuris trichiura worms This is likely to occur because both of them like to pick up food that has fallen on the bottom of the cage or the floor of the cage. The proboscis monkey cage at the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI) at the bottom is not directly soil but cement. However, even so, usually, there are many piles of feces and food scraps in the area. According to Pumipuntu (2018), infection with digestive tract parasitic worms can occur through contaminated food or drink—contamination with infective helminth eggs. Sources of contamination for the transmission of parasitic worm infections can be in the form of feces, soil, and water as a place for developing worm eggs into an infective form.

The cage's cleanliness is very important in determining parasitic worms' presence. Cages that are routinely cleaned can prevent worm infections in animals. Various previous studies have stated that aspects of cage cleanliness significantly influence various cases of helminthiasis (Nurhidayah et al., 2019). Based on observations at the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI), cage cleaning is routinely performed every evening. Cleaning the cage includes spraying

water on the area under the cage to clean food residue and feces and sweeping the area around the enclosure from leaves. However, sometimes the cage floor is not cleaned because it is quite difficult to clean, so there is usually leftover food and feces attached to the iron on the cage floor. In addition, the feces cleaned in the cage are only disposed of in the area behind the cage, which can be a source of contaminants.

Selection and cleanliness of feed are also very influential on worm infection. The feed given must be feed that has been cleaned with running water so that worm eggs that may be on the surface of the feed can be lost and do not enter the animal's digestion. Based on observations at the the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI), the food given has been cleaned beforehand with running water; only if the food has fallen on the floor of the cage, it is not possible to pick it up and clean it again, and the proboscis monkeys usually continue to eat it. Most of the proboscis monkeys fed in SBI are vegetables, so it is important to pay attention to cleanliness. This is because in Indonesia, when growing vegetables, they often use manure to fertilize plants, so there may be infective worm eggs in the fertilizer. Worm eggs that are already infective and contained in the fertilizer can be carried by plants that will be given to proboscis monkeys at SBI. Therefore, washing feed is very important to prevent the inadvertent entry of worm eggs into primate digestion (Staf Pengajar Bagian Parasitologi FKUI, 2002).

Another factor that influences the presence of parasitic worms in the animal's body is environmental conditions. An environment with high humidity and a lack of exposure to sunlight is ideal for developing worm eggs. Moist soil is a good place for the development of parasitic nematode eggs into an infective stage, especially parasitic nematodes belonging to Soil Transmitted Helminths (Kusumamihardja, 1992 in Riwidiharso et al., 2020). Hatching and developing worm eggs from L1 to L3 takes about 2–3 weeks at 10–25°C, and L3 can last for several weeks or even months under these conditions. High temperatures and exposure to direct sunlight in open cages can reduce the number of L3 worm larvae that contaminate the cage (Nielsen et al., 2007). According to Nielsen et al. (2007), L3 worm larvae will soon die if exposed to adverse environmental conditions, such as direct sunlight and temperature changes. Based on observations at the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI), the proboscis monkey cage environment has quite high humidity because the cage is under a roofed building and is surrounded by various types of plants so that a significant quantity of sun exposure can enter the cage area. This is what makes the proboscis monkey's cage quite humid.

Preventive and curative measures can be taken to reduce worm infections in animals. Prevention activities can be carried out by breaking the life cycle of worms and administering drugs regularly to animals. Termination of the life cycle of worms can be done by cleaning and disinfecting regularly in the cage area. It is also necessary to pay attention to adjusting the intensity of the sunlight shining on the cage to break the life cycle of the worms because some parasitic worms cannot tolerate hot and dry environments. In addition, regular deworming is also important to prevent or reduce parasitic worm infections in the animal's body. Deworming should be given 3-4 times a year. This aims to kill the worms in the animal's body and excrete it through the feces so that the animal's body can be free from parasitic worms that attack (Staf Pengajar Bagian Parasitologi FKUI). In primates, parasitic infections are usually treated by administering the anthelmintic drugs of the pyrantel pamoate group and broad-spectrum mebendazole groups (Fauzi, 2006). Anthelmintic administration is generally carried out periodically every 3-4 months. However, it must also be noted that the continuous use of anthelmintics using the same type of drug can stimulate worm resistance to anthelmintics (Habib et al ., 2022).

4. CONCLUSIONS

Parasitic worms found in proboscis monkeys at the Bekantan Rescue Center Sahabat Bekantan Foundation (SBI) are *Trichuris trichiura*, *Trichostrongylus* sp., and *Oesophagostomum* sp. *Trichuris trichiura* worm *and Oesophagostomum* sp. were found in proboscis monkey Mimin, while *Trichuris trichiura* and *Trichostrongylus* sp. were found in

proboscis monkeys Chikita and Pedro. Prevalence of *Trichuris trichiura* worm type by 35% and *Oesophagostomum* worms sp. by 5% in Mimin proboscis monkeys, the prevalence of the worm type *Trichuris trichiura* by 15% and *Trichostrongylus* sp. by 10% in Chikita proboscis monkeys, while the prevalence of the worm type *Trichuris trichiura* by 15% and *Trichostrongylus* sp. by 5% on the proboscis monkey Pedro. The highest prevalence was found in the type of *Trichuris trichiura* worm found in Mimin's proboscis monkey, which is 35%.

5. ACKNOWLEDGMENTS

This study was financially supported by Grant from Lambung Mangkurat University, namely Program Dosen Wajib Meneliti (PDWM) 2022 No. 025.51/UN8.2/PL/2022. The authors are grateful to staff of Sahabat Bekantan Indonesia Foundation for the technical assistance during observation.

6. REFERENCES

Bennett, E. L. (1988). Proboscis Monkeys and their Swamp Forests in Sarawak. *Oryx*, *22*(2), 69–74.

Boonratana, R. (1993). The Ecology and Behaviour of The Proboscis Monkey (*Nasalis larvatus*) in The Lower Kinabatangan, Sabah. *Dessertation*. Mahidol University.

CITES. (2010). *Checklist of CITES Species*. Retrieved from www.cites.org.

El Shazly, A. M., Awad, S. E., Sultan, D. M., Sadek, G. S., Khalil, H. H., & Morsy, T. A. (2006). Intestinal Parasites in Dakahlia Governorate, with Different Techniques in Diagnosing Protozoa. *Journal of the Egyptian Society of Parasitology*, *36*(3), 1023-1034.

Fauzi, R. P. S. (2006). Media Konservasi Berbasis Kesejahteraan Hewan: Studi Kasus pada Orangutan di Taman Margasatwa Ragunan. *Skripsi*. lnstitut Pertanian Bogor, Bogor (ID).

Habib, A. A., Arif, R., & Ridwan, Y. (2022). Prevalensi, Faktor Risiko dan Derajat Helminthiasis pada Sapi Limousin di Bptu-hpt Padang Mengatas. *Jurnal Kajian Veteriner*, *10*(1), 29-37.

IUCN. (2014). *IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland.

Kuntum, R., Yusuf, R., Darusman, H.S. (2020). Evaluasi Manajemen Pemeliharaan terhadap Endoparasit Saluran Pencernaan pada Kukang Sumatera (*Nycticebus coucang*). *Jurnal Primatologi Indonesia*, *17*(1), 22-27.

Kusumamihardja, S. (1992). *Parasit dan Parasitosis pada Hewan Ternak dan Hewan Piaraan di Indonesia*. Pusat Antar Universitas Bioteknologi Institut Pertanian Bogor, Bogor.

Murdayasa, I. W. G., Wandia, I. N., & Suratma, N. A. (2019). Prevalensi Parasit Cacing Saluran Pencernaan pada Monyet Ekor Panjang (*Macaca fascicularis*) di Pulau Nusa Penida, Klungkung, Bali. *Indonesia Medicus Veterinus*, 8(6), 798-805.

Natadisastra, D & R. Agoes. (2009). *Parasitologi Kedokteran: Ditinjau dari Organ Tubuh yang Diserang*. Penerbit buku kedokteran EGC, Jakarta.

Nielsen, M. K., Kaplan, R. M., Thamsborg, S. M., Monrad, J., Olsen, S. N. (2007). Climatic Influences on Development and Survival of Free-living Stages of Equine Strongyles: Implications for Worm Control Strategies and Managing Anthelmintic Resistance. *Veteriner Journal*, 174, 23–32.

Nofyan, E., Kamal, M., Rosdiana, I. (2010). Identitas Jenis Telur Cacing Parasit Usus pada Ternak Sapi (*Bos* sp.) dan Kerbau (*Bubalus* sp.) di Rumah Potong Hewan Palembang. *Jurnal Penelitan Sains Ed Khusus Juni*. 10, 6–11.

Nurhidayah, N., Satrija, F., Retnani, E. B., Astuti, D. A., & Murtini, S. (2019). Prevalensi dan Faktor Risiko Infeksi Parasit Saluran Pencernaan pada Kerbau Lumpur di Kabupaten Brebes, Jawa Tengah. *Jurnal Veteriner*, *20*(4).

Prianto, L. A., Tjahaya, P. U. & Darwanto. 2010. *Atlas Parasitologi Kedokteran*. Jakarta Gramedia Pustaka Utama, Jakarta.

Pumipuntu, N. (2018). Detection for Potentially Zoonotic Gastrointestinal Parasites in Longtailed Macaques, Dogs and Cattle at Kosamphi Forest Park, Maha Sarakham. *Veterinary Integrative Sciences*, *16*(2), 69-77.

Purwanta, N., Josephina, D. H., Sri, S. (2009). Identifikasi Cacing Saluran Pencernaan (Gastrointestinal) pada Sapi Bali Melalui Pemeriksaan tinja di Kabupaten Gowa. *Jurnal Agrisistem*, 5 (1).

Puspitasari, A., Setiawan, B., Koesdarto, S., Kusnoto, K., Soeharsono, S., & Hastutiek, P. (2019). The Distribution of Goat Gastrointestinal Tractus Worm Egg at Rambon District of Nganjuk Regency. *Journal of Parasite Science (JoPS)*, *3*(2), 59-66.

Rabiati, M., Kartono, A. P., & Masyud, B. (2015). Populasi Bekantan (*Nasalis larvatus*) di Suaka Margasatwa Kuala Lupak, Kalimantan Selatan, Indonesia. Media Konservasi, *20*(3), 242-251.

Rahmah, F., & Salmah, S. (2013). Cacing Parasit Saluran Pencernaan Pada Hewan Primata di Taman Satwa Kandi Kota Sawahlunto Provinsi Sumatera Barat. *Jurnal Biologi Universitas Andalas*, *2*(1), 14-19.

Riwidiharso, E., Nasution, E. K., & Triaji, H. (2020). Keragaman dan Prevalensi Nematoda Parasit Usus pada Monyet Ekor Panjang (*Macaca fascicularis*) di Kawasan Wisata "Masjid Saka Tunggal". *Majalah Ilmiah Biologi BIOSFERA: A Scientific Journal*, *37*(1), 55-59.

Shepherd, C. R. (2008). Illegal Primate Trade in Indonesia Exemplied by Survey Carried Out Over a Decade in North Sumatra. *Inter-Research Online Journals* 11, 201-205.

Soendjoto, M. A. (2004). New Record on Habitat of The Proboscis Monkey (*Nasalis larvatus*) and its Problems in South Kalimantan, Indonesia. *Tigerpaper*, *31*(2), 17–18.

Staf Pengajar Bagian Parasitologi FKUI. (2002). *Parasitologi kedokteran*. Balai Penerbit FKUI, Jakarta.

Syukran, M., El-Rahimi, S. A., & Wijaya, S. (2017). Intensitas dan Prevalensi Ektoparasit Pada Ikan Cupang Hias (*Betta splendens*) di Perairan Kabupaten Aceh Besar dan Kota Banda Aceh. *Jurnal Ilmiah Mahasiswa Kelautan Perikanan Unsyiah*, *2*(1).

Thienpoint. (1995). *The Inspection of Worm Eggs in Animals Feces. 13th Ed*. Cornel University Press, Ithaca and London (UK).

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Ethnobotanical Study of Tea Plants Based on Local Wisdom in Ngargoyoso District, Karanganyar Regency, Central Java

Kharisma Margiyana Dinda Hapsari, Efri Roziaty*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: er375@ums.ac.id

KEYWORDS:
Ethnobotany
Local wisdom
Ngargoyoso
Tea Plant

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Ethnobotany is the relationship between humans and natural resources to meet needs such as food, medicines, traditional ceremonies, and other community life. Tea plants are plants that have a high selling value and have many health benefits. This study aims to determine the ethnobotanical aspects ethnobotanical of tea plants based on local wisdom in Ngargoyoso District, Karanganyar Regency, Central Java. This type of research is qualitative using data collection methods with surveys and interviews conducted by finding reliable informant sources. The data analysis used qualitative descriptive means. The results showed that there were 48 out of 50 people liked tea drinks, 37 people used tea plants as drinks, and 13 people used them as medicine. The level of knowledge of the Ngargoyoso people on the ethnobotany of tea plants is relatively low. The parts of the tea plant that can be used are young leaves, old leaves, young stems, and old stems.

1. INTRODUCTION

Ethnobotany is a branch of biology that studies the relationship between humans and plants in their traditional use activities. In line with the rapid pace of science and technology, ethnobotany has developed into a branch of science that includes the relationship between humans and natural resources, for example food, medicine, traditional ceremonies, and other community life (Karina., 2022). This is also in line with research (Nuraeni., 2022) Ethnobotany can be used to document the knowledge of traditional societies that utilize various plants used in everyday life.

Ethnobotanical studies can be seen not only through the use of plants but also through how communities maintain and preserve existing plants and the reciprocity between humans and plants (Rahimah., 2019). Humans can adjust to daily life to satisfy themselves and their desires by the availability of natural resources in their environment. The interaction that occurs between humans and their environment can produce a local culture that is in harmony with their environment. Ethnobotanical studies are very important so that knowledge of the local wisdom of traditional communities in the use of these plants is not lost due to the flow of modernization.

The view of life and science as well as various life strategies in the form of activities carried out by the community in meeting their needs are called local wisdom. The scope of local wisdom is so broad and diverse. This is in line with research (Njatrijani, 2018) Local wisdom can be wisdom that has recently emerged in a community as a result of its interaction with the natural environment and its interaction with other communities and cultures. Local wisdom is different from traditional wisdom. Local wisdom emphasizes place and lokaitas from generation to generation.

Some ethnobotanical researchers choose Indonesia as a research destination because Indonesia is rich in flora and fauna. Indonesian people utilize the natural resources of plants and animals to meet daily needs such as food, health, education, and cultural needs. According to research (Mutmainnah, 2020) Indonesian society has long utilized abundant natural resources and knowledge passed down from generation to generation.

One of the plants used in everyday life is the tea plant. Tea plants include plants originating from the subtropics. Tea plants can thrive well at altitudes of 500-2,000 m asl and temperatures ranging from 10-27°C. Tea plants have a high selling value and affect the economy in Indonesia as a source of income for the community, create extensive jobs, and encourage agro-industry in the area around the region. Tea plants can be used as ingredients for tea drinks. The tea-drinking culture in most of the population on the island of Java likes tea drinks. So that this habit can support the prospect of tea in Indonesia. Tea, in general, is divided into three types, namely oolong tea, green tea, and black tea (Azurianti, 2022). Tea production is highly dependent on climatic conditions, increased rainfall, high dry season, and lack of moisture can result in decreased tea production. High and low production of tea plants does not escape the quality of the soil and the availability of nutrients and management (Robi, 2019). Soil that is suitable for tea plants is soil that contains organic matter, does not rock, and has a pH between 4-6. One of the areas of Central Java that is suitable for tea plants is the Ngargoyoso area, Karanganyar Regency.

Ngargoyoso area is a sub-district located in Karanganyar Regency, Central Java which has a very large tea plantation land and has an altitude ranging from 800 – 1,540 m asl. The air around the plantation area is quite cool and cold. With this vast tea plantation, local people can use the plantation as a tourist area that has its attraction for visitors who come. Tea production in the Ngargoyoso area is very well known by tourists as typical souvenirs of Ngargoyoso.

Based on the problems described, tea plants have many benefits in everyday life and in supporting the economy, therefore this study aims to determine the ethnobotanical aspects ethnobotanical of tea plants based on local wisdom in Ngargoyoso District, Karanganyar Regency, Central Java to support knowledge and culture about tea plants.

2. MATERIALS AND METHODS

2.1. Location and Time of Research

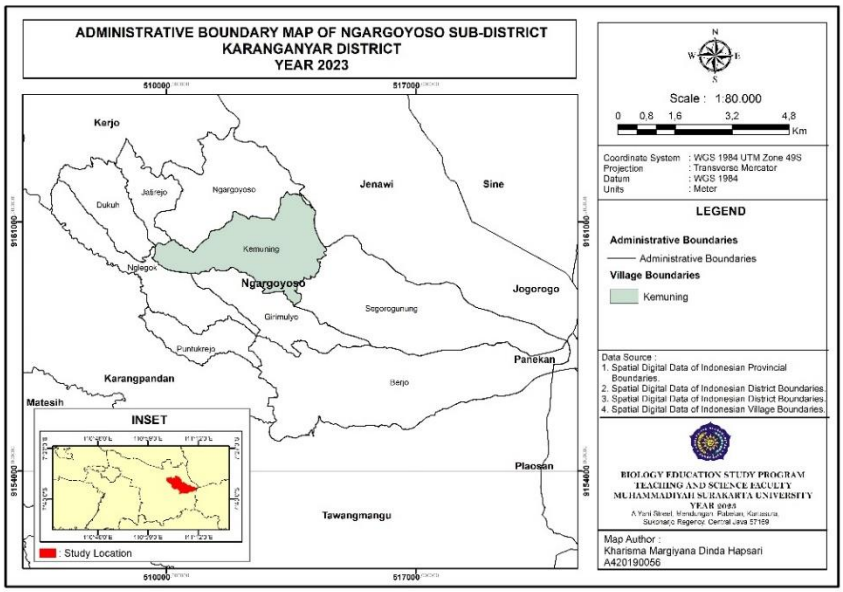


Figure 1. Map of Research Location

This research was conducted in Ngargoyoso District, Karanganyar Regency, Central Java. Ngargoyoso sub-district is divided into 9 villages, namely Kemuning, Ngargoyoso, Girimulyo, Berjo, Dukuh, Jatirejo, Nglegok, Puntukerjo, and Segorogunung. The research location taken from the 9 villages is Kemuning village because people's houses, tea factories, and tourist areas closest to tea plantations are Kemuning village. This region has an altitude of 1,114 m asl, with temperatures between 18 - 21°C. This research will be conducted in February – July 2023.

2.1.1. Observation and Sampling Techniques

The sampling technique used is the Purposive sampling method. The selection of respondents used purposive sampling by considering the respondents' knowledge of the tea plant, namely tea farmers, native residents of Ngargoyoso District, elders in the Ngargoyoso Kesamatan area, and the surrounding community. The data collection techniques used in this study were observation techniques, interview techniques, and documentation techniques. Observation techniques involve two components, namely the perpetrator and the object being observed. The observation technique carried out is to look at the village and look for reliable informants. The interview technique is carried out by asking questions to the resource persons to know the needs of users. Respondents with the criteria of women and men, aged 20 to 80 years, indigenous people and immigrants in the Ngargoyoso sub-district. The interview was conducted semi-structured which refers to the questionnaire guide. Interviews were conducted with local people to find out the use of parts of the tea plant. Documentation is carried out by collecting supporting documentation of research data needed in this study.

2.1.1.1. Data Analysis

Data analysis of the results of this study uses qualitative description analysis. Content analysis based on respondents' knowledge data on the benefits of a plant. Qualitative data is obtained from the results of community interviews on knowledge about tea plants, organs used, sources of acquisition, and how to use plants.

3. RESULTS AND DISCUSSION

3.1. Utilization of Tea Plants Based on Local Wisdom in Ngargoyoso District

From the results of observations and interviews with local people, the results of this study show that the level of preference for tea drinks and the benefits of tea in the Ngargoyoso area is described in the form of Figure 2

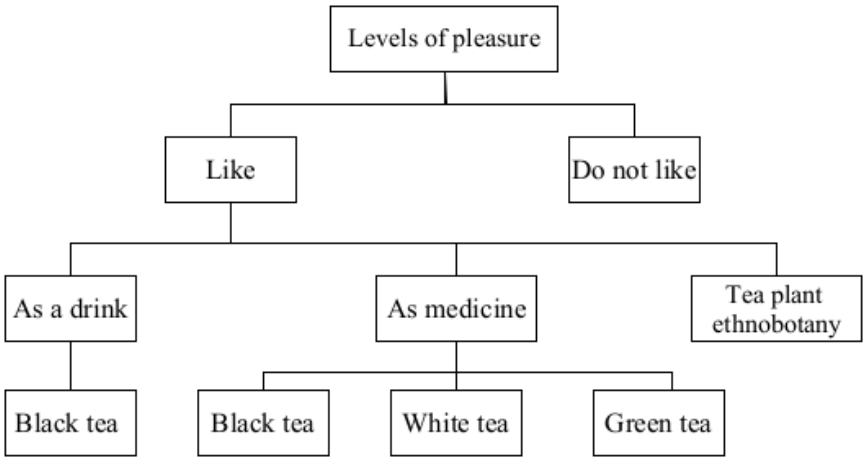


Figure 2. The Level of People's Liking For Tea Plants

Based on the picture, the level of liking to drink tea is divided into two benefits, namely as a daily drink and as a medicine. From 50 respondents, the level of liking is different. Presented picture 3 shows that there are 50 respondents with a level of tea liking, there are 96% who like to drink tea and 4% who don't like it. There are 2 benefits, namely as a drink and as a medicine. 74% out of 50 respondents chose tea plants as daily drinks and 26% used tea plants as medicine.

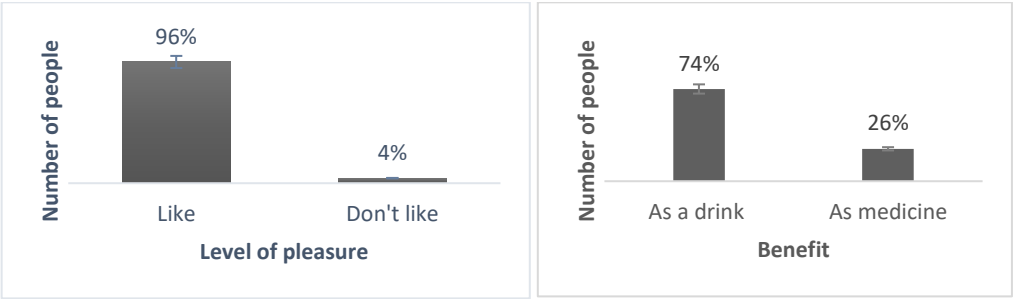


Figure 3. Number of People's answers The level of Liking and Benefits of Tea Plants

The most processed products from tea plants in Ngargoyoso District are tea drinks. People like tea drinks because they are easily obtained and pure from local plantations that have been processed and traded. Tea plantations in Ngargoyoso are mostly owned by PT. Rumpun teh Kemuning and a small part of private property. The tea drink that most people like is black tea. Black tea (Figure 4) is the most popular tea by the people of Ngargoyoso, in addition to daily drinks, black tea also has medicinal properties. The benefits of black tea as a medicine are maintaining low sugar levels, lowering cholesterol, and increasing endurance. The process of making black tea uses old leaves. Black tea contains compounds such as flavonoids, tannins, and caffein.

Processed tea drinks in Ngargoyoso are not only black tea, there are white tea and green tea with each having medicinal benefits. White tea (Figure 4) is the best tea for medicine because it has high antioxidants compared to black tea and green tea. White tea has a selling power that is quite expensive because the process of making white tea can also affect the properties present in white tea. This is in line with research (Hayati, 2022) states that the processing and serving technique of white tea will greatly affect the effectiveness of white tea as a functional food or as a medicine.

White tea contains caffein, flavonoid ,and phenolic compounds (Choiriyah, 2021). Processed white tea has benefits to prevent cancer, prevent heart disease, prevent osteoporosis, is good for oral and dental health, and stabilizes blood pressure. Judging from the health benefits of white tea including one of the functional foods. The process of making white tea uses young shoot leaves. According to (Choiriyah, 2021) White tea is harvested in the morning and the part taken is 1 bud on 1 part of the leaf.

Processed tea drinks as medicine as a further medicine are green tea (Figure 4). Green tea is most famous for its benefits as a weight loss or used as a diet companion drink. This can be seen in research (Nugroho, 2020) There was a decrease in weight of a man after being given green tea extract for 1 month. Apart from being a companion drink to the diet, green tea has medicinal benefits, namely to lower cholesterol, prevent diabetes, improve the digestive system, and prevent gingivitis. Green tea contains the main polyphenol and caffein compounds in tea leaves. This is in line with research (Rahmanisa, 2016) Green tea contains polyphenolic compounds and caffein. The process of making green tea uses young leaves.

Figure 4. *a. Green tea; b. White tea; c. Home-owned black tea in Ngargoyoso*

3.1.1. Ethobotanical Knowledge of Tea Plants in Ngargoyoso

The use of tea plants ethnobotically in Ngargoyoso is not widely known. From table 1, there were 50 respondents for those who knew only 32% and those who did not know 68% (figure 5). Ethnobotany is the use of plants as benefits for everyday life. Presented table of 3 tea plant organs that can be used.

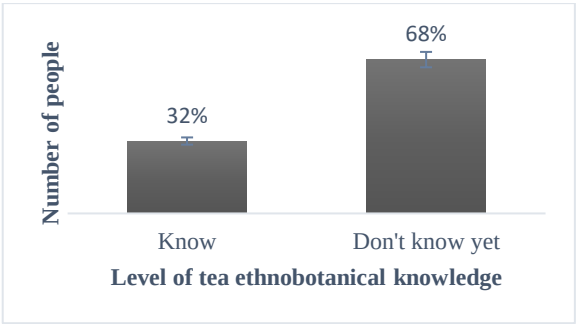


Figure 5. Knowledge Level of Tea Ethnobotany

Ethnobotany is the use of plants as benefits for everyday life. Presented in Table 1 of usable tea plant organs. Utilization of tea leaves other than as medicine and as a drink can be used as

natural compost. Old leaves (Figure 6) are leaves used as natural compost. Old fallen leaves in the soil can nourish the soil well. Part of the organ can be used in addition to the leaf, namely the stem. The stem part is divided into 2, namely the young stem (Figure 6) and the old stem. Young stems are used to mix tea drinks because young stems give the tea a strong aroma and flavor. Then the old stem part is not widely used because the tea plant has a long life span. Usually, old sticks are used for firewood for residents. The acquisition of old stems is usually at the time of pruning tea plants, pruning tea plants is done about once every 6 months to support new and good quality tea leaves.

Table 1. Tea Plant Organs That Can Be Used

No.	Tea Plant Organs	Special Uses
1	Young Leaves	Making green tea and white tea beverages
2	Old Leaves	Making black tea beverages and natural compost
3	Young Stems	Tea drink mixture
4	Old Trunk	Firewood

From Figure 5, as much as 32% of the people of Ngargoyoso District know the ethnobotanical aspects of the tea plant and 68% do not know the ethnobotanical aspects of the tea plant. The tea plants in Ngargoyoso can only be used as medicine, daily drinks, and firewood. The only used parts of the tea plant are the leaves and stems. The roots, seeds, and flowers of the tea plant cannot be used because from generations there is no benefit that is specific to this part. Therefore, the use of tea plants in Ngargoyoso, Karanganyar Regency, Central Java, has not had any special innovations and benefits.

Figure 6. a. Young Leaves; b. Old Leaves; c. Young Steams of Tea Plants

4. CONCLUSION

From the ethnobotani aspect of tea plants, there are 96% of people who like tea drinks. As much as 74% is used for daily drinks and the rest is used as medicine. Public knowledge about the ethnobotanical aspects of tea plants is low because only 32% of people know about the ethnobotanical aspects of tea plant organ parts that can be used. The only parts of the tea plant that can be used are young leaves for making green tea, shoots or buds of young leaves for making white tea, old leaves for making black tea, young stems for tea mixtures, and old stems for firewood. This tea plant thrives at an altitude of 1,114 m asl.

5. REFERENCES

Anjarsari, I. R. (2021). Pengaruh metode pemangkasan dan pendekatan hormonal terhadap analisis pertumbuhan tanaman teh klon GMB 7 pada periode pemetikan produksi. Kultivasi, 20(1), 62-71. https://doi.org/10.24198/kultivasi.v20i1.31982

Azurianti, R. W. (2022). Kajian Hubungan Hara Tanah Terhadap Produktivitas Tanaman Teh Produktif Di Perkebunan Teh Pagar Alam Sumatra Selatan. Jurnal Tanah dan Sumberdaya Lahan, Azurianti, R. W., Athallah, F. N. F., & Prijono, S. (2022). Kajian Hubungan Hara Tanah Terhadap Produktivitas Tana9(1), 153-161. doi: 10.21776/ub.jtsl.2022.009.1.17

Choiriyah, N. A. (2021). KOMPOSISI KIMIA, POTENSI ANTIOKSIDAN DAN ANTIMIKROBA SERTA MANFAAT KESEHATAN TEH PUTIH. Jurnal Industri Hasil Perkebunan, 16(2), 97-104. http://dx.doi.org/10.33104/jihp.v16i2.6689

Fezih, F. N. (2018). Studi etnobotani tumbuhan obat di Desa Wonoharjo, Kabupaten Pangandaran, Jawa Barat. Jurnal Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia, 122-132. DOI: 10.13057/psnmbi/m040205

Hayati, A. W. (2022). KANDUNGAN GIZI DAN MANFAAT TEH HERBAL. uwais inspirasi indonesia.

Jain., S. (2018). Manual of Ethnobotany. India : Scientific Publisher.

Juandi, R. (2020). Pengelolaan Usaha Perkebunan Berkelanjutan Terhadap Keberadaan Kearifan Lokal Pada Masyarakat Hukum Adat Suku Dayak Ngaju Di Kabupaten Seruyan Kalimantan Tengah. Jurnal Hukum, 1-10.

Karina, N. (2022). Etnobotani Pemanfaatan Berbagai Jenis Pisang (Musa spp) Oleh Masyarakat Desa Makarti Kecamatan Tumijajar Kabupaten Tulang Bawang Barat. Lampung: Doctoral dissertation, UIN RADEN INTAN LAMPUNG.

Kurniati, Y. D. (2022). Etnobotani Tanaman Pangan di Desa Cigedug Kabupaten Garut. SAINTIFIK, 8(2), 151-158. DOI:10.31605/saintifik.v8i2.340

Mutmainnah, A. T. (2020). Keragaman Familia Tumbuhan Obat Masyarakat Kota Parepare Sulawesi Selatan. bionature, 21(2).

Njatrijani, R. (2018). Kearifan Lokal Dalam Perspektif budaya Kota Semarang. . Gema Keadilan, 16-31. DOI: https://doi.org/10.14710/gk.2018.3580

Nugroho, A. A. (2020). MANFAAT EKSTRAK TEH HIJAU TERHADAP PENURUNAN BERAT BADAN. Jurnal Ilmiah Keperawatan dan Kesehatan Alkautsar (JIKKA), 1(1).

Nuraeni., S. S. (2022). Kajian Etnobotani Tanaman Rempah Sebagai Bumbu, Obat, dan Kias. Umbara, 7(2), 27-38. DOI: https://doi.org/10.24198/umbara.v7i2.39395

Nurchayati, N. &. (2019). Pengetahuan Lokal Tanaman Pangan dan Pemanfaatannya pada Masyarakat Suku Using Kabupaten Banyuwangi. Biotropika: Journal of Tropical Biology, 7(1), 11-21. https://doi.org/10.21776/ub.biotropika.2019.007.01.02

Pebiana, N. P. (2020). Kajian Etnobotani Loloh dan Teh Herbal Lokal sebagai Penunjang Ekonomi Kreatif Masyarakat Desa Tradisional Penglipuran Kabupaten Bangli-Bali. Bioma: Berkala Ilmiah Biologi, 23(2), 91-99. DOI: https://doi.org/10.14710/bioma.23.2.91-99

Rahimah, R. H. (2019). Kajian Etnobotani (Upacara Adat Suku Aceh Di Provinsi Aceh). BIOTIK: Jurnal Ilmiah Biologi Teknologi dan Kependidikan, 6(1), 53-58. http://dx.doi.org/10.22373/biotik.v6i1.4045

Rahmanisa, S. &. (2016). Pengaruh ekstrak teh hijau terhadap penurunan berat badan pada remaja. Jurnal Majority, 5(2), 106-111.

Robi, Y. &. (2019). Etnobotani rempah tradisional di desa empoto kabupaten sanggau kalimantan barat. Jurnal Hutan Lestari, 7(1). DOI: http://dx.doi.org/10.26418/jhl.v7i1.31179

Rosniawaty, I. A. (2020). Studi ekofisiologis tanaman teh guna meningkatkan pertumbuhan,. Jurnal Kultivasi, 19(3), 1181-1188. DOI : https://doi.org/10.24198/kultivasi.v19i3.26623

Safitri, I. A. (2018). Manajemen Pemangkasan Tanaman Teh (Camellia sinensis (L.) O. Kuntze) di Unit Perkebunan Tambi, Jawa Tengah. Buletin Agrohort, 6(3), 344-353. DOI: https://doi.org/10.29244/agrob.v6i3.21098

Silalahi, M. N. (2022). Kajian Etnobotani Tumbuhan Obat Oleh Masyarakat Lokal Etnis Batak Mandailing Di Desa Tanjung Julu, Kabupaten Mandailing Natal, Sumatra Utara. AL-KAUNIYAH: Jurnal Biologi, 5(1), 107-120.

Syafitri, E. R. (2020). Studi Kepustakaan Teori Konseling Dialectical Behavior Therapy. Jurnal BK Universitas Negeri Surabaya,, 11, 53-59.

Tuty, A. A. (2020). Proses Dan Manfaat Teh. Yogyakarta: GUEPEDIA.

Widana, I. N. (2021). Etnobotani Tabia bun (Piper retrofractum Vhal.) (Kajian Teoritik). Jurnal Emasains: Jurnal Edukasi Matematika dan Sains, 10, 2124. DOI: https://doi.org/10.5281/zenodo.5472059

Widyastuti, I. B. (2021). Pengaruh Media pada Karakter Biokimia dan Keberhasilan Pencangkokan Tanaman Teh (Camellia sinensis L.(O.) Kuntze) pada Klon TRI 2025. Jurnal Ilmu Pertanian Indonesia, 26(1), 113-119. DOI: https://doi.org/10.18343/jipi.26.1.113

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Scientific Learning with PJBL and PBL Models of Science Process Skills Student Learning Outcomes

Farid Nur Yusron*, Sarwanto, Mohammad Masykuri
Science Education Department Faculty Eleven University Teacher Training and Education March. Jalan Ir. Sutami 36 Kentingan, Jebres, Surakarta 57126, Central Java, Indonesia
*Corresponding Author. E-mail address: faridnuryusron@gmail.com

KEYWORDS:
Project Based Learning, Problem Based Learning, Science Process Skills

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

This study aims to determine 1. differences in student learning outcomes based on high and low science process skills. 2. interaction between project-based learning and problem-based learning models with science process skills on student learning outcomes. This research uses experimental research with a research design using a 2x2 factorial design. Sampling using purposive sampling. The sample of this research was 43 students of 8th grade of Islamic Junior High School. The instrument used is the treatment instrument namely lesson plans, worksheets. The data collection instrument was a test of learning outcomes in terms of knowledge and science process skills, an attitude aspect questionnaire and an observation sheet for skills learning outcomes. Data analysis using SPSS 16.0. The results of the study concluded that: 1. There were differences in learning outcomes in the aspects of knowledge, attitudes and skills between students who were given learning using project-based learning and problem-based learning models who had high and low science process skills. The scores of knowledges, attitudes and skills of students who were given project-based learning were 82.24 78.10 and 83.67 respectively, while students who were given problem-based learning were 80.00 72.59 and 80.64. 2. There is interaction between the project-based learning model and the problem-based learning model on student learning outcomes because the Anava Test also shows 3 aspects of learning outcomes have a p-value <0.05, which means there is interaction in the Project Based-Learning and Problem models -Based learning with science process skills to the results of learning aspects of knowledge, attitudes and skills.

1. INTRODUCTION

The quality of education is something that is always sought to be improved by changing the educational paradigm, including at the junior high school level. Scientific learning has the goal of improving students' thinking skills, and can form students sensitive to a problem so they are able to solve it, and can train students to communicate ideas or ideas in learning.

Education in schools must have the characteristics of complex knowledge with processes that are able to shape the intelligence, skills and attitudes of students according to their needs, so that students will become students who develop even better. The characteristics of science that can be applied to science learning include empirical, systematic, objective, analytical and verification. However, learning that does not go through a scientific process can cause students to not have direct experience of the theory that has been presented. So that science process skills in learning activities of the respiratory system material are very helpful in showing actual skills or abilities. Based on the results of observations that had been made before the research, namely the science process skills in schools so far were still relatively low which resulted in inadequacies in the learning process.

Science process skills are closely related to science learning which of course requires a model that is appropriate to the material of the respiratory system, such as the selection of *Project Based Learning* models and *Problem Based Learning*. Science process skills themselves are a learning approach that is used to develop the physical and psychological abilities of students even better, but these abilities are still simple and need stimulation in order to show their true identity (Omar, 2013).

Based on the observations and research that has been done, the *Project Based Learning* model can be suggested for educational practitioners, especially science learning as a consideration as an alternative to the *Project Based Learning* (PJBL) model that can be applied in class in order to increase student learning creativity to design a project and train students. critical thinking. The next alternative uses the *Problem Based Learning* (PBL) model because it has the characteristic of authentic investigation which can make students carry out objective investigations in the form of formulating problems, making hypotheses, collecting data, analyzing data, conducting experiments and drawing conclusions (Triyanto, 2007). So that the PBL and PjBL learning models are very suitable for use in developing students' science process skills in the learning process. Project-based learning can train students to use their attitudes, skills and knowledge to solve problems and adapt to unwanted circumstances in life (Chang et al, 2011).

Skills in the field of science include: observing, grouping, communicating, measuring, recognizing and using the relationship between time and space, making inferences, making operational definitions, developing hypotheses, controlling variables, analyzing data and conducting experiments (Omar, 2013). Science is a way of working, a way of thinking and solving problems, not just information about facts and concepts (Sudana, 2010). Project Based Learning is a learning model that focuses on the main concepts and principles of a discipline, involving students in problem solving activities. The PjBL model emphasizes learning activities that are relatively long duration, holistic-interdisciplinary, student-centered, and integrated with real-world practices and issues (Ngalimun, 2012), while the Problem Based Learning model is a learning model based on a problem and can be provide active learning conditions to students (Arends, 2008).

Science learning is a process related to finding out about objects and living things in the surrounding environment objectively. Science is a process of discovery that involves concepts, facts and principles (Depdiknas, 2006). Through science process skills, students are expected to gain new knowledge and be able to develop it. Process skills put forward in the growth and development of skills possessed by students. Science process skills can make students process information so that new things are found in the form of concepts, facts and the development of attitudes and values (Wibowo, 2012). Learning is a process of changing behavior as a result of interaction with the environment in order to meet the needs of life (Saiful, 2005).

Based on observations at Islamic Junior High School of Surakarta, it shows that teachers still use learning methods that communicate in one direction and do not involve science process skills, so that learning still prioritizes cognitive aspects, and does not consider much of the processes carried out by students. The aims of this study were: 1. To find out the differences in student learning outcomes at Islamic Junior High School of Surakarta based on high and low science process skills. 2. Knowing the interaction between *Project Based Learning* models and *Problem Based Learning* with science process skills on student learning outcomes at Islamic Junior High School of Surakarta.

2. MATERIALS AND METHODS

This study used an experimental method with the Project Based Learning model and problem based learning with a population of 43 grade 8 students at Islamic Junior High School of Surakarta for the 2021/2022 academic year. Sampling used purposive sampling, namely by direct selection carried out in class 8 A as the experimental class I and class 8 B as the experimental class II. The experimental class I used the project based learning method and the experimental class II used the

problem based learning method. Data collection methods: observation, documentation, and tests. The research design uses a 2x2 factorial design:

Table 2.1. Research design

Moderator Variable	Variabel Bebas	
	Model *Project Based Learning* (A1)	Model *Problem Based Learning* (A_2)
Higher Science Process Skills (B1)	A_1B_1	A_2B_1
Higher Science Process Skills (B2)	A_1B_2	A_2B_2

Keterangan :

A_1 : Model *Project Based Learning*
A_2 : Model *Problem Based Learning*
B_1 : Higher Science Process Skills
B_2 : Higher Science Process Skills

3. RESULTS AND DISCUSSION

The data that has been collected in this study include: 1) Science Process Skills, 2) Learning Outcomes include aspects of knowledge, attitudes and skills. Data obtained from class 8A as a class with a *Project based learning* model and class 8B with a Problem based learning model. The research data was taken during the learning activities (aspects of skills) and after teaching and learning activities (aspects of knowledge and attitudes). The purpose of this research itself is to determine differences in student learning outcomes based on high and low science process skills, and to determine interactions between *Project based learning and Problem based learning* models with science process skills on student learning outcomes.

Table 3.1 Average Student Learning Outcomes by Model *Project Based Learning* and *Problem Based Learning*

Learning model	Learning outcomes		
	Knowledge	Attitude	Skills
Project Based Learning	84,24	78,10	83,67
Problem Based Learning	80,00	72, 59	80,64

Based on the results of research that has been done on the knowledge aspect of the *project based learning* model 84.24 and the problem based learning model 80.00 while the results on the attitude aspect of the project based learning model are 78.10 and the *problem based learning* model is 72.59. The results on the skill aspect of the *project based learning* model were 83.67 and the problem based learning model was 80.64. So it can be seen that learning with project-based learning and problem-based learning models is not too different, because the use of project-based learning and problem-based learning models is something students are still new to. In addition, the direct involvement of students during learning activities also affects student learning outcomes.

Table 3.2 Average Learning Outcomes based on Science Process Skills

Science Process Skills	**Learning outcomes**		
	Knowledge	**Attitude**	**Skills**
High Science Process Skills	85,48	82,05	85,21
Low Science Process Skills	75,00	67,48	70,75

The mean of learning outcomes based on Science Process Skills contained in the aspect of student knowledge, obtained students with high science process skills, namely 85.48, while

students who had low science process skills, namely 75.00. For the results on the attitude aspect of science process skills the highest average is 82.05 and students who have low science process skills are 67.48. And the results on the skills aspect of students who have high science process skills are 85.21, then students who have low science process skills are 70.75. Based on the three aspects that have been carried out in this study, the learning outcomes of students who have high science process skills have a better average than students who have low science process skills, namely excelling in the aspects of knowledge, attitudes and skills.

Project based learning is able to train students to use their attitudes, knowledge and skills to solve problems and be able to adapt to unwanted or unwanted circumstances in life (Chang et al, 2011). *Project Based Learning* has several characteristics by using science process skills such as students being able to make decisions about a framework, being able to pose a problem or challenge to students, being able to design processes to determine solutions to problems, being able to be collaboratively responsible for accessing and managing information to solve a problem, an evaluation is carried out continuously, can reflect on the activities that have been carried out (Daryanto, 2014).

Science process skills have a characteristic in the form of a learning process that can provide learning experiences to students, so that students have many skills such as: physical skills, psychological skills, and social skills. Teacher competence is needed in the application of process skills so that students' teaching and learning activities can have comprehensive capabilities (Epon, 2013).

Based on the results of the Test of Between Effects, the calculated F value = 0.087 with p-value = 0.048 then H0 is accepted, which means that there is interaction in the Project Based Learning and Problem Based Learning models with science process skills on learning outcomes aspects of knowledge, attitudes and skills influencing learning outcomes good student. In the research that has been carried out, it has produced several findings, including: project-based learning and problem-based learning models in terms of science process skills can affect student learning outcomes, namely learning that is not too much different, because it includes new things that students know and are able to affect student learning outcomes. Project based learning and problem based learning models are able to facilitate students in solving a problem and finding their own concepts about respiratory system material in grade 8 in everyday life. For students when they find something new that is fun for students, so that it can cause students' learning motivation to increase so students don't feel bored in participating in learning activities. The real environment can provide important stimulation for students in learning and exploring and discovering something new for themselves (Ristanto, 2010).

The results of research that has been done there is an interaction between project based learning and problem based learning with Science Process Skills on learning outcomes. Through hypothesis testing, a p-value <0.05 is obtained, which means that there is an interaction between project-based learning and problem-based learning with science process skills on learning outcomes in knowledge, attitudes and skills aspects. As in research, the project-based learning model for students is more fun in determining methods and performance, so high creativity is required, whereas in the problem-based learning model students still receive guidance from the teacher in solving problems.

Science process skills (KPS) can be developed using two models, namely project based learning and problem based learning in terms of student learning outcomes through written and oral tests. The development of KPS (Science Process Skills) can be carried out with practical activities in learning such as material on the respiratory system in humans. The division of KPS (Science Process Skills) consists of ten stages including: observing (observation), interpreting, making classifications, making estimates, communicating, making temporary conjectures, making plans, conducting experiments, applying concepts, making questions and concluding (Nuryani, 2005).

KPS (Science Process Skills) students will be more involved and interact so that students who have high science process skills will try to understand concepts quickly. In the project based learning model students are more free in determining how and how to perform, students are

required to have high creativity, whereas in the problem based learning model students still receive guidance from the teacher in solving the problem. However, the two models have similar characteristics and characteristics in the application of KPS (Science Process Skills) which are used for learning outcomes, namely the teacher as a facilitator, student-centered learning, training students to think critically in solving a problem, and training students to seek various sources of information.

Based on the factors described above, that the *project based learning* and *problem based learning* models affect the teaching and learning process of students, there are 2 factors that can influence, namely internal factors and external factors. Internal factors are factors that exist within the individual, while external factors are factors that exist outside the individual (Slameto, 2010). If in the learning process students do not fulfill these factors properly, it will also affect the learning outcomes achieved by students. Therefore, to achieve learning outcomes, teachers must also pay attention to these factors so that learning outcomes can be achieved. In this study, the material used is the respiratory system in humans, including:

3.1. Structure and Function of the Respiratory Tract

The respiratory tract is divided into two parts, namely the upper respiratory tract and the lower respiratory tract. The upper respiratory tract includes the nostrils, nasal cavities, pharynx and larynx. The lower respiratory tract consists of the trachea, bronchi, bronchioles and lungs (Young, 2007).

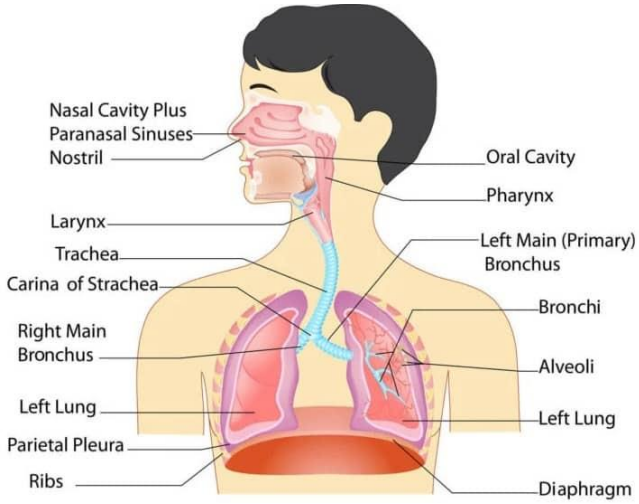


Figure 1. Respiratory Tract
Source: Mulyani (2013)

3.2.Breathing Mechanism

The process of breathing is divided into two, namely inspiration (inhale) and expiration (exhale). The respiratory center is very sensitive to excess CO2 levels in the blood and deficiencies in the blood (Syaifuddin, 2006).

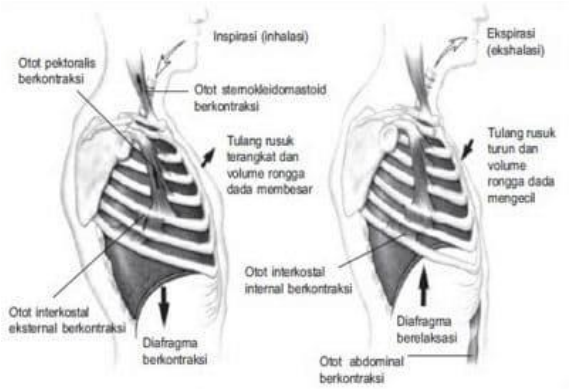


Figure 8. Breathing Mechanism
Source: Britannica (2006)

Chest breathing occurs when the muscles between the outer ribs contract or contract, the ribs lift up so that causes the chest cavity to expand which causes the air pressure in the chest to decrease so that air enters the body (Mulyani, 2013).

3.3. Gas Exchange Process

The process of exchanging oxygen and carbon dioxide occurs in the lungs, especially in the alveoli because the walls of the alveoli are attached to blood capillaries.

3.3.1. Oxygen Transport

3.3.2. Transport Carbon Dioxide

3.4. Breathing Speed and Control

3.4.1. Control By Nerves

The respiratory center is an automatic center within the medulla oblongata that transmits efferent impulses to the respiratory muscles.

3.4.2. Chemical Control

This chemical factor is the main factor in controlling and regulating the frequency, speed, and depth of respiratory movements. The respiratory center in the marrow is very sensitive to chemical reactions.

3.5. Breathing Air Volume and Capacity

The volume of air in the lungs and the rate at which it is exchanged inspiration and expiration can be measured through a spirometer (Setiadi, 2007).

3.5.1. Volumes

3.5.2. Capacity

3.6. Abnormalities, Disorders and Diseases of the Respiratory System

Setiadi (2007) in his book describes several abnormalities in the respiratory system:

3.6.1. Hypoxia (anoxia)

3.6.2. Hypercapnia

3.6.3. Hypocapnia

3.6.4. Asphyxia (suffocation)

3.6.5. Dyspnea

4. CONCLUTIONS

There are differences in learning outcomes in the aspects of knowledge, attitudes and skills between students who are given learning with project-based learning models and problem-based learning who have high and low science process skills. _ Scores of knowledge, attitudes and skills provided by students _ Project based learning respectively 8 2, 24 78, 10 and 8 3, 6 7 while students given problem based learning 80.00 72.59 and 8 0.64 . There is an interaction between the project-based learning model and the problem-based learning model on student learning outcomes because the ANOVA test also shows 3 aspects of learning outcomes have a p-value <0.05, which means H0 is rejected.

5. REFERENCES

Arends Richard. 2008. *Learning to Teach*. New York: McGraw Hill Company.

Chang, C. S., Wong, W. T., & Chang, C. Y. 2011. Integration of project based learning strategy with mobile learning: case study of mangrove wetland ecology exploration project. Tamkang Journal of Science and Engineering, 14 (3), 265 – 273.

Daryanto. 2014. Pembelajaran Tematik Terpadu Terintegrasi Kurikulum 2013. Yogyakarta: Gava Media.

Depdiknas. 2006. Model Silabus dan Rencana Pelaksanaan Pembelajaran Mata Pelajaran Ilmu Pengetahuan Alam. Jakarta: Badan Standar Nasional Pendidikan.

Epon Ningrum. 2013. Pengembangan Strategi Pembelajaran. Bandung: Putra Setia.

Ngalimun. 2012. *Strategi dan Model Pembelajaran.* Yogyakarta: Aswaja Presindo.

Nuryani, Y. Rustaman, dkk.2005.*Strategi Belajar Mengajar Biologi*. Malang: Universitas Negeri Malang Press.

Omar Hamalik.2013. *Kurikulum Dan Pembelajaran.* Jakarta: Bumi Aksara.

Saiful Sagala. 2005. *Konsep dan Makna Pembelajaran*. Bandung: Alfabeta.

Slameto. 2010. *Belajar dan Faktor-faktor yang Mempengaruhinya*. Jakarta: Rineka Cipta.

Sudana. 2010. *Bahan Ajar Pendidikan IPA SD*. Singaraja: FIP Undiksha.

Triyanto. 2007. *Model-model Pembelajaran Inovatif Berorientasi Konstruktivisme*. Jakarta: Prestasi Pustaka.

Wibowo. Pandu H. 2012. ”Pengaruh Penggunaan Modul Hasil Penelitian Bentos Pada Pokok Bahasan Pencemaran Lingkungan Terhadap Keterampilan Proses Sains Siswa Kelas X SMA Negeri 1 Mojolaban”. (Jurnal Pendidikan Biologi, 1 (11): 7.

Wulandari, Ade Sintia; I Nyoman Suardana dan N.L. pande Latria Devi. 2019. “Pengaruh Model Pembelajaran Berbasis Proyek Terhadap Kreativitas Siswa SMP Pada Pembelajaran IPA”. *JPPSI: Jurnal Pendidikan dan Pembelajaran Sains Indonesia* ISSN: 2623-0852 Volume 2, Nomor 1. Singaraja: Universitas Pendidikan Ganesha

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

WATER QUALITY IN SATUI RIVER AND HISTOLOGICAL STRUCTURE STUDY OF LIVER OF BAUNG FISH (*Mystus nemurus*)

Dinda Triana, Heri Budi Santoso*, Anang Kadarsah
Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Lambung Mangkurat. Jl. A. Yani KM 36 70174 Banjarbaru, Kalimantan Selatan, Indonesia
*Corresponding Author. E-mail address: heribudisantoso@ulm.ac.id

KEYWORDS:
Histopathology
Quality
River
Water

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

Satui River is a river that has quite dense activity along the river flow, this is thought to result in a decrease in the quality of river waters. Fish is one of the organisms that can be used in tests to determine some chemical contamination in an aquatic environment. Baung fish are widely found in the waters of the Satui river and baung fish is thought to have properties that are sensitive to environmental changes. Histopathological testing in fish can provide a picture of tissue changes such as the kidneys and liver. Preparation of histological preparations using the paraffin method. Water quality analysis is compared with PP Water Quality Standard No. 22 of 2021 and analyzed using the Pollution Index method. Qualitative histopathological analysis is carried out by descriptive and quantitative analysis using scoring. The conclusion of this study is that the quality of the satui river is classified as lightly polluted with a value of P1 1.11 and P2 2.31. Histopathological damage to the liver of baung fish includes fat degeneration, congestion and necrosis.

1. INTRODUCTION

Satui River is a river that flows through the Tanah Bumbu district, the Satui subdistrict to be precise. This river has a length of 58,596.66 m and passes through several villages in the Satui sub-district, one of which is the East Satui village. Heavy activities along the Satui river in the East Satui village area, such as the transportation of fishing boats or large ships, agriculture, mining and households are suspected of causing water pollution. As a result of the influence of increased human activity that utilizes waters can produce uncontrolled waste, so that the waters will experience pressure (stressed), which tends to lead to a decrease in water quality (Yulista, 2020).

The quality of a water is very important because it is related to the biota that live in it. Polluted waters will result in contamination of biota that live in these waters and become unsafe for consumers who consume them (Dwiyitno *et al.*, 2008). Menurut Geonarso (1988) fish is one of the organisms that can be used in tests to determine the toxic effects of several chemical contaminants in an aquatic environment. baung fish (Mystus nemurus) is a fish native to Indonesian waters and has high economic value in South Kalimantan, because the meat has a delicious taste and has a high selling value (Komari *et al.*, 2012). Biologically, the baung fish grows and develops in tropical waters but its adaptability is relatively low, it can respond quickly to environmental changes and disease attacks. Biota that is sensitive to a water condition can be part of a biological indicator that can easily reflect the quality of an ecosystem (Muhammad & Triyoni, 2018).

Histopathological testing on fish can provide an overview of tissue changes that are thought to be due to exposure to environmental pollutants through microscopic observation through stained preparations. Tissues that can be used as indicators for observations such as kidneys and liver (Safratilofa, 2017). The increase in anthropogenic activities of the people of East Satui Village along the banks of the Satui river is thought to have resulted in a decrease in the quality of river

waters and tissue damage to aquatic biota, namely fish due to contaminants that enter the fish's body. Therefore, it is necessary to carry out research related to monitoring the quality of the Satui river waters, through measuring water quality parameters and making histological preparations of baung fish by looking at the damage that occurs in the liver.

2. MATERIALS AND METHODS

2.1. Tools and materials

The tools used in this study included fishing rods, surgical instruments, microscopes, thermometers, smartphones, bottles, pipettes, ovens, paraffin molds, microtome, microtome knife,waterbath,cover glass, object glass,refrigerator, digital DO meter, desiccator containing silica gel, oven, analytical balance and vacuum pump, UV-vis spectrophotometer, DO bottle, incubator, and DO meter. The materials used in this study included label paper, latex, distilled water, 10% BNF, series alcohol (70%, 80%, 90%, 95%, 100%), xylol, paraffin, distilled water, eosin, gelatin, haematoxylin, paraffin, xylol, Whatman Grade 934 AH filter paper with 1.5 µm pore size, and distilled water, concentrated sulfuric acid solution anddigestive solution and tissues.

2.2. Metode

2.2.1. Research Location Profile

This research was conducted in the Satui river, Satui Timur Village, Satui District, Tanah Bumbu Regency. The research was conducted in February-May 2023. Satui Timur Village has an area of approximately 33,825.4 Ha. Satui Timur Village is a village located in the lowlands, to be precise on the banks of the Satui river in the Satui sub-district. The Satui River has a length of 58,596.66 m, which originates from the Batulaki River and flows down to the West Satui coast.

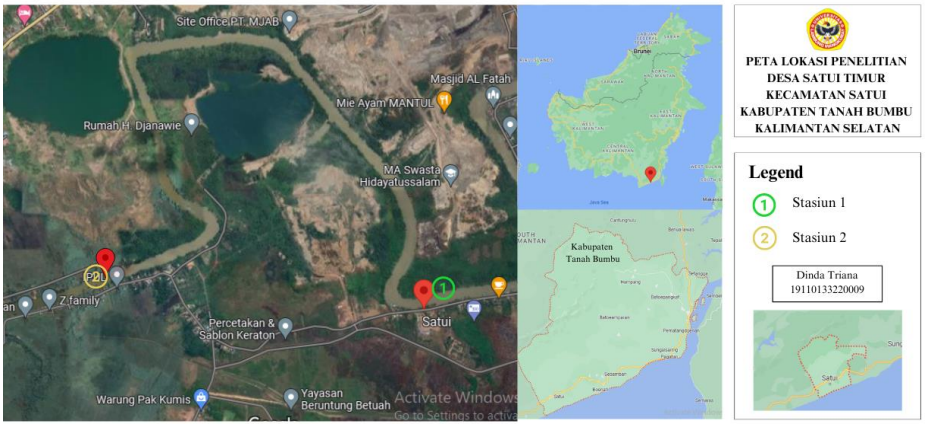


Figure 1. Research Location

2.2.2. Sampling

The collection was carried out on the outskirts of the Satui River, Satui Timur Village. Water samples were taken using plastic bottles. Sampling of baung fish (*Mystus nemurus*) carried out using fishing rods and trap tools assisted by fishermen. Fish were taken as many as 6 fish at each station, namely the area of ship activity and dense population. The size of the fish taken is done randomly, then the fish is put in a medium-sized container and given a little river water.

2.2.3. Water Quality Analysis

Water quality analysis was carried out using physical and chemical parameters. Physical parameters used include temperature, TSS and salinity. The chemical parameters used include pH, BOD, and DO in accordance with the test method that refers to the applicable SNI as shown in the following table.

Tabel 1. Parameter Physics, chemistry and methods of analysis

No	Parameter	Unit	Method Specifications
Field			
1.	Suhu	℃	Thermometer
2.	Ph	-	pH indicator
Laboratory			
3.	BOD	mg/L	SNI 6989.72:2009
4.	TSS	mg/L	SNI 06-6989.3:2019
5.	COD	mg/L	SNI 6989.2:2019
6.	DO	Mg/L	DO meter digital

2.2.4. Making Histological Preparations

Histological preparations carried out in this study used the liver of baung fish(*Mystus nemurus*).Preparation of preparations begins with fish surgery and taking liver organs. The next step is to fix the liver of the baung fish in 10% BNF, followed by graded dehydration in 70%, 80%, 90%, and absolute alcohol. Furthermore, celaring was carried out in xylol for 2 repetitions and continued with infiltration 2 repetitions for 1.5 hours each. After that, it is planted in a paraffin block until it is ready to be cut. Tissue band cutting was performed using a microtome with a thickness of 5 microns. Then, do the coloring using dyes 5 Author et al. Making histological preparations using the paraffin method refers to Angka *et al* (1984) which has been modified.

2.2.5. Analisis Data

Data analysis in this study consisted of 2 stages, namely water quality analysis and histopathological analysis. Analysis of water quality is compared according to the Water Quality Standards stipulated based on Government Regulation Number 22 of 2021 concerning Implementation of Environmental Protection and Management regarding Designation of River Water Quality Standards. Then, it was analyzed using the Pollution Index method based on the Decree of the State Minister for the Environment Number 115 of 2003. Based on the IP index class, if the score is $0 \leq Pij \leq 1.0$ then the status of the waters is classified as good, if the score is $1.0 < Pij \leq 5.0$ then the status of the waters is classified as lightly polluted, if the score is $5.0 < Pij \leq 10$ then the status of the waters is classified as moderately polluted and if the score is $Pij > 10$ then the status of the waters is classified as heavily polluted, analysis of pollution indices is carried out using the help of Microsoft Excel.

Histopathological analysis was carried out qualitatively and quantitatively. Qualitative analysis was carried out descriptively by observing histopathological images on liver preparations microscopically by comparing the histological images obtained with references.Atlas of Fish Histologyand other references (Genten *et al.*, 2009). Then, a quantitative analysis was carried out using the scoring method. The percentage value of damage and scoring is if the damage is 0-25% = 0 is normal, 25%-50% = 1 is mild, 50%-75% = 2 is moderate, and more than 75% = 3 is severe or severe (Lestari *et al.*, 2018).

Tabel 2. Water quality status based on Pollution

No	IP Value	Water Qualitu Status
1.	$0 \leq IP \leq 1,0$	According to Quality Standards
2.	$1,0 < IP \leq 5,0$	Light Polluted
3.	$5,0 < IP \leq 10$	Moderate Polluted
4.	$IP > 10$	Heavily Polluted

Table 3. Histopathological Damage Scoring Value

Damage (%)	Score	Category
< 25%	0	Normal
25% - 50%	1	Light
50% - 75%	2	Keep
>75%	3	Heavy

3. RESULTS AND DISCUSSION

3.1.Result

3.1.1. River Water Quality Measurement

Tabel 4. River Water Quality Measurement Results

No	Parameter	Unit	Average		Class II Quality Standard According to PP No 22 Th 2021
			P1	P2	
1.	pH	-	7,5	8	6 sd 9
2.	Suhu	℃	27	28,5	28-30
3.	BOD_5	mg/l	2,9	7,8	3
4.	COD	mg/l	0	27	25
5.	DO	mg/l	6,45	5,3	4
6.	TSS	mg/l	36,1	27,5	50

Description: P1 (1st sampling) & P2 (2nd sampling)

3.1.2. Pollution Index Value

Tabel 5. River Pollution Index

Average Pollution Index Value		Index Pollution	Category
P1	P2		
1,11	2,31	1,0<IP≤5,0	Light Polluted

Description: P1 (1st sampling) & P2 (2nd sampling)

3.1.3. Histopathological Picture

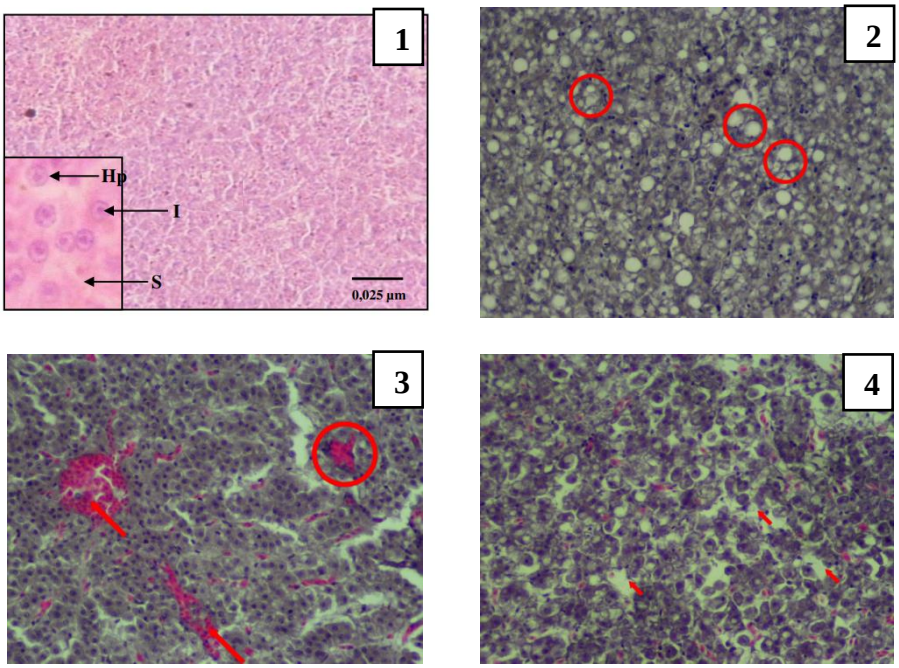


Figure 1. Normal liver structure consists of Hp (Hepatocyte), I (cell nucleus), S (Sinusoids) (1) (HE, 400X) (Jumaida *et al.*, 2022), Liver Pathology showing Cell Degeneration (2), Liver Pathology showing

Congestion (3), Liver Pathology showing Necrosis (4), Magnification 400x, 5µm.

Tabel 6. Liver Histological Damage Score Average *Mystus nemurus*

No	Group	Stasiun	Liver Histology Damage Score (Mean ±SD)		
			Degenerasi	Congestion	Nekrosis
1	P 1	1	0.26 ± 0.30^{a}	0.13 ± 0.23^{a}	0.13 ± 0.23^{a}
		2	0.06 ± 0.11^{a}	0.60 ± 0.20^{a}	0.00 ± 0.00^{a}
2	P 2	1	0.00 ± 0.00^{a}	0.93 ± 0.61^{a}	0.00 ± 0.00^{a}
		2	0.33 ± 0.30^{a}	0.66 ± 0.98^{a}	0.33 ± 0.57^{a}

Note: Numbers followed by the same letter in the same column show no significant difference

3.2. Discussion

The quality of the river will undergo changes in accordance with the development of the river environment which is influenced by various activities and human life ((Mardhia & Abdullah, 2018). The water quality of the Satui River, seen from the physical and chemical parameters of the water, indicates that there has been a decrease in quality. This can be seen from several water quality parameters that have exceeded the quality standards required in Government Regulation Number 22 of 2021 concerning Implementation of Environmental Protection and Management regarding Designation of River Water Quality Standards.

The results of measuring the degree of acidity of the Satui river water showed that the pH of the water in the 1st and 2nd sampling was in normal conditions in the range 6-9 at class II water quality standard. The increase in PH from the 1st sampling was 7.5 with the 2nd being 8. According to Yuliastuti (2011), the increase in the value of the degree of acidity or pH was influenced by organic and inorganic waste that was disposed of into the river. so that the increase in the pH of the Satui river water from the 1st and 2nd samples was due to industrial, domestic and waste disposal activities from agricultural activities that entered the Satui river. As a result of the waste released by the industry can cause a decrease in the pH value which will be fatal to aquatic organisms (Yulis, 2018).

The results of measuring the temperature of the Satui river water, taking the 1st and 2nd samples, which include stations 1 and 2, show that the water temperature is between 27-29℃. The highest temperature on the 2nd sampling reached 29℃. The optimum temperature for the life of organisms in water is 25 ℃ to 30 ℃ (Mardhia & Abdullah, 2018). The high water temperature is caused by the high intensity of sunlight entering the water body because the sample measurement location is an open area exposed to direct sunlight. The more intensity of solar radiation that hits a body of water, the higher the temperature of the river water (Marlina *et al.*, 2017).

Chemical Oxygen Demand (COD) shows the amount of oxygen needed to chemically oxidize organic matter, both of which can be degraded biologically (biodegradable) and those that are difficult to biodegrade (non-biodegradable)(Marlina *et al.*, 2017). The results of measuring the COD parameters of the Satui river water showed significant or undetectable results (0) in the 1st sample, while the COD measurement results in the 2nd sample were 27 mg/l. The COD quality standard value according to Government Regulation Number 22 of 2021 is 25 mg/L. The COD value which exceeded the quality standard in the 2nd sampling was possibly caused by the presence of a ship docking near the sampling point and disposal of domestic waste from the surface which was carried away by the currents. A high COD concentration indicates a greater level of pollution that occurs in a waters (Yudo, 2010).

The results of the analysis of the BOD concentration of Satui river water were 2.9 mg/L in the 1st sample, while in the 2nd sample it was 7.8 mg/L. The greater the concentration of BOD indicates that the water has been polluted, the concentration of BOD whose pollution level is still low and can be categorized as good waters has BOD levels ranging from 0 - 10 mg/l, while waters with BOD concentrations of more than 10 mg/l are considered polluted (Mahyudi *et al.*, 2015). From the results of measurements of the BOD parameter in the Satui river, it is still categorized as

good waters, but when compared with the class II water quality standard criteria of 3 mg/L, the Satui river's water quality conditions are not suitable for their designation based on the BOD parameter. A high BOD value indicates a high level of organic matter in water, because the BOD value is a value that indicates the need for oxygen by bacteria to oxidize organic matter in water (Yohannes *et al.,* 2019). The highest BOD level was in the 2nd sample of 7.8 mg/L, this is because in the 2nd sample taken in the morning many residents dispose of domestic waste such as dishwashing waste, bathing and clothing washing waste. In addition, during the second sampling, many ships were moored on the banks of the river. So that many types of pollutant received from domestic waste and industrial waste.

The results of the dissolved oxygen (DO) measurement of Satui river water in the 1st sample were 6.45 mg/L, while in the 2nd sample it was 5.3 mg/L. A water can be said to be good and has a low level of pollution if the dissolved oxygen (DO) level is greater than 5 mg/l (Salmin, 2005), while the dissolved oxygen concentration (DO) in unspoiled waters has a DO value of less than 10 mg/L (Effendi, 2003). When compared with the class II water quality standard for the DO parameter based on Government Regulation Number 22 of 2021, which is 4 mg/l, the Satui river water quality conditions for the DO parameter are still in accordance with their designation, except for the 1st sample. The amount of DO concentration in this water can be influenced by several factors such as TSS content, salinity, temperature, degradation of organic matter (Christiana *et al.,* 2020).

Total Suspended Solids (TSS) are suspended materials (diameter > 1 μm) which are retained on the Millipore filter with a pore diameter of 0.45 μm. TSS consists of silt and fine sand and micro-organisms, which are mainly caused by soil erosion or soil erosion carried into water bodies (Djoharam *et al.,* 2018). . The results of river water TSS measurements in the 1st sample were 36.1 mg/L, while in the 2nd sample they were 27.5 mg/L. The TSS value of the Satui river is still below the threshold for class II water quality standard PP NO 22 of 2021 of 50 mg/L, so it can still be used according to the designation in TSS parameters. The suitability of TSS values for fisheries, according to Effendi, (2003) ranges from 25-80 mg/L. High turbidity values can interfere with the osmoregulation system of aquatic organisms. The results of TSS measurements in the Satui river ranged from 21-37.5 mg/L, this did not affect fish cultivation, because it was in accordance with its designation.

Analysis of River Water Quality Status shows the level of contamination of a water source in a certain time, compared to the set water quality standards. A river is said to be polluted if it cannot be used according to its normal designation. Based on the results of the calculation of the pollution index, it can be seen that there has been an increase from the results of the pollution index taking the 1st sample of 1.11 by the 2nd sample of 2.31. The water quality status of the Satui river is included in the slightly polluted category based on the results of the calculation of the pollution index. This makes the quality of the Satui river water that flows through the East Satui village area cannot be utilized in accordance with Class II water designation, namely water that can be used as water recreation facilities/infrastructure, freshwater fish cultivation, animal husbandry, water for irrigating plantations and or other uses that require the same water quality as said use. So that it is necessary to control pollution of the Satui river water so that it can be utilized and maintain the quality of the Satui river water in accordance with water quality.

This study also showed histological changes in the liver of baung fish. Histological changes in the liver showed cell degeneration, congestion and necrosis. Cell degeneration is characterized by the presence of a cell nucleus that begins to shrink, the color is more intense and in the cytoplasm there are vacuoles which contain fat inside. Degeneration occurs due to the presence of fat that is not removed from the cell (Lekatompessy *et al.,* 2021). According to Silviany's research (2004), states that fish exposed to lead metal causes the liver to experience fatty degeneration so that complex liver functions are lost. Furthermore, cells that experience continuous degeneration will experience congestion (Juanda & Edo, 2018). Congestion is a condition where there is a very dense accumulation of red blood cells in the blood vessels which indicates an abnormal condition in the fish liver (Sulistyorinie *et al.,* 2020). Necrosis is one of the advanced stages of damage to cell

degeneration which is characterized by the loss of tissue structure and the area of necrosis has bleeding spots. With necrosis, there is inflammation in the living tissue (Lekatompessy *et al.*, 2021). Based on the average result, the histopathological scoring value on liver tissue damage is <1, which means normal.

4. CONCLUSIONS

The conclusion of this study is to show that the quality of Satui River waters is classified as lightly polluted based on pollution index analysis with values in the 1st take 1.11 and 2nd 2.31. Histopathological damage to the liver of baung fish includes fatty degeneration, congestion and necrosis.

5. ACKNOWLEDGMENTS

The author thanks Dr. Heri Budi Santoso S.Si, M.Si. and Anang Kadarsah S.Si, M.Sc. who have guided and provided a lot of assistance to the author during the research process to writing this scientific article, as well as all parties who have also helped so that this research is carried out properly and smoothly to completion.

6. REFERENCES

Aliza, D. (2020). Histopathological Picture of Mujair Fish Kidney (Oreochromis mossambicus) exposed to mercury chloride ($HgCl_2$). *Jurnal Ilmiah Mahasiswa Veteriner*, *5*(1). DOI: org/10.21157/j.med.vet..v7i2.2950

BSN. (2019). SNI 6989.72:2009 Test Method for Biochemical Oxygen Demand (Biochemical Oxygen Requests/BOD). National Standardization Body, Jakarta, Indonesia.

BSN. (2019). SNI 6989.2:2019 Closed Reflux COD Analysis by Spectrophotometry. Body National Standardization Body, Jakarta, Indonesia.

BSN. (2019). SNI 6989.3:2019 Total Suspended Solids Test Method (Total Suspended Solids/TSS) Gravimetrically. National Standardization Body, Jakarta, Indonesia.

Camargo, M. M. P., & Martinez, C. B. R. (2007). Histopathology of gills, kidney and liver of a Neotropical fish caged in an urban stream. *Neotropical Ichthyology*, *5*(3), 327–336. DOI. org/10.1590/s1679-62252007000300013

Chamarthi, R. R. (2014). Histopathological Alterations in the Gill, Liver and Brain of *Cyprinus Carpio* on Exposure to Quinalphos. *American Journal of Life Sciences*, *2*(4), 211. DOI: org/10.11648/j.ajls.20140204.14

Christiana, R., Anggraini, I. M., & Syahwanti, H. (2020). Analysis of Water Quality and Quality Status As well as the Pollution Burden of the Mahap River in Sekadau Regency, West Kalimantan. *Jurnal Serambi Engineering*, *5*(2). DOI: org/10.32672/jse.v5i2.1921

Djoharam, V., Riani, E., & Yani, M. (2018). Analysis of water quality and load carrying capacity Pollution of the Pesanggrahan River in DKI Jakarta Province.. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, *8*(1), 127-133. DOI: org/10.29244/jpsl.8.1.127-133

Dwiyitno, Aji, N., & Indriati, N. (2008). Heavy Metal Residues in Fish. *Jurnal Pascapanen Dan Bioteknologi Kelautan Dan Perikanan*, *3*(2), 147–155. DOI: org/10.15578/jpbkp.v3i2.19

Effendi, H. (2003). Study of Water Quality for Resource and Environmental Managemen. Kanisius, Yogyakarta.

Goenarso, D. 1988. Changes in Fish Physiology as an Indicator of the Presence of Insecticides and Detergents In water. Dissertation. ITB. Bandung.

Handy, R. D. and W. S. Penrice. 1993. The influence of high oral doses of mercuric chloride on organ toxicant concentrations and histopathology in rainbow trout, Oncorhynchus mykiss. Comparative Biochemistry and Physiology (C), 106: 717-724. DOI: org/10.1016/0742-8413(93)90232-a

Jumaida, Morina R, S., & Iesje, L. (2022). Histopathology of *Mystus nemurus* Liver That Were Fed With Feed Added With *Psidium guajava* and *Andrographis paniculata* NESS. *Diss. Riau University*, *10*(1), 1–52.

Johnson, W. S., & Allen, D. M. (2005). *Zooplankton of the Atlantic and Gulf coasts: a guide to their identification and ecology*. University Press, Baltimore and London.

Komari, N., Irawati, U., & Novita, E. (2012). Content of Cadmium and Zinc in Baung Fish (Hemibagrus nemurus) in the Trisakti Waters of Banjarmasin, South Kalimantan. *Sains Dan Terapan Kimia*, *7*(1), 42–49. https://ppjp.ulm.ac.id/journal/index.php/jstk/article/view/2119

Lekatompessy, A. A., Pattipeiluhu, S. M., & Pattiasina, B. J. (2021). Histopathology and Expression TNF-α (Tumor Necrosis Factor-α) Against Liver Damage due to Parasite Invasion in Mackerel (Rastrelliger brachysoma). *Jurnal Sumberdaya Akuatik Indopasifik*, *5*(4), 447-452. DOI: org/10.46252/jsai-fpik-unipa.2021.vol.5.no.4.176

Lestari, W. P., N. I. Wiratmini, & A. A. G. R. Dalem. 2018. Histological Structure of Fish Gills Mujair (Oreochromis mossambicus L.) As an Indicator of Water Quality in Lagoon Nusa Dua, Bali. Simbiosis, 6(2), 45-49. DOI: org/10.24843/jsimbiosis.2018.v06.i02.p03

Mahyudin, M., Soemarno, S., & Prayogo, T. B. (2015). Water quality analysis and strategy control of Metro River water pollution in Kepanjen City, Malang Regency. *Indonesian Journal of Environment and Sustainable Development*, *6*(2). https://jpal.ub.ac.id/index.php/jpal/article/view/193

Mardhia, D., & Abdullah, V. (2018). Analysis of the water quality analysis of the Brangbiji river, Sumbawa Big. Journal of Tropical Biology, *18*(2), 182-189. DOI: org/10.29303/jbt.v18i2.860

Marlina, N., Hudori, H., & Hafidh, R. (2017). Effect of Channel Roughness and River Water Temperature on Water Quality Parameters COD, TSS in the Winongo River Using QUAL2Kw Software.Journal of Environmental Science & Technology, *9*(2), 122-133. DOI: org/10.20885/jstl.vol9.iss2.art6

Muhammad R, C dan Triyoni, P. (2018). Bioindicator Concept for Degradation Markers Environment in Indonesia. in Coastal Water Health Monitoring: Potential and Use of Biota Indicators.*Gadjah Mada Press.*, *1*, 1–24.

Parameswari, W., A. D. Sasanti dan Muslim. (2013). Bacterial Population, Histopathology, Survival and Growth of Snakehead Fish Seeds reared in Media with the Addition of Probiotics. Journal of Indonesian Swamp Aquaculture. *1*(1): 76-89. https://ejournal.unsri.ac.id/index.php/jari/article/view/1781

Republic of Indonesia Government Regulation Number 22 of 2021 (2021) concerning Implementation of Environmental Protection and Management. Ministry of Environment. Jakarta.

Purwaningsih, U., Indrawati, A., & Lusiastuti, A. M. (2015). Pathogenesis of Disease Co-Infection Fish Tuberculosis and Motile Aeromonas Septicemia in Gouramy (*Osphronemus gouramy*). Aquaculture Research Journal, *10*(1), 99-107. DOI: org/10.15578/jra.10.1.2015.99-107

Roberts, J. R. (1978). Fish Patalogy. University of Stirling. Scotland. London. 27-282.

Safratilofa, S. (2017). Histopathology of Liver and Kidney of Catfish (*Pangasionodon hypopthalmus*) injected bacteriaAeromonas hydrophila.Journal of River And Lake Aquaculture, *2*(2), 83-88. DOI: org/10.33087/akuakultur.v2i2.21

Sianturi, I. T., Kamlasi, Y., Panuntun, M. F., & Oktovianto, H. A. (2022). Organ Histopathology Goldfish Goldfish Gills and Hearts (*Cyprinus carpio*) Cultivator Seed Results in Batuplat, Kupang City, East Nusa Tenggara. inProceedings of the National Research Seminar, 5(1). https://ejurnal.politanikoe.ac.id/index.php/psnp/article/view/124

Silviany, V. (2004). The Effect of Lead on the Morphology and Histology of Carp Livers (*Cyprinus Carpio*). Thesis. Biology Department. Faculty of Mathematics and Natural Sciences. Universitas Sriwijaya. Palembang.

Yohannes, B. Y., Utomo, S. W., & Agustina, H. (2019). River Water Quality Studies and Efforts Water Pollution Control. *IJEEM-Indonesian Journal of Environmental Education and Management*, *4*(2), 136-155. DOI: org/10.21009/ijeem.042.05

Yudo, S. 2010. The condition of the Ciliwung River Water Quality in the DKI Jakarta Region in terms of Organic Parameters, Ammonia, Phosphates, Detergents and Coli Bacteria. Journal of Indonesian Aquaculture, 6, 34 - 42. DOI: org/10.29122/jai.v6i1.2452

Yulistia, E. (2020). The Impact of Community Activities on the River Rim on Water Quality Ogan River in Baturaja City, OKU Regency. *UNBARA Environmental Engineering Journal (UEEJ)*, *1*(1), 26-31. https://www.journal.unbara.ac.id/index.php/UEEJ/article/view/735

Yulis, P. A. R. (2018). Analysis of levels of mercury (Hg) and (Ph) in Kuantan River water affected by unlicensed gold mining (PETI).Orbital: Journal of Chemistry Education, *2*(1), 28-36. DOI: org/10.19109/ojpk.v2i1.2167

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

Profile of Creative Thinking Skill of New Normal Era at Junior High School Students

Farida Amrul Almuharomah*, Widha Sunarno, Mohammad Masykuri
Science Education Department, Faculty of Teacher Training and Education, Sebelas Maret University, Jl Ir. Sutami no.36, Kentingan, Kec. Jebres, Kota Surakarta 57126, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: farida.amrul.a@student.uns.ac.id

KEYWORDS:
Profile,
Creative Thinking Skill,
Junior High School,
New Normal Era

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

The demands of teachers to train 21st century skills are very challenging, especially in the current pandemic era. This study aims to determine the creative thinking ability of junior high school students in Ponorogo district. Quantitative descriptive is used as a research method. The population used is a junior high school in Ponorogo district. The sample was taken as many as one class in each school. the achievement of creative thinking indicators on average is 33.5% in the less category. Analysis of fluency indicators is 35%, flexibility is 32%, originality is 39%, and elaboration is 28%. The achievement of 4 indicators of creative thinking is in the less category. Students creative thinking ability level of in the creative category of 2.88%, and the non-creative category is 19.42%. Students at the creative level are at SMPN 1 Mlarak by 20% and at SMPN 1 Kauman by 3.33%. Creative thinking skills can be trained through learning including always doing apperception before starting learning, using project-based learning models, or using STEM-based learning approaches.

1. INTRODUCTION

21st century skills are an issue in the world of education today. Ease of access to information without knowing regional boundaries requires us to have adequate skills to be able to compete. 21st century skills generally refer to certain competencies such as collaboration, digital literacy, critical thinking, problem solving, which will help students thrive in a globalized world (“T He E Uropean U Nion ' SE Astern P Artnership :” nd). The demands of teachers to train 21st century skills are very challenging, especially in the current pandemic era. Covid-19 has changed the learning system in schools. Students are required to take part in all learning activities online. Learning is less effective because the material is not conveyed thoroughly. The activity most teachers do is just giving assignments(Handayani and Jumadi 2021). Elementary to high school students' perceptions of PJJ agree that they do not like studying at home(Megawanti et al. 2020). The availability of learning platforms such as Google Classroom, Google Meet and Zoom makes it easier for us to organize learning. One of the online learning innovations is the 4C strategy, namely, critical thinking, creative thinking, collaboration and communication(Haryati, M. Pd and Sukarno 2021). Effective online learning uses a project-based Blended Learning (BL) system(Yustina et al. 2020). Online creative learning using Canva and Instagram media(Hidajat 2021). Learning by utilizing local wisdom can attract students' interest in learning. Apart from being knowledge, local wisdom has the potential to foster a sense of nationalism and pride in one's region(Adinugraha 2016).

As a unit of Natural Science (IPA) or science, it is formed from a reciprocal relationship that influences each other between scientific attitudes and processes, investigations of natural phenomena, and scientific products(Carin 1997). Science is a science that studies natural phenomena and the physical world(Rahayu et al. 2012). Science is related to knowing the universe in systematic steps so that science is also a process of discovery(Listyawati 2012). However, online

science learning in Riau Province saw a decline of 93.3%. Limited facilities and infrastructure amounted to 70%, and lack of student concentration reached 76.7%. Based on research at 7 junior high schools and the equivalent in Ponorogo Regency, the results showed that online learning was limited by 85.7% of students being less interactive, 71.4% of communication with students was limited, 14.3% of learning activities were less interesting, and students were unable to experiment of 42.9%. Even though science is a way of knowing the universe in systematic steps, science is also a process of discovery(Listyawati 2012). So online science learning requires concrete steps to teach science according to its essence. Creative thinking skills are needed by students to study and understand natural objects and phenomena(Anjarsari 2014).

Creative thinking skills are in the affective realm while creative thinking skills are in the cognitive. This view finds a systematic place for creative thinking skill in the realm of intelligence. The construction includes fluency, flexibility, originality, and elaboration(Guilford 1975). Based on the results of the global creativity index, Indonesia is ranked 115th out of 139 countries(Florida et al. 2015). The creative thinking skill of students during online learning at SMPN 62 Surabaya are in the creative category. 12% of students are very creative, 48% are in the creative category, and 40% are in the quite creative category. Based on the achieved indicators of fluency 75%, flexibility 60%, Originality 73%, and Elaboration 46%(Qomariyah and Subekti 2021).

Based on the description above, researchers are interested in knowing the profile of creative thinking skill of junior high school students in Ponorogo Regency. The aim of this research was to determine the creative thinking abilities of class IX students by using an instrument with indicators of creative thinking skill integrated with local wisdom in Plancungan Village, Slahung District, Ponorogo Regency.

2. MATERIALS AND METHODS

2.1. Quantitative Descriptive Method

This research uses a quantitative descriptive method. This method aims to reveal something as it is. Descriptive research is carried out by searching for information, explaining the objectives, approach used, and collecting data.

2.1.1. Research design

This research was conducted in semester 2, namely March to April. Data collection was carried out by interviewing Class IX science teachers at each school. Interviews were conducted by distributing Google forms via WA. The test instrument in the form of essay questions is given to students directly. Because at the time of conducting the research, 4 schools were already implementing face-to-face meetings, while three schools were still implementing 50% face-to-face meetings.

The population used was 7 junior high schools in Ponorogo district. These schools were SMPN 3 Slahung, MTS Miftahul Ulum, MTSN 4 Ponorogo, SMPN 1 Mlarak, SMP Darur Rohmah, SMPN 2 Balong, and SMPN 1 Kauman. Samples were taken from one class in each school.

The research design used was non-equivalent control group-post-test-only. This design is used in cases where there is no randomization due to practical considerations or it is not possible to collect pretest data. Although this design is less complex than other designs, with low error propagation, and is susceptible to internal validity threats(Krishnan 2019).

Data analysis uses the following percentages:

S = x $100\frac{R}{N}$

Information:

S = Creative Thinking Skill Score

R = Correct Score

N = Maximum Score

2.1.1.1. The achievement of each Creative Thinking Skill Indicator is made into a percentage and then the results are compared with (Table 1) below:

Table 1. Indicator Criteria for Creative Thinking Skill

In Percent (%)	Conclusion
81 – 100	Very good
61 – 80	Good
41 – 60	Enough
21 – 40	Not enough
0 – 20	Very less

Source :Astuti, W (2014)

2.1.1.2. The level of students' creative thinking skill is made into a percentage and then categorized by comparing the results in (Table 2) as follows:

Table 2. Level of Students' Creative Thinking Skill

Total Score (%)	Category
81.00 – 100.00	Very creative
61.00 – 80.00	Creative
41.00 – 60.00	Quite Creative
21.00 – 40.00	Less Creative
0.00 – 20.00	Not Creative

Source: Riduwan, 2015

3. RESULTS AND DISCUSSION

3.1.Barriers to Online Learning

From the results of interviews with junior high school science teachers in 7 schools in Ponorogo Regency, it can be seen that several obstacles to online learning can be seen in (Figure 1) below:

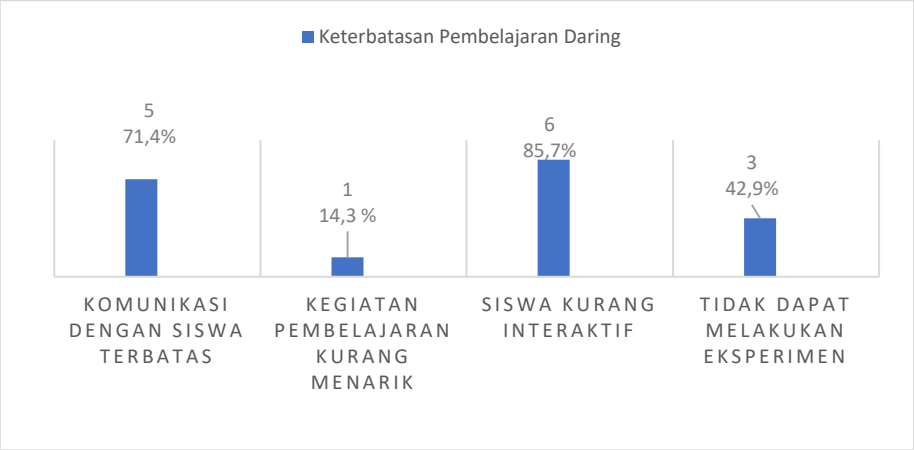


Figure 1. Barriers to Online Learning

The reason students are less interactive in online learning is because the use of learning platforms disrupts two-way communication with students. Communication can run smoothly if the facilities and infrastructure are met. In reality, there are several significant obstacles to online learning, such as lack of technological mastery, internet costs, and additional work for parents.(Purwanto et al., 2020). Lack of preparation in learning management, assessment and supervision (Rigianti, 2020). Therefore, training is needed in order to be technologically literate for school residents so that online learning runs smoothly.

Efforts to increase student participation can be done by implementing interesting learning models. Teachers need to determine effective learning strategies to foster student interest(Handayani & Jumadi, 2021). We can observe the learning model used in (Figure 2)

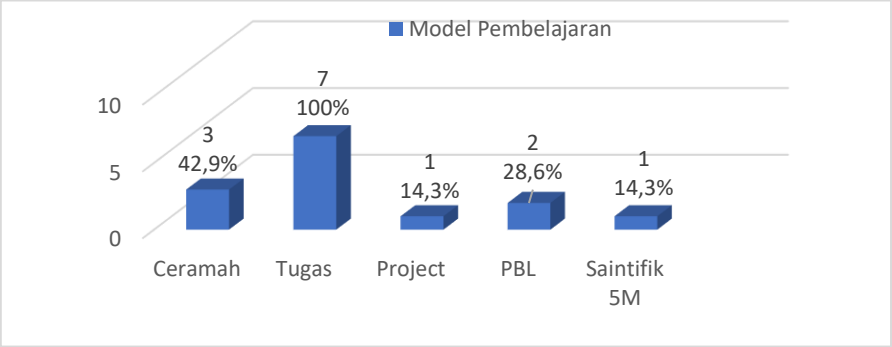
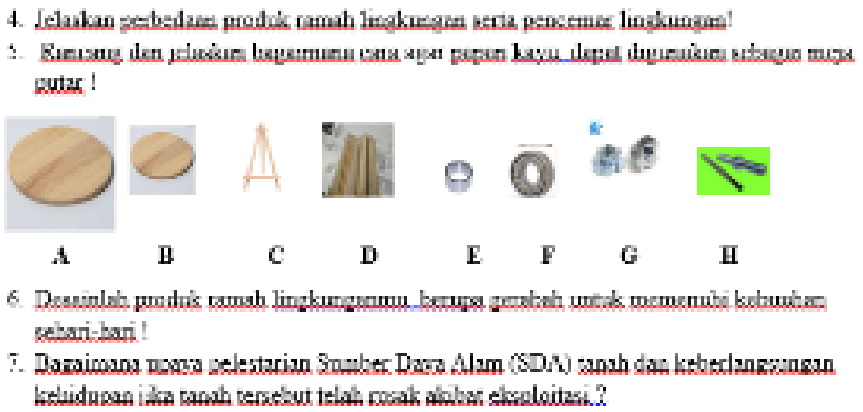


Figure 2. Learning Model

The assignment model is always applied to online learning. Other models need to be implemented so that the implementation of learning can be maximal, like face-to-face (Purwanto et al., 2020). The aim of online learning is to increase the effectiveness of the learning process (Popa et al., 2020). Online learning will be beneficial when teachers use media such as videos or virtual meetings(Dhawan, 2020). The surrounding environment as a learning source in the form of videos, direct observation, and the application of a caring attitude are solutions for online learning.

The obstacles to learning science online are well known. Next, prepare a test instrument in the form of essay questions to determine the profile of students' creative thinking skill. This instrument was developed using indicators of creative thinking skill that are integrated into local wisdom in Plancungan Village. The local wisdom of Plancungan Village is the pottery industry. Pottery products include jugs, layah, plates and other household utensils.

Environmentally friendly products in the form of pottery are never absent from traditional ceremonies such as mantu, piton-piton, tingkepan and so on. So a question was developed about the differences between environmentally friendly products and pollutants in question number 4. Furniture in the form of a turntable used in the pottery making process was integrated in question number 5. Question number 6 was designing products from earthenware as an effort to preserve the environmentally friendly product industry so that it remains popular with generations. millennial. The main ingredient for pottery is clay from the mountains. Therefore, land needs to be used sustainably so that the ecosystem is not disturbed and people's needs are met. The instruments used are as shown in (Figure 3) below:


4. Jelaskan perbedaan produk ramah lingkungan serta pencemar lingkungan!
5. Rancang dan jelaskan bagaimana cara agar papan kayu dapat digunakan sebagai meja putar !

A B C D E F G H

6. Desainlah produk ramah lingkungannya berupa gerabah untuk memenuhi kebutuhan sehari-hari !
7. Bagaimana upaya pelestarian Sumber Daya Alam (SDA) tanah dan keberlangsungan kehidupan jika tanah tersebut telah rusak akibat eksploitasi ?

Figure 3. Questions about creative thinking skills integrated with local wisdom

This description question has been validated by experts and the four items have been declared valid. The distribution of questions in 7 schools was carried out on different days and with different numbers of students. This is because 3 schools are still implementing 50% face-to-face learning.

Local wisdom is often defined as local knowledge, local intelligence, and local policy(Siswandi, Taruna, & Punaweni, 2011). Javanese culture is a form of intelligence and wisdom resulting from the experience of the Javanese people(Rahyono, 2015). Science learning now needs to be balanced with the cultivation of scientific values and local wisdom in society(Suastra, 2010). Integrating local wisdom in learning through a scientific approach can foster students' creative abilities.

3.2. Achievement of Creative Thinking Skill Indicators

The results of creative thinking skill based on the achievement of fluency, flexibility, originality and elaboration indicators are presented in (Table 3) as follows:

Table 3. Achievement of Creative Thinking Skill Indicators

Name School	Total Indicator Score Creative Thinking Skill of 139 Students			
	Fluency	**Flexibility**	**Originality**	**Elaboration**
Mlarak I Middle School	37	57	50	46
SMPN 3 Slahung	35	28	59	40
MTS Miftahul U.	30	8	30	17
Darur R Middle School	33	48	40	18
MTSN4 Ponorogo	25	43	50	21
SMPN 2 Balong	24	19	25	21
Kauman 1 Middle School	109	64	69	74
Total	293	266	232	237
Percentage (%)	35	32	39	28
Average - Average	**33.5% Not enough**			

Based on the table above, the total score of the four indicators of creative thinking skill can be calculated. The average creative thinking skill of 33.5% is in the poor category. These results are in line with the profile of Creative Thinking Skill at SMPN 15 Surakarta with an average of 39.84% low criteria(Kurnia et al., 2021). The results of Creative Thinking Skill for each indicator at Muhammadiyah 5 Ngoro Middle School for class VIII students are an average of 25.5%(Asivah & Wulandari, 2020).

The percentage of achievement of indicators at SMPN 1 Mlarak and SMPN 1 Kuman is between 41-60 so it is in the sufficient category. These results are in line with the profile at SMPN 2 Balong before the pandemic. The achievement of creative thinking indicators was 55.38% in the sufficient category(Almuharomah & Mayasari, 2018). Achieving indicators of creative thinking skill can be done by implementing learning strategies. The explanation for the Creative Thinking Skill Indicators based on construction includes fluency, flexibility, originality and elaboration(Guilford, 1975) are as follows :

3.2.1. Skill to Think Fluently (Fluency)

Fluent thinking is related to Ideational Fluency (giving different names), Association Fluency (looking for similarities), and Expression Fluency (writing different sentences)(Guilford, 1975). This corresponds to generating lots of ideas so that you can find a solution(Awang & Ramly, 2008). So thinking fluently is an skill that produces various appropriate answers(Munandar, 2009).

The percentage of fluent thinking skill in 7 junior high schools in Ponorogo Regency is 35% in the poor category. These results are in accordance with the profile at SMPN 2 Balong of 39.20 in the poor category(Almuharomah & Mayasari, 2018). The deficient category in the ability to think fluently was also found at SMPN 15 Surakarta at 39.81%(Kurnia et al., 2021). The ability to think fluently can be improved one way by means of creative discussions.

3.2.2. Flexible Thinking Skill (Flexibility)

Flexible thinking skill is related to spontaneous and adaptive attitudes(Guilford, 1975). In line with students' ideas, they provide many answer themes(Fauziah, 2013). Meanwhile, Munandar's idea of thinking luwer has different directions(Munandar, 2009). Basically, this flexible thinking ability is characterized by solving problems in different ways.

The percentage of flexible thinking abilities in 7 junior high schools in Ponorogo Regency is an average of 32% in the poor category. The category obtained is the same as the low category obtained at SMPN 15 Surakarta but with a different percentage(Kurnia et al., 2021). Creative students are more flexible in changing approaches when faced with complex problems.

3.2.3. Original Thinking Skill (Originality)

The skill to think original is related to unique thinking, different designs, reinterpretations, or new emphases(Guilford, 1975). The definition of original thinking is thinking that is different from other people's is also explained by(Fauziah, 2013) (Munandar, 2009). Original thinking is new thinking that is different from other people.

The percentage of original thinking ability in 7 junior high schools in Ponorogo Regency is 39% in the low category. These results are in accordance with the percentage of original thinking at SMPN 15 Surakarta of 38.02 in the low category(Kurnia et al., 2021). Genuine thinking skill can be improved by planning, designing and creating work.

3.2.4. Detailed Thinking Skill (Elaboration)

The skill to think in detail is related to remembering structured activities, as well as making detailed lists(Guilford, 1975). The idea of detailed thinking is carried out by explaining the cause and effect of each answer(Fauziah, 2013). In line with this idea, detailed thinking is carried out by adding, modifying, expanding and enriching ideas(Munandar, 2009). So detailed thinking can be done by making lists, explaining cause and effect, and enriching ideas.

The percentage of Detailed Thinking Skill in 7 junior high schools in Ponorogo Regency is 28% in the poor category. These results are in accordance with the profile at SMPN 15 Surakarta of 35.67 in the low category(Kurnia et al., 2021). Detailed thinking can be trained by providing apperception before learning related to a problem.

3.3. Level of Creative Thinking Skill

The level of students' creative thinking skill can be calculated by adding up the creative thinking ability scores of each student and then converting it into a percentage. After being a percentage, it was analyzed again into 5 levels of Creative Thinking Ability. The results can be seen in (Table 4) below:

Table 4. Percentage of Creative Thinking Skill Categories

Name School	Percentage % Categories Very Creative (SK), Creative (K), Quite Creative (CK), Less Creative (KK), Not Creative (TK)				
	Very creative	**Creative**	**Enough Creative**	**Not enough Creative**	**No Creative**
Mlarak I Middle School	0	20	73.33	6.67	0
SMPN 3 Slahung	0	0	0	73.08	26.92
MTS Miftahul U.	0	0	0	53.33	46.67
Darur R Middle School	0	0	18.75	81.25	0
MTSN4 Ponorogo	0	0	0	63.64	36.36
SMPN 2 Balong	0	0	0	66.67	33.33
Kauman 1 Middle School	0	3.33	73.33	23.33	0

Students at the creative level are at SMPN 1 Mlarak at 20% and at SMPN 1 Kauman at 3.33%. The creative thinking skill of class IX junior high school students in Ponorogo Regency are mostly at the Less Creative level.

4. CONCLUSIONS

The demands of teachers to train 21st century skills are very challenging, especially in the current pandemic era. Face-to-face learning has changed to online. Elementary to high school students' perceptions of PJJ agree that they are not happy with studying at home. Obstacles to online science learning in Ponorogo Regency include limited communication with students, less interesting learning activities, less interactive students, and not being able to carry out experiments. The online learning model that is usually used is in the form of assignments via WhatsApp groups. The lecture learning model is in the next position. The Problem Based Learning (PBL), Project Based Learning (PjBL) learning models and the 5M scientific approach are only partially used.

Creative Thinking Skills need to be trained in online learning. However, the average achievement of creative thinking indicators is 33.5% in the poor category. The indicator analysis is fluency at 35%, flexibility at 32%, originality at 39%, and elaboration at 28%. Achievement of 4 indicators of creative thinking is in the poor category.

The creative thinking skill level of junior high school students at the creative level is 2.88%, and the non-creative category is 19.42%. Students at the creative level are at SMPN 1 Mlarak at 20% and at SMPN 1 Kauman at 3.33%. The creative thinking skill of class IX junior high school students in Ponorogo Regency is at the Less Creative level. So it is necessary to make efforts to improve students' creative thinking skill. These efforts include the use of project learning models, integrating local wisdom, and learning with a STEM approach.

5. ACKNOWLEDGMENTS

Thank you to the supervisor, the principal, Mr and Mrs teachers, for guiding the research. Thank you also to the class IX students who participated in this research..

6. REFERENCES

Adinugraha, F. (2016). Potensi Reresik Sumur Pitu Sebagai Pendekatan Kearifan Lokal Dan Budaya Pada Pembelajaran Biologi. *Pendidikan Surya Edukasi*, *6*(April), 16–32.

Almuharomah, F. A., & Mayasari, T. (2018). Profil Kemampuan Berpikir Kritis Matematis Siswa Smp. *Jurnal Pendidikan Tambusai*, *2*, 793–801.

Anjarsari, P. (2014). Optimalisasi Implementasi Kurikulum 2013 dengan Workshop Pengembangan LKS IPA Berpendekatan Guided Inquiry untuk Mengembangkan Thinking Skills dan Sikap Ilmiah Siswa. *Pentingnya Melatih Keterampilan Berpikir (Thinking Skills) Dalam Pembelajaran IPA SMP*. *In Makalah Disampaikan Dalam PPM*, *Vol 23*(Anjarsari, P. (2014). Pentingnya melatih keterampilan berpikir (thinking skills) dalam pembelajaran IPA SMOptimalisasi Implementasi Kurikulum 2013 dengan Workshop Pengembangan LKS IPA Berpendekatan Guided Inquiry untuk Mengembangkan Thinking Skills dan Si).

Asivah, N. D. A., & Wulandari, F. E. (2020). Creative Thinking Skills of Students on Enviromental Pollution Theory at Muhammadiyah School. *Academia Open*, *3*, 1–11. https://doi.org/10.21070/acopen.3.2020.504

Awang, H., & Ramly, I. (2008). Creative thinking skill approach through problem-based learning. *World Academy of Science, Engineering and Technology*, *16*(1), 635–640. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.306.7430&rep=rep1&type=pdf

Carin, A. A. (1997). *Teaching Science Through Discovery* (8th editio). Merrill Publ. Co.

Dhawan, S. (2020). Online Learning: A Panacea in the Time of COVID-19 Crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. https://doi.org/10.1177/0047239520934018

Fauziah, S. (2013). The Effectiveness of PBL Online on Physics Students ' Creativity and Critical Thinking : A Case Study at Universiti Malaysia Sabah. *International Journal of Education and Research*, *1*(3), 1–18.

Florida, R., Mellander, C., & King, K. (2015). *The Global Creativity Index 2015*. Martin Prosperity Institute.

Guilford, J. P. (1975). Varieties of creative giftedness, their measurement and development. *Gifted Child Quarterly*, *19*(2), 107–121. https://doi.org/10.1177/001698627501900216

Handayani, N. A., & Jumadi, J. (2021). Analisis Pembelajaran IPA Secara Daring pada Masa Pandemi Covid-19. *Jurnal Pendidikan Sains Indonesia*, *9*(2), 217–233. https://doi.org/10.24815/jpsi.v9i2.19033

Haryati, M.Pd, D. S., & Sukarno, S. (2021). Inovasi Pembelajaran Daring Di Era Pandemi Covid-19. *Indonesian Journal of Education and Learning*, *4*(2), 479. https://doi.org/10.31002/ijel.v4i2.3717

Hidajat, F. A. (2021). European Journal of Educational Research. *European Journal of Educational Research*, *10*(3),1199–1213.https://www.researchgate.net/profile/Ebru Eren/publication/348382981_Education_Policies_in_the_Context_of_Political_Communication_in_Turkey/links/5ffc2aeba6fdccdcb846cc03/Education-Policies-in-the-Context-of-Political-Communication-in-Turkey.pdf

Kurnia, A., Sukarmin, & Sunarno, W. (2021). Profil Kemampuan Berpikir Kreatif Siswa Menggunakan Soal Tes Pilihan Ganda pada Pembelajaran Ilmu Pengetahuan Alam. *Indonesian Journal of Educational Science (IJES)*, *4*(1), 27–32. https://doi.org/10.31605/ijes.v4i1.1147

Krishnan P(2018) A review of the non-equivalent control group post-test-only design. Nurse Researcher. doi: 10.7748/nr.2018.e1582

Listyawati, M. (2012). Pengembangan Perangkat Pembelajaran Ipa Terpadu Di Smp. *Journal of Innovative Science Education*, *1*(1).

Megawanti, P., megawati, erna, & Nurkhafifah, siti. (2020). Persepsi Peserta Didik Terhadap Pjj Pada Masa Pandemi Covid 19. *Faktor : Jurnal Ilmiah Kependidikan*, *7*(2), 75–82. https://journal.lppmunindra.ac.id/index.php/Faktor/article/view/6411

Munandar. (2009). *Pengembangan kreativitas Anak Berbakat.* Rineka Cipta.

Popa, D., Repanovici, A., Lupu, D., Norel, M., & Coman, C. (2020). Using Mixed Methods to Understand Teaching and Learning in COVID 19 Times. *Sustainability*, *12*(20), 8726. https://doi.org/10.3390/su12208726

Purwanto, A., Pramono, R., Asbari, M., Hyun, C., Wijayanti, L., Putri, R., & Santoso, P. (2020). Studi Eksploratif Dampak Pandemi COVID-19 Terhadap Proses Pembelajaran Online di Sekolah Dasar. *Journal of Education, Psychology and Counseling*, *2*((1),), 1–12.

Putra, H. D., Akhdiyat, A. M., Setiany, E. P., & Andiarani, M. (2018). *Kemampuan Berpikir Kreatif Matematik Siswa SMP di Cimahi*. *9*(1), 47–53.

Qomariyah, D. N., & Subekti, H. (2021). Analisis Kemampuan Berpikir Kreatif: Studi Eksplorasi Siswa di SMPN 62 Surabaya. *Pensa E-Jurnal: Pendidikan Sains*, *9*(2), 242–246. https://ejournal.unesa.ac.id/index.php/pensa/index

Rahayu, P., Mulyani, S., & Miswadi, S. S. (2012). Pengembangan pembelajaran IPA terpadu dengan menggunakan model pembelajaran problem base melalui lesson study. *Jurnal Pendidikan IPA Indonesia*, *1*(1), 63–70. https://doi.org/10.15294/jpii.v1i1.2015

Rigianti, H. A. (2020). *Kendala Pembelajaran Daring Guru Sekolah Dasar Di Kabupaten Banjarnegara Henry*. *2507*(February), 1–9.

T He E Uropean U Nion ' S E Astern P Artnership : (n.d.). 143–155.

Yustina, Syafii, W., & Vebrianto, R. (2020). The effects of blended learning and project-based learning on pre-service biology teachers' creative thinking skills through online learning in the COVID-19 pandemic. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 408–420. https://doi.org/10.15294/jpii.v9i3.24706

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

The Feasibility and Effectiveness of High-Level Thinking Tests on Virus to Mapping The Ability of Prospective Science Teacher (Introduction Study on The Development of Integrated Learning Models)

Annur Indra Kusumadani*, Sentot Budi Rahardjo, Sri Yamtinah, Baskoro Adi Prayitno
Faculty of Teacher Training and Education, Universitas Sebelas Maret,
Central Java, Indonesia
*Corresponding Author. E-mail address: aik110390@student.uns.ac.id

KEYWORDS:
Test Research and Development,
Higher Order Thinking Test,
Instrument Measurement

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

This research aims to determine the feasibility and effectiveness of a higher - order thinking test developed on material of virus. The test instrument developed was aimed at mapping the ability of prospective science teacher in the preliminary study of developing an integrated learning model. This research is a *Research and Development* referring to Borg and Gall (1989) with 10 stages of research, namely : (1) Initial research and data collection , (2) Planning , (3) Initial product manufacture , (4) Initial trial (expert validation) , (5) Initial product improvement , (6) Test field trial , (7) Operational product improvement , (8) Operational field test (effectiveness test/external validity test) , (9) Final product revision, and (10) Dissemination. The research involved the following experimental subjects : (1) The initial trial involved virus material experts, research and education evaluation experts ; (2) The small group trial involved 36 student teacher candidates at the University of Muhammadiyah Surakarta for the 2020/2021 academic year; (3) The large group trial involved 60 student teacher candidates at the University of Muhammadiyah Surakarta for the 2020/2021 academic year ; and (4) an operational field test (effectiveness test/external validity test) involving 30 teacher candidates at the Muhammadiyah University of Surakarta for the 2020/2021 academic year. The data analysis techniques used were the validity of AIken at the validation stage, item test analysis in the field trial and Pearson correlation analysis at the operational /effectiveness field test stage. The final results of this research are computer-assisted higher order thinking test with 8 questions of higher order thinking on virus material that has strong internal validity with an Aiken validity index of more than 0.73 (0.84 to 0.92), reliability coefficient 0.814 > 0.213 (r table) which means high reliability, difficulty index of 0.17 (difficult) to 0.455 (medium), and discriminant index (differentiation power) of 0.2 (enough) to 0.745 (good). External validity/effectiveness is 0.626 (strong enough) to 0.831 (strong) which is the correlation of higher order thinking test results developed with other higher-order thinking tests on virus. The conclusion of this research is that the developed test instrument is feasible and effective to measure the higher order thinking ability of virus.

1. INTRODUCTION

Humans who are successful in the era of globalization are humans who are able to think well. Good thinking skills are shown by creative and critical humans so that they are able to produce tools and services needed to meet the needs of world development and solve life's problems. Thinking skills can be empowered through innovative education. Innovative education in the real world is carried out by educators, one of which is by using various learning models and moduls (Setyaningsing, et.al., 2022). The business form of innovative education is the development of

learning models, learning modules, learning media, and evaluation/evaluation instruments. Development of evaluation instruments/assessment is very important because it is strategically valuable to find out the thinking ability map of prospective science teacher as a reflection of learning so that lecturers know the follow-up learning including the development of learning models. Questions as test instruments to measure the success of learning objectives must have good quality. This quality can be measured by the level of cognition expected from students (Mustafidah, 2022).

The low fulfillment of evaluation/ assessment standards is evidenced by the results of the analysis of the question bank used by the lecturers of the Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta for formative and summative evaluations, showing that the percentage of using Bloom's cognitive domain in questions is 10% memorizing (C1), 40% understanding (C2) and 30% apply (C3), 15% analyze (C4), 5% evaluate (C5), while the creative domain (C6) has not been used by lecturers. Therefore, it can be concluded that the test instrument used has not been able to measure higher order thinking skills.

The factor causing the test instrument used has not been able to measure high-level abilities is that the lecturer feels that he has made questions to measure higher-order thinking skills but the questions that are made include low-level thinking questions. In addition, time is also limited because it is felt that it takes longer to make higher-order thinking questions. As a result, the ability of students in higher-order thinking is not mapped so that teachers do not know the extent to which students' abilities in higher-order thinking are. On the other hand, prospective science teacher are required to be able to think at a higher level. Higher order thinking skills are the skills needed in order to remain competitive in the era of globalization.

Moreover, the era of globalization demands the use of technology. The rapid development of technology and communication science has resulted in technology becoming a basic need that must be known and understood by everyone (Sutama, 2021). The world of education is required to adapt to technological developments and there are ongoing demands for 21st century learning skills, the development of the industrial revolution 4.0, and society 5.0. (Ratih, et.al., 2021). This also has a positive impact on the use of technology in tests so that it can simplify and speed up the assessment. The test used by the lecturers of the Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta for formative and summative evaluations has not been computer assisted. The obstacle that was complained by the majority of lecturers was that most of the development of computer-assisted test instruments had a high level of difficulty in manufacturing. On the other hand, one of the advantages of computer-assisted tests is that they are fast and accurate in scoring and profiling abilities.

Based on the problems above, it is necessary to develop a computer-assisted assessment capable of measuring higher order thinking skills that are valid, reliable, objective, and practical. One way that can be done is to use a multiple choice test to analyze the relationship between computer-assisted things with *Microsoft Powerpoint* and *Visual Basic for Applications*. Multiple-choice tests that analyze the relationship between things have reasons in each question statement which is a development of the ordinary multiple-choice question type. The existence of reasons in each question statement can measure students' higher-order thinking skills more deeply and anticipate *ghessing* in answering questions. The test instrument was developed with computer assistance with *Microsoft Powerpoint* and *Visual Basic for Applications* so that it can automatically display student work and display high-level thinking profiles of prospective science teacher. In addition, the test instrument developed is equipped with instructions for use so that it also makes it easier for lecturers to make computer-assisted high-level thinking test instruments with *Microsoft Powerpoint* and *Visual Basic for Applications*. The test instrument developed is limited to the material of the virus. The material on virus must have been taught before students work on the developed test instrument. The test instrument developed can operate on all *operating systems* and all types of laptops/PCs that have been *installed Microsoft Office*.

The purpose of the study was to determine the feasibility and effectiveness of higher order thinking tests on virus materials computer assisted with *Microsoft Powerpoint* and *Visual Basic for Applications* .

2. RESEARCH METHODS

Research model to be carried out is a modification of *Research and Development* (*R & D*) (Borg and Gall, 1989) on the number of trial subjects at each stage of the trial . The research consisted of 10 stages, namely research and initial data collection, planning, initial product creation, initial trial (expert validation), initial product improvement, field trials, operational product improvements, operational trials (effectiveness test/external validity test), final product improvement, and dissemination. The stages in detail are as follows.

Research and initial data collection includes 2 needs analysis activities. An overview of the test instruments used by the lecturers of the Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta for formative and summative evaluations was obtained from the interview answers. The question bank analysis was conducted to determine the percentage of use of the bloom taxonomy level in the questions used by lecturers and to analyze the difficulties of teachers in conducting assessments/ evaluations.

Activities carried out in planning and development refer to the *Delphi Method* (2002). The Delphi method is a technique for planning and developing product development without having to meet directly from all experts and practitioners to make product development. The activities carried out are identification of competency standards and basic competencies as well as the type of material to be developed to determine indicators of learning materials and indicators of higher order thinking questions, making material indicators and questions of higher order thinking skills adapted from Anderson and Krathwohl (2001) then making questions based on the indicators provided. has been established.

The initial trial phase (expert validation) involves 5 material experts, namely lecturers of human anatomy and physiology , 3 an expert on evaluation instruments , namely a lecturer in charge of educational research and evaluation courses. Validation using product validation and assessment sheets. The function of a material expert in research is to validate the content or concept of the material and constructs so that they are able to avoid discrepancies with SK, KD, indicators, and objectives as well as misconceptions on the questions. The function of the evaluation instrument expert is to validate the form of the questions and the suitability of the questions with indicators so that they can ensure that the questions developed actually measure higher-order thinking skills . Content and construct validation by experts using the Aiken Formula (Aiiken, 1985b). After getting validation from the experts in the initial trial (expert validation), revisions were made until the expert declared the test instrument was feasible (good) .

Field trial 1 (small group) involved an microbiology lecturer and 36 student science teacher candidates, Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta for the Academic Year 2020/2021 who took the microbiology course . Lecturers in this case as practitioners. The function of the practitioner is to validate the content of the material, readability, and time sufficiency problem solving , while students comment on the readability of the questions and the adequacy of processing time . The data from discussions and interviews with students are then in percentage. Revision carried out according to the results of discussions and interviews with students . The result of field trial 1 is *draft* I II a computer-assisted higher order thinking test that is ready to be tested in large groups. Field test 2 (large group) was conducted at 60 student science teacher candidates, Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta for the Academic Year 2020/2021 who took the microbiology course . The trial is an internal validation of the questions. Internal validation of the questions includes reliability testing, differentiating power of questions, and the level of difficulty of the questions. The trial has the aim of determining whether the resulting product has the feasibility of being a valid, reliable, and objective question . Field trial data were analyzed, if the results did not meet the internal validity

standard , a revision was made to the product. The results of field trials and operational product revisions are computer-assisted higher order thinking tests that are valid, reliable , objective and practical and ready for operational field tests (effectiveness test/external validity test) .

Operational field test (effectiveness test/external validity test). carried out on 20 prospective science teacher of the Faculty of Teacher Training and Education, University of Muhammadiyah Surakarta in the 2020/2021 academic year who took the microbiology course . External validity refers to *concurrent validity* (Crocker & Algina, 1986). The instrument is said to have *concurrent validity* if the results are in line with the existing criteria. Existing criteria can be in the form of other instruments that measure the same thing. Alignment is indicated by the correlation index (*Pearson Correlation*). The purpose of the trial was to determine the external validity of the test by correlating the results of the developed higher-order thinking test with the results of standardized higher-order thinking tests/other developments on the same material and on the same students so that it was known to what extent the questions developed were effective in measuring thinking skills. high-level college students by looking at the Pearson correlation coefficient. The stronger the correlation, the better the effectiveness/external validity of the test. If the results are not effective, then the product is revised. The result of the operational field test and final product revision is a computer - assisted higher order thinking test which is effective and ready to be disseminated.

The dissemination was carried out through lecturers of the Faculty of Teacher Training and Education, Muhammadiyah University of Surakarta. Dissemination is carried out after the product developed is feasible and effective to measure the higher-order thinking skills of prospective science teacher.

3. RESULTS AND DISCUSSION

The data from the validation results with 10 validators with 4 assessment criteria shows the Aiken validity index of more than 0.73 (0, 84 to 0, 92) for all items. That is, the 8 items developed are items that are valid in content and constructs. In addition, the truth of the concept of the question gets a total percentage of 93.2%, meaning that the truth of the concept is very good. The suitability of the material level for students gets a total score percentage of 98.1%, meaning that the questions are very in line with the students' thinking level. The novelty aspect of the questions also gets a total score percentage of 100%, meaning that the questions used are relatively new and have never been used for tests. The clarity of the meaning of the question gets a total score percentage of 96%, meaning that the clarity of the meaning of the question is very good. Clarity and ease of question terms for students to understand get a total score percentage of 93.7%, meaning that the terms used are clear and easy for students to understand.

Along with content and construct validation, the *software aspect was validated by ICT* experts and the test form used by educational research and evaluation experts. The results of validation with *ICT experts* show that the level of ease of operation of the test gets a percentage of the total score of 100%, meaning that the ease of operation is very good. The specificity of the test function got a total score of 87.5%, meaning that the specificity of the test function was very good. The test communication got a percentage of the total score of 75%, meaning that the test communication was good. Completed instructions get a total score percentage of 75%, meaning that the test instructions are good. The display design and logic design get a total score percentage of 87.5%, meaning that the display and test logic are very good.

The results of the validation with research and education evaluation experts showed that the suitability of SK, KD, and indicators got a total score percentage of 92.7%, meaning that the questions were in accordance with SK, KD, and indicators. The coverage of the questions in the higher-order thinking domain and the knowledge dimension got a total score percentage of 91.9%, meaning that the questions correctly covered the higher-order thinking domain and the knowledge dimension. The clarity of the meaning of the question gets a total score of 94.1%, meaning that the clarity of the meaning of the question is very good. Clarity and ease of question terms for students

to understand get a total score percentage of 93.6%, meaning that the terms used are clear and easy for students to understand.

Field trial 2 (large group) aims to determine the reliability, discriminatory power, and level of difficulty of the higher-order thinking test developed. The reliability, discriminating power, and difficulty level of the higher-order thinking test developed were obtained from the results of tests carried out by students. Student test results were analyzed by items .

The results of the item analysis show that the test reliability coefficient is 0.814> 0.213 (r table), meaning that the higher-order thinking test developed is said to be highly reliable. The formula used to calculate test reliability on *ANSOFT1 software* is KR- 20 (Linn & Groundlund, 2000; Widoyoko, 2010).

The results of the item analysis show that the index of the difficulty level of the test is 0.17 to 0.455, meaning that the higher-order thinking test developed has questions classified as difficult to moderate questions. The smaller the index of difficulty, the more difficult the questions. Measurement of the level of difficulty using the index of difficulty level along with standard limits (Azwar, 2003; Allen & Yen, 1986; and Sudjiono, 2005)

The results of the item analysis showed that the discriminant index (differentiating power) was 0.2 to 0.745, meaning that the higher-order thinking test developed had sufficient to good distinguishing power. The greater the discriminant index, the better the question is in distinguishing students who have good and low-level thinking skills. The measurement of discriminant power uses a discriminant index along with standard limits (Yen, 1992; Crocker & Algina, 1986) .

Operational field test (effectiveness test/external validity test) refers to *concurrent validity* (Crocker & Algina, 1986). The instrument is said to have *concurrent validity* if the results are in line with the existing criteria. Existing criteria can be in the form of other instruments that measure the same thing. Alignment is indicated by the correlation index (*Pearson Correlation*). The results of the effectiveness test (external validity test) between the higher-order thinking test developed with the higher-order thinking test and the development of other tests on the same material, namely the virus in measuring the ability to analyze, show a correlation coefficient of 0.831 with a significance level of 0.000<0.05, meaning that there is a correlation. strong positive. In conclusion, both the developed higher-order thinking test and other developed higher-order thinking tests have good external validity so that they can be used to measure analytical skills.

The results of the effectiveness test (external validity test) between the higher-order thinking test developed and the higher-order thinking test the development of another test on the same material, namely the virus in measuring the ability to evaluate, shows a correlation coefficient of 0.626 with a significance level of 0.000<0.05, meaning that there is a correlation strong positive. In conclusion, both the higher-order thinking test developed and the higher-order thinking test developed by other tests have good external validity so that they can be used to measure the ability to evaluate.

The results of the effectiveness test (external validity test) between the higher-order thinking test developed and the higher-order thinking test the development of another test on the same material, namely the virus in measuring creative ability, shows a correlation coefficient of 0.687 with a significance level of 0.000<0.05, meaning that there is a correlation. strong positive. In conclusion, both the higher-order thinking test developed and the higher-order thinking test developed by other tests have good external validity so that they can be used to measure creative abilities.

Effectiveness test using a comparison of other higher-order thinking test instruments on the same material, namely the virus because it shows the alignment of the measuring instrument, namely measuring higher-order thinking skills on the material of virus. The effectiveness test is more perfect when there is a comparison in the form of a standardized or standardized high-level thinking test. Although there is no standardized comparison of higher-order thinking tests, other higher-order thinking tests can be used for the development of the same material, namely virus.

This means that if the developed higher-order thinking test and other developmental higher-order thinking tests are used to measure higher-order thinking skills of the same students and show a positive correlation, the developed higher-order thinking test and other developmental higher-order thinking tests can is said to be effective for measuring students' higher order thinking skills.

4. CONCLUSIONS and RECOMMENDATIONS

The test instrument developed was a computer- assisted high-order thinking test (*computer based test*). The test consists of 8 items of higher-order thinking on valid virus material with an Aiken validity index of more than 0.73, high reliability with a reliability index of 0.954> 0.257 (r table), objective which is different with a discriminant index of 0.2 (enough) to 0.745 (good) and difficulty index 0.15 (difficult) to 0.467 (medium). The developed test is able to measure higher order thinking skills on the dimensions of factual, conceptual, and procedural knowledge on the material of virus in the microbiology course. The form of the test used is multiple choice analysis of the relationship between things.

The test instrument was declared feasible by 5 material experts, 3 research experts and educational evaluation experts. In expert validation, the Aiken validity index was found to be more than 0.73 (0.83 to 0.93). The test instruments are eligible for field tests 1 and 2 with a reliability index of 0.814> 0.213 (r table) meaning high reliability, discriminant index 0.2 (adequate) to 0.745 (good) and difficulty index 0.17 (difficult) to 0.455 (moderate).

The test instrument was declared effective for measuring higher-order thinking skills in the material of virus after undergoing an effectiveness test by correlating the measurement results of the developed higher-order thinking test instrument with the measurement results of other higher-order thinking test instruments on the same material, namely the virus using *Pearson* correlation formula. There is a strong positive correlation in the measurement results of the ability to analyze with a correlation coefficient of 0.831 and a significance level of 0.000 <0.05. There is a fairly strong positive correlation in the measurement of the ability to evaluate with a correlation coefficient of 0.626 with a significance level of 0.000 <0.05. There is a fairly strong positive correlation in the measurement of creative ability showing a correlation coefficient of 0.687 with a significance level of 0.000 <0.05. The results of the correlation test indicate that the test instrument developed has good effectiveness as well as strong external validity so that it can be used to measure higher order thinking skills.

Other researchers who are interested in continuing to develop higher order thinking tests on virus is expected to pay attention to the limitations of research and research products, so as to make the test instruments that have been developed better.

5. REFERENCES

Aiken, L. R. (1985a) . Content Validity and Realibility of Single Items or Questionnaires. *Educational and Psychological Measurement, 40* , 955-959.

Aiken, L. R. (1985b) . Three Coefficients for Analyzing The Realibility and Validity of Ratings. *Educational and Psychological Measurement, 8* , 131-142.

Allen, MJ & Yen, WM (1979). *Introduction to measurement theory* . Monterey, California: Brookd/Cole Publishing Company.

Anderson, L. W. _ & Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing* . New York: Longman.

Azwar, S. (2012). *Preparation of the Psychological Scale. Edition II* . Yogyakarta: Student Library.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook 1 Cognitive Domain.* New York: David McKay.

Borg, W. R. _ & Gall, M. D. (1983). *Educational research an introduction (4th Ed)* . White Plains: Logman Inc.

Borg, WR and Gall, & D. (1989). *Educational Research.* New York: Longman.

Crocker, L. & Algina, J. (1986). *Introduction to Classical and Modern Test Theory.* Forth Worth: Holt, Rinehart, and Winston, INC.

Mustafidah, H., Suwarsito, S., & Pinandita, T. (2022). Natural Language Processing for Mapping Exam Questions to the Cognitive Process Dimension. International Journal of Emerging Technologies in Learning, 17(13)

Ratih, K., Syah, M.F.J., Nurhidayat, & Buckworth, J. (2021). Learning Patterns during the Disruptive Situation in Informal Education: Parents' Efforts and Challenges in the Adjustment of Progressive Learning. *Indonesian Journal on Learning and Advanced Education*, 3(3), 180-193.

Sudjiono, A. (2005). *Introduction to Educational Evaluation* . Jakarta: PT Raja Grafindo Persada.

Sutama & Fajriani, I.N. (2021). WEB-Based E-Learning Media at the Vocational High School Level. *Jurnal Varidika*, 33(2), 129-140

Widoyoko, SEP (2010). *Evaluation of Learning Programs* . Yogyakarta: Student Library.

Yen, WM (1992). "Item Response Theory". in Alkin MC (Eds.), *Encyclopedia of Educational Research* (pp. 657-666). New York: Macmillan Library Reference USA.

International Conference on Biology Education, Natural Science, and Technology
Vol. 1 No. 1 (2023)

PBL-Based Science Learning on Living Things Interaction in Junior High School

Hariyatmi*, Hidayatus Sholihah Tisniasari
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: hariyatmi@ums.ac.id

KEYWORDS:
Author
Publication
learning,
learning outcomes,
PBL,
science

© 2023 The Author(s). Published by Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
This is an open access article under the CC BY-NC license: https://creativecommons.org/licenses/by-nc/4.0/.

ABSTRACT

To obtain high learning outcomes, a teacher is required to teach students to use the right learning model. This study aims to analyze the effect of Problem Based Learning on the interaction of living things with their environment on learning outcomes in junior high schools. Experimental research with pretest posttest nonequivalent control group design. The object of this study is the results of student learning on the cognitive, affective, and psychomotor aspects. The sample used was two classes of students, as an experimental class and a control class and each of 28 students. Data collection techniques used were pretest-posttest, observation, and documentation. The research data were analyzed using the Independent Sample T-Test and the N-Gain test. The results showed that the average learning outcomes in the experimental class were higher than the average learning outcomes in the control class (N-gain 76>36.54); on Affective (73.21> 64.73) and Psychomotor (77.68> 65.62) aspects. Then analyzed using the Independent sample T-test. Based on the analysis of research results and discussion, it can be concluded that Problem Based Learning learning in the interaction of living things with their environment has an effective effect on junior high school student learning outcomes.

1. INTRODUCTION

Science learning will be more meaningful if it is designed to give students opportunities to find facts, construct concepts, and discover new values. Students as learning subjects in learning, as subjects of scientific work, not as spectators of teacher scientific work. Science learning in schools is expected to be a place for students to learn about the environment independently and apply it in everyday life. Through scientific learning, students receive direct information through observation, discussion and simple research (Noviyanti, E, Rusdi, Ristan, 2019)Science or Science is not only knowledge in the form of facts, concepts or principles, but also the process of discovery. Science learning emphasizes direct experience to develop skills in order to understand the natural environment through research and application, which helps students deepen their understanding (Bahtiar, Dukomalamo, 2019).

According to (Tayeb, 2017) the learning model is a conceptual framework that describes a structured approach to integrating learning experiences, achieving certain learning objectives and serving as a guide for teachers when preparing and carrying out learning activities. The things that must be considered by the teacher in choosing the model and method used in class are the characteristics of the material, student characteristics, facilities and infrastructure, and the teacher's ability to apply learning models and methods. The selected model and method must be adapted to the material, sometimes different materials must be delivered in different ways (Paradina, D. Connie, Medriati, 2019).

Problem based learning can accommodate students' knowledge in learning and improve the ability to solve mathematical problems encountered in everyday life. The philosophy underlying

PBL learning can be viewed as a collaborative, independent, collaborative and contextual activity. As an educational strategy that attracts many educators provide a guiding framework that supports active and group learning based on the belief that effective learning occurs when students construct ideas through social interaction and independent learning (Yew, E.H.J., Goh, 2016). According to (Phungsuk, R., Viriyavejakul, C., Ratanaolarn, 2017), PBL is active learning based on the use of unstructured problems as a learning stimulus that prioritizes problem solving or questions and focuses on interdisciplinary relationships, authentic research, collaboration and production. Also work or display of work and focused results.

According to (Saharsa, U., Qaddafi, M., 2018) the purpose of the PBL model is to master the concept of discovery learning and develop problem solving skills. With PBL students are trained to think, solve problems, find ideas and make decisions. Students become more understanding because they are directly involved in actively growing new knowledge, and become more aware of all concepts and principles. Using PBL means teaching students to face real life problems as a basis for learning or students learn through problems. This is corroborated by (Supiandi, M. I., & Julung, 2016) that consistently implementing PBL can improve students' ability to solve problems.

According to (Haryanti, Y.D. Febrianto, B., 2017) and (Tyas, 2017) the characteristics of PBL include: a. pose problems or questions that are relevant and personally meaningful to students because they reflect authentic real life, avoid easy answers, and allow multiple solutions to the situation; b. focus on interdisciplinary relationships; c. authentic research, students analyze and define problems, develop hypotheses and predictions, collect and analyze data, conduct experiments (if necessary), draw conclusions; and d. produce and display products or works. But there are also those who state that the characteristics of PBL (Cahyaningsih, U., & Ghufron, 2016) include: a. Learning; b. problem based; c. solution to problem; d. determine their own way to solve the problem; e. iterative, that is when students receive information, they bring it back to the problem at hand and solve it; f. cooperative; g. self reflection h. Self-monitoring: re-evaluating, observing again from the beginning to find out what progress and what has been achieved; and i. original. Therefore, the characteristics of PBL are student-centered learning, problem-oriented learning, where the problem is authentic and the teacher acts as a facilitator, and from this learning students can later find their own way to solve problems.

One way to improve students' creative thinking skills in learning is to use appropriate learning models to achieve learning goals (Malasari, E. Y. U., Rasiman., 2018). In learning science in the 21st century, teachers are required to conduct learning that reflects the four skills known as the 4Cs, namely critical thinking, communication, collaboration, and creativity. As conveyed by (Paradina, D. Connie, Medriati, 2019), PBL learning is suitable for honing the competence of student learning outcomes and optimizing science learning.

This is in line with research results (Fauzan, M., Gani, A., & Syukri, 2017)that there is an increase in student learning outcomes in cognitive, affective, and psychomotor aspects by applying the PBL model to science learning. The advantage of PBL according to (Rosa, N. M., & Pujiati, 2016) is that in learning it shows students have the ability to think critically and creatively and helps students develop thinking skills and problem solving as independent learners. Supiandi, M. I., & Julung, (2016) also holds the same view, which claims that consistent PBL implementation has proven successful in improving student problem solving and learning with PBL consistently improving student learning outcomes (cognitive).

According to (Hartati, 2016) PBL makes a good contribution to the development of scientific literacy attitudes, it can even be used to train students to develop and investigate problems by raising awareness of different ways of thinking and solving problems (Baysal, 2017). Likewise according to (Baysal, 2017; (Bashith, A., & Amin, 2017), PBL can improve critical thinking as indicated by the active attitude of students in the class through discussions and questions with real problems. PBL also improves students' mind map placement skills at a fairly good level in all respects (Karyatin, 2016) as well as improves cognitive, affective, and psychomotor thinking skills (Fauzan, M., Gani, A., & Syukri, 2017) and (Amalia et al., 2017). The application of PBL is much

better than the traditional model and has a positive effect, and can create a fun learning environment and encourage optimal learning (Schettino, 2016). PBL allows students to carry out in-depth studies of material and problems, combine theory and practice, and apply various knowledge and skills to develop solutions to problems given by the teacher (Andini, S. A., Susanto, S., & Hobri, 2017).

According to (Tyas, 2017) PBL is not a learning model that is easy to implement, so teachers don't want to use it. One reason is that the teacher is not used to it, so the teacher's habits are still the same as traditional learning. The weaknesses of PBL are revealed in long and complex lessons that demand higher student activity and concentration, as well as results that depend on group abilities. Another weakness is that the problem solving process requires time and special attention (Maulidiyahwarti, G., Sumarmi., &Amirudin, 2016). The results of the study (Tyas, 2017) also show that teachers encounter obstacles, namely at the planning stage, it is difficult to determine the right problem to create and encourage a good atmosphere for discussion, as well as to stimulate students' intellectual development.

Long-term limitations in planning and implementing learning come from the teacher's lack of understanding of PBL learning. It is not easy for teachers to position themselves as trainers and mentors, deepen understanding and support student initiatives. Another weakness of applying the PBL model is that students who are not interested or do not believe that the problem being studied is difficult to solve, are reluctant to try it. Arousing students' interest in the problem-solving process is an important step in learning. Weaknesses in the application of PBL are certainly not a reason not to implement this model. PBL development that seeks a way out of these weaknesses must be carried out as an effort to further develop this learning model (Purwanto, W., Djatmika, E. T., 2016)

Student learning outcomes from the learning process at school, can be in the form of behavior, values, perceptions, attitudes, appreciation and skills. According to (Ilmiyah, N.H., & Sumbawati, 2019) learning outcomes are changes in students' knowledge, attitudes, skills and behavior as a result of experience. Learning outcomes can also be interpreted as the result of hard work and activities that are completed both individually and in groups after participating in the learning process (Komariyah, S., & Laili, 2018). Learning outcomes are nothing but changes in behavior after students learn which is an indication of student attitudes (Paradina, D. Connie, Medriati, 2019). Science learning in schools is expected to be a place for students to learn about the environment independently and apply it in everyday life. Through scientific learning, students receive direct information through observation, discussion and simple research (Noviyanti, E, Rusdi, Ristan, 2019).

The results of the site survey showed that students had difficulty solving scientific problems. Students are also difficult to ask questions based on the problems presented, and students often wait for the teacher to explain rather than find out for themselves. This happens, one of the reasons is that the teacher has not aroused students' creative thinking and activity. Learning is still teacher-centered, so students are less actively involved in learning and problem solving. In connection with these problems, teachers must develop innovative learning models such as PBL. With PBL learning it is hoped that good communication will be established between students. Students exchange thoughts and opinions, discuss existing problems among themselves, making it easier for them to find and present ideas or solutions to solve existing problems. In addition, students can be actively involved in the learning process and acquire critical thinking to achieve the best possible learning outcomes.

Based on various research results, it was concluded that PBL can improve the quality of learning in high schools (Andini, S. A., Susanto, S., & Hobri, 2017; Karyatin, 2016). This is in accordance with research (Wulandari, N. I., Wijayanti, A., & Budhi, 2018) which shows that there are significant differences in the learning outcomes of 7th grade students of SMP Negeri 11 Yogyakarta in the 2016/2017 academic year between PBL and traditional learning models according to ability student communication. Likewise with the results of the study (Saharsa, U.,

Qaddafi, M., 2018) which showed that the application of PBL had a positive influence on the conceptual understanding of class VIII students of SMPN 19 Bulukumba in science learning as evidenced by the high average results of participants' understanding of the concept.

Previous research on problem-based learning in class VIII students of SMP Negeri 1 Tasikmadu at SMP Negeri 1 Tasikmadu for the 2018/2019 academic year on learning showed that there was a significant influence on student learning outcomes in science learning. Learning-based learning has never been applied to the material interactions of living things with their environment. With this background, a problem-based learning research was carried out on the material interaction of living things with their environment at SMP Negeri 1 Tasikmadu. Based on the description presented, it is important to study science learning based on PBL on the interaction of living things and their environment on student learning outcomes at SMP Negeri 1 Tasikmadu semester 2021/2022. The results of this study can be used to provide input in learning similar material and allied classes in learning using Problem Based Learning, as well as input for prospective teachers in preparing PBL-based learning.

2. MATERIALS AND METHODS

2.1. Types and Research Design

This research is an experimental research with pretest posttest nonequivalent control group design. This study involved two classes, namely the experimental class and the control class. These two classes were given different treatment. The experimental class was used as the treatment class, namely the implementation of learning using the PBL model while the control class used a non-PBL learning model (Table 1.).

Table 1. Pretest Posttest Nonequivalent Control Group Design

Pretest	Treatment	Posttest
O_1	PBL	O_2
O_3	Non PBL/Control	O_4

Note:
O1 = Pretest experimental class
O2 = Posttest experimental class
O3 = Pretes control class
O4 = Posttest control class

2.2. Population, sample and research sampling

This research was conducted at SMPN 1 Tasikmadu which is located at Buran Village, Tasikmadu, Kranggan, Buran, Tasikmadu District, Karanganyar Regency, Central Java during the even semester of the 2021/2022 school year. The population used in this study were all class VII students of SMPN 1 Tasikmadu which consisted of 8 classes. The research samples were students in class VII A, totaling 28 students as the experimental class and class VII D, totaling 28 students as the control class. Determination of the sample by random sampling. The data used in this study are the learning outcomes of class VII students at SMP Negeri 1 Tasikmadu even semester for the 2021/2022 academic year with the application of Problem Based Learning on the interaction of living things with their environment (Table 2).

Table 2. Data Sources, Data Collection Techniques, Instruments

Aspects of learning outcomes	Data Sources	Data Collection Techniques	Instruments
Cognitive	Student	Pretest and posttest	Multiple choice questions
Affective	Student	Observation : Discussion	Observation sheet

Aspects of learning outcomes	Data Sources	Data Collection Techniques	Instruments
		Observation Cooperation Summing up the learning outcomes	
Psychomotor	Student	Presentation observation	Presentation observation sheet

2.3. Research Procedures

Beginning with the preparation of lesson plans using PBL and not PBL and its tools for learning material on the interaction of living things with their environment, accompanied by teaching materials according to the material, determining learning media that are appropriate to the material, LKPD, and learning outcomes assessment instruments including cognitive assessment instruments (pretest and posttest questions), affective assessment, and psychomotor assessment. Trials of research instruments and instrument validation were carried out to obtain valid and reliable measuring instruments.

The implementation of learning begins with giving pretests to the two research classes, then learning is carried out according to the planned lesson plans. In the Experiment class, using PBL, the class is grouped into five groups, studying with the LKPD guide according to the material on the interaction of living things with their environment. Classes run according to the planned lesson plans. During the learning activities, an assessment of the observation of the interaction of living things with their environment is carried out when activities outside the classroom use LKPD, the location of the observations according to the agreement of each group. Then an assessment of the discussion of the results of observations, together with an assessment of cooperation during group activities, and an assessment of the presentation of the results of observations and group discussions. Learning to complete the material: 1. Patterns of interaction of living things, 2. Food chains and food webs, 3. Symbiosis, 4. Role of living things in the environment, carried out in 2 meetings. At the second meeting, at the final meeting a post test was carried out. The same learning steps are carried out in the control class, the difference is that they are not problem-based but use other learning. The six assessments were carried out to obtain research data. The data collection technique used was a test (Pre and Post test) for cognitive learning outcomes data, affective and psychomotor learning outcomes were carried out by observation. All data obtained were analyzed using hypothesis testing using the Independent Sample T-Test (Figure 1).

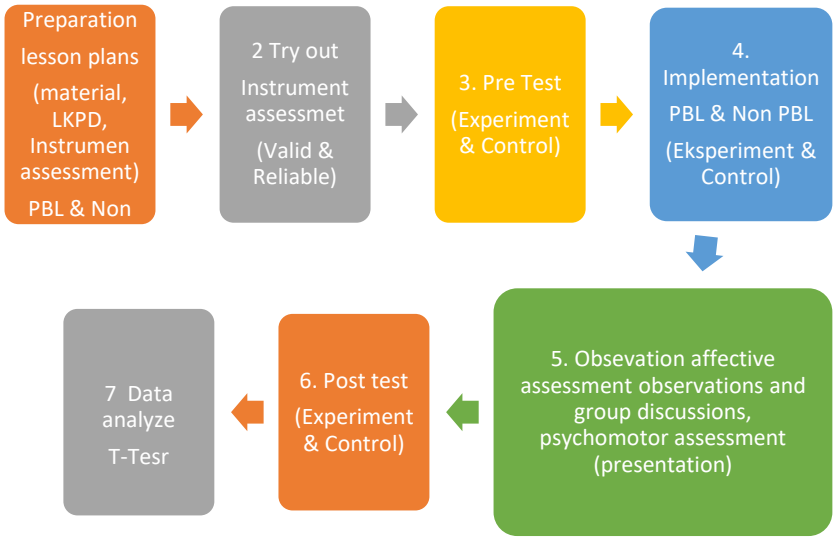


Fig. 1. Research Procedures

3. RESULTS AND DISCUSSION

3.1. Result

The research data is in the form of student learning outcomes after completing learning with PBL learning models and without PBL. Learning outcomes are based on students' ability to complete cognitive pre- and post-test assessments, observation of students' attitudes during learning as an affective assessment, and the ability to present the results of observations as a psychomotor assessment (Table 3).

Table 3. Learning Outcomes of Pre and Post tests, Affective and Psychomotor using PBL on Living Things Interaction Material.

Learning outcomes	*Problem Based Learning*					Without Problem Based Learning				
	Pre	Post	Ngain (%)	Affec	Psycho	Pre	Post	Ngain (%)	Affect	Psycho
Max	80	100	100	100	100	80	90	75	87.50	87.50
Min	40	70	40	50	50	40	50	16,67	37.50	37.50
Mo	70	90	66.67	75	75	60	80	33,33	62.50	62.50
Me	60	90	75	75	75	60	70	33,33	62.50	62.50
Mean	58.57	88.93	76 (Ef)	73.21 (G)	77.68 (G)	57.86	72.86	36.54 (IE)	64.73 (E)	65.62 (E)

Note :

Category Interpretation of Effectiveness N-Gain (%)
<40 = Ineffective (I)
40-55 = Less effective (LE)
56-75 = Effective enough (EE)
>76 = Effective (Ef)
(Nurhayati, 2021)

Affective and Psychomotor Score Criteria
80-100 = Very good (VG)
70-79 = Good (G)
60-69 = Enough (E)
< 60 = Less (L)
(Amyani, 2018)

Based on Table 3, it can be seen that learning using PBL shows higher post-test learning outcomes than learning outcomes using learning models without PBL (88.93> 72.86), as evidenced by greater N-gain results (76%/Ef > 36.54 %/IE) which means learning using PBL effectively improves learning outcomes in the cognitive domain. In the affective domain, the learning outcomes obtained show that the average affective learning result using PBL is higher than not using PBL (73.21/G> 64.73/E), which means that learning using PBL is better than not using PBL which is shown to be sufficient criteria. Likewise shown in the psychomotor aspects, the average shows higher results than not using PBL, namely 77.68/G> 65.62/E, which means that learning using PBL gives higher results on psychomotor aspects as explained in Figure 2.

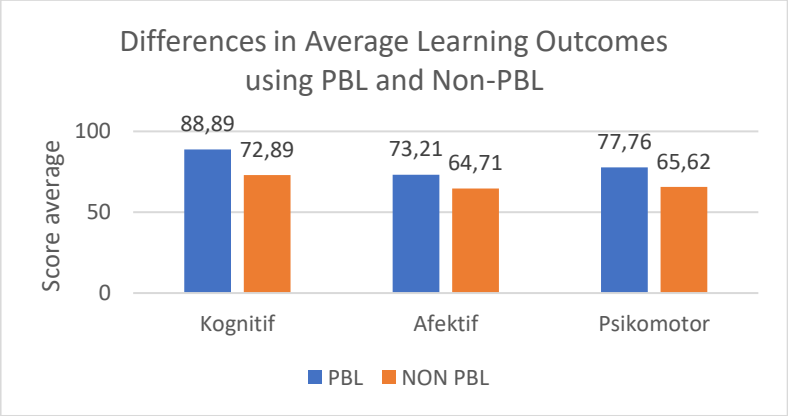


Fig. 2. Analysis of the average results of learning outcomes on cognitive, affective and psychomotor aspects

3.2. Normality and Homogeneity Prerequisite Test

Testing the learning outcomes data using the Kolmogorov-Smirnov test, shown in table 4.

Table 4. The results of testing the normality of learning outcomes for junior high school students using PBL

Aspect	Class	Significance Setting	Significance	Decision
Cognitive	Experiment	0,05	0,16	Normal
	Control	0,05	0,07	Normal
Affective	Experiment	0,05	0,97	Normal
	Control	0,05	0,52	Normal
Psychomotor	Experiment	0,05	0,10	Normal
	Control	0,05	0,12	Normal

Based on Table 4. It shows the results of the normality test of the three learning outcomes with PBL learning including normal distribution (significance value is greater than the significance constant). Likewise for the next prerequisite test, namely the homogeneity test (Table 5), all three showed normal results (the significance value was greater than the significance constant).

Table 5. The results of testing the Homogeneity of Junior High School Students' Learning Outcomes using PBL

Learning outcomes	Significance Setting	Significance	Decision
Cognitive	0,05	0,16	Homogeneous
Affective	0,05	0,88	Homogeneous
Psychomotor	0,05	0,87	Homogeneous

3.3. *Test Independent Sample T-Test*

Subsequent analysis with the Independent Sample T-Test, comparison of the probability value of Sig. (2-tailed) that is, if the probability (sig.) > 0.05, then H0 is accepted, and if the probability (sig.) < 0.05, then H0 is rejected. From the three learning outcomes data (Cognitive, Affective and Psychomotor) it shows that learning outcomes at thit > ttab, which means that student learning outcomes on cognitive, affective and Psychomotor show differences with higher results, which means the hypothesis that learning using PBL affects learning outcomes studied in junior high school students on science material (Table 6).

Table 6. Test Independent Sample T-Test Student Learning Outcomes using PBL

Learning outcomes	Class	N	Mean	t_{hit}	t_{tab}	*Sig. (2-tailed)*	Conclusion
Cognitive	Experiment	28	88,93	5,78	2,005	0,00	Differences
	Control	28	72,86				
Affective	Experiment	28	73,21	2,85	2,005	0,006	Differences
	Control	28	64,73				
Psychomotor	Experiment	28	77,68	2,74	2,005	0,008	Differences
	Control	28	65,62				

3.4. N-Gain Test

There is an increase in students' learning comprehension abilities using PBL learning, a normalized gain analysis (N-Gain) is carried out, while the results are in Table 7.

From table 7, learning science on the interaction of living things using PBL shows an increase in understanding from pre-test to posttest by 75. 83% which is included in the effective category to improve learning outcomes, even though the increase is only 0.83 from the effective limit. In contrast to learning science with the same material but not using PBL learning, the increase in students' learning understanding only increased by 36.54%, which means it was not effective/Ineffective.

Table 7. N-Gain Test Pretest and Posttest student learning outcomes using PBL on the Interaction of Living Things

Class	N-gain (%)	Category
Experiment	75.83	EE
Control	36.54	IE

Note :

Category Interpretation of Effectiveness N-Gain (%) (Nurhayati, 2021)

<40 = Ineffective (I) 56-75 = Effective enough (EE)
40-55 = Less effective (LE) >76 = Effective (Ef)

3.5. Cognitive Learning Outcomes of Junior High School Students using PBL on the Interaction of Living Things

Science learning about the interaction of living things in high school using PBL shows an effective increase in understanding. According to (Hartati, 2016), PBL contributes to increasing science literacy, training to develop and investigate problems by encouraging different ways of thinking when solving problems (Baysal, 2017). Also emphasized by (Astuti, 2019), that learning science using PBL helps students process information and gather their knowledge about nature and the surrounding environment. This statement is relevant to this research which also studies the interaction of living things with their environment. In fact, according to (Afni et al., 2018), the habit of applying problem-based learning models and their impact on increasing mastery of biology concepts for high school students indicates that the application of PBL which is carried out on an ongoing basis can have a positive impact on student learning outcomes.

In contrast to the results of the study (Warabula, M; Papilaya, P.M., Rumahlatu, 2020), which found that the discovery learning learning model and video-assisted PBL learning model did not affect motivation but did affect cognitive learning outcomes. Similarly, according to (Anggraini et al., 2020) it was concluded that the PBL model can improve cognitive biology learning outcomes. Almost the same as stated by (Kasuga et al., 2022), PBL-based learning on the development of science process skills on the topic of safety in our environment in secondary schools in Tanzania, proved to have no statistically significant difference in achievement by gender compared to the method traditional. This study recommends the continued use of learner-centred approaches such as PBL in science teaching and learning.

As stated by (Kasuga et al., 2022), students' critical and creative thinking skills are honed better when learning uses PBL. Gradually assisting students in cultivating thinking competence and skills in solving problems in everyday life which makes students independent learners, in line with today's independent learning. This is also supported by (Supiandi, M. I., & Julung, 2016), who argues that science learning using PBL consistently proves its success and improves students' cognitive abilities. This is shown from the results of the post test scores

of students who are higher than those who do not use PBL (90> 70). Similar to the results of research (Karan, E. Brown, 2022), that there is a significant average difference in solving problems before and after using PBL and students get higher scores compared to students in the control group.

3.6. Affective Learning Outcomes of Junior High School Students using PBL on the Interaction of Living Things

The affective domain is a domain related to attitudes (Karan, E. Brown, 2022). In the affective domain, the learning outcomes of students using the PBL model are higher than those of the non-PBL model. Student learning outcomes improve because PBL encourages the application of student knowledge to real-world situations. Learning using PBL affects students' affective learning outcomes because this learning model has steps that involve students to be actively involved in the process of solving real problems in their environment. Besides that, it can increase students' curiosity about science learning material. They are passionate about learning, thus affecting student learning outcomes. The steps of the problem-based learning model are: a. orient students to problems, b. organize students to study, c. guiding individual and group research, d. develop and present works, e. analyze and evaluate the problem solving process (Paradina, D. Connie, Medriati, 2019) In fact, according to (Maulidya et al., 2021) suggests that the syntax of the PBL learning model that can improve students' analytical abilities includes orienting students to problems, helping students to investigate independently and in groups, analyze and evaluate processes. Likewise according to (Ati, A.F.S. Biato, M.A. Aprillya, 2022), found that PBL supported by AR is more effective than only PBL and the teaching methods currently used in terms of increasing reflective thinking skills towards problem solving and decision making abilities, as well as achievement persistence academic in learning science.

Based on research (Ati, A.F.S. Biato, M.A. Aprillya, 2022) it was stated that learning using PBL can improve critical thinking as indicated by the active attitude of students in the class. Students become active during the learning process through discussions and questions based on real problems. PBL can create a fun learning environment and encourage optimal learning (Schettino, 2016) Likewise, according to (Fitriyyah et al., 2019), it was concluded that the PBL learning model had an effect on the critical thinking skills of Kragan 3 Public Middle School students on global warming material. Likewise, what was stated by (Dewi et al., 2019) stated that the application of the PBL model could increase student learning activities and student learning outcomes in biology on Environmental Pollution Material for Class X Students of SMA Negeri 1 Jatisrono.

In fact, according to (Herlina et al., 2020) that the PBL model uses audio-visual media has an effect on student interest and learning outcomes. PBL encourages teachers to always train students to think logically and analytically to solve problems according to the structure of the subjects being taught. In PBL, the teacher creates learning situations that are challenging and arouse students' curiosity to find answers (Karyatin, 2016) also allows students to carry out in-depth studies of material and problems, combine theory and practice, and apply various knowledge and skills to develop solutions to problems given by the teacher (Amalia et al., 2017) Strengthened (Webster et al., 2022) which conveys that for those who wish to implement PBL and other complex learning approaches in a way that is responsive to the learner's life experiences needs to be done.

3.7. Psychomotor Learning Outcomes of Junior High School Students using PBL on the Interaction of Living Things

The psychomotor domain refers to a person's skill or ability to act in learning (Webster et al., 2022), psychomotor learning outcomes are manifested in the form of individual skills and abilities. Research shows that learning using PBL has an influence on students' psychomotor

learning outcomes, namely actively developing basic problem-solving skills and acquiring knowledge through interaction with others (Phungsuk, R., Viriyavejakul, C., Ratanaolarn, 2017)). PBL improves students' ability to place mind maps at a fairly good level in all (Karyatin, 2016) and improves cognitive, affective and psychomotor thinking skills (Fauzan, M., Gani, A., & Syukri, 2017). Learning using PBL has an impact on learning outcomes because PBL offers the following advantages: a. meaningful student learning processes where students learn to solve problems through the application of their knowledge; b. students simultaneously integrate knowledge and skills and apply them in relevant contexts; c. improve critical thinking, encourage student initiative at work, internal motivation to learn, and be able to develop interpersonal relationships in group work (Fauzan, M., Gani, A., & Syukri, 2017). Based on various research results (Andini, S. A., Susanto, S., & Hobri, 2017) and (Karyatin, 2016) it is concluded that PBL can improve the quality of learning in secondary schools. This is in line with research (Wulandari, N. I., Wijayanti, A., & Budhi, 2018), which shows that there are significant differences in the learning outcomes of 7th grade students of SMP Negeri 11 Yogyakarta in the 2016/2017 academic year between problem-based learning and traditional learning. Likewise, the results of the study (Saharsa, U., Qaddafi, M., 2018) show that the problem-based learning model has a positive effect on students' conceptual understanding of SMPN 19 Bulukumba Class VIII in science learning as evidenced by the high average of the study.

There are obstacles in this study, namely learning according to PBL which requires a longer time. The same thing happened in research (Tyas, 2017) which showed that teachers faced obstacles in implementing PBL, namely at the planning stage, it was difficult to determine the right problem to create a good atmosphere so that discussions could run well and could encourage students' intellectual development. Long-term limitations in planning and delivering lessons stem from teachers' unfamiliarity with PBL learning. It is not easy for teachers to position themselves as trainers and mentors, deepen understanding and support student initiatives.

Also added by (Tyas, 2017), PBL is not a learning model that is easy to apply, so teachers don't want to use it. This is due to several factors, one of which is not being willing to implement it so that the teacher's habits are still the same as traditional learning. Weaknesses of problem-based learning are revealed in long and complex lessons that demand a higher level of student activity and concentration, as well as results that depend on the ability of the group. Another weakness is that the problem solving process requires time and special attention (Maulidiyahwarti, G., Sumarmi., &Amirudin, 2016). Another weakness of PBL is that students are not interested or unsure that the problem to be studied is difficult to solve, so they are reluctant to try it. However, learning using PBL according to research (Hartati, 2016)shows student responses that fall under very high criteria. From this it can be argued that arousing students' interest in PBL is an important step in learning. Weaknesses in the application of PBL learning are certainly not a reason not to apply this model. The development of the PBL model that seeks a way out of these weaknesses must be carried out as an effort to further develop this learning model in everyday learning.

4. CONCLUSIONS

Based on the research and discussion, the conclusion is that science learning based on PBL on the interaction of living things with their environment has an effective effect on the learning outcomes of junior high school students.

5. REFERENCES

Afni, M., Zahroh, A., Anwar, N., Irjasy, A., & Fauzi, A. (2018). Pembiasaan penerapan model problem based learning dan dampaknya terhadap peningkatan penguasaan konsep biologi siswa SMA. *Prosiding Seminar Nasional IV 2018: Peran Biologi Dan Pendidikan Biologi Dalam Revolusi Industri 4.0 Dan Mendukung Pencapaian Sustainability Development Goals (SDG's)*, 23–30. http://research-report.umm.ac.id/index.php/psnpb/article/download/2518/2352

Amalia, E., Surya, E., & Syahputra, E. (2017). MATHEMATICS PROBLEM SOLVING ABILITY FOR JUNIOR HIGH SCHOOL THE EFFECTIVENESS OF USING PROBLEM BASED LEARNING (PBL) IN MATHEMATICS PROBLEM SOLVING ABILITY FOR JUNIOR HIGH SCHOOL. *IJARIIE*, *3*(January), 2395–4396.

Andini, S. A., Susanto, S., & Hobri, H. (2017). Students' activity in problem-based learning (PBL) math classroom be oriented lesson study for learning community (LSLC). *International Journal of Advanced Research*, *5*(9), 1395–1400. https://doi.org/http://dx.doi.org/10.21474/IJAR01/5458

Anggraini, W. N., Purwanto, A., & Nugroho, A. A. (2020). Peningkatan Hasil Belajar Kognitif Biologi Melalui Problem Based Learning Pada Siswa Kelas X SMA Negeri 1 Bulu Sukoharjo. *IJIS Edu : Indonesian Journal of Integrated Science Education*, *2*(1), 55. https://doi.org/10.29300/ijisedu.v2i1.2864

Astuti, T. P. (2019). Model Problem Based Learning dengan Mind Mapping dalam Pembelajaran IPA Abad 21. In D. S. Ristanto, R.H. darmawan, E. Suryanda, A., Ismirawati, N. Prajoko, S. Utomo, A.P., Rini, (Ed.), *Proceeding of Biology Education* (pp. 64–73). Universitas Negeri Jakarta. https://doi.org/https://doi.org/10.21009/pbe.3-1.9

Ati, A.F.S. Biato, M.A. Aprillya, M. . (2022). Science Augmented Reality Program Media for Elementary School Students. *Jurnal Pendidikan Indonesia*, *11*(3), 456–465. https://doi.org/https://doi.org/10.23887/jpiundiksha.v11i3.41378

Bahtiar, Dukomalamo, . (2019). Basic science process skills of biology laboratory practice_ improving through discovery learning.pdf. *Biosfer: Jurnal Pendidikan Biologi*, *12*(1), 83–93. https://doi.org/DOI: https://doi.org/10.21009/biosferjpb.v12n1.83-93

Bashith, A., & Amin, S. (2017). The Effect of Problem Based Learning on EFL Students' Critical Thinking Skill and Learning Outcome. *AL-TA'LIM JOURNAL*, *24*(2), 93–102. https://doi.org/10.15548/jt.v24i2.271

Baysal, Z. N. (2017). The problem-based learning process: Reflections of pre-service elementary school teachers. *Educational Research and Reviews*, *12*(4), 177–188. https://doi.org/DOI: 10.5897/ERR2016.3045

Cahyaningsih, U., & Ghufron, A. (2016). PENGARUH PENGGUNAAN MODEL PROBLEM-BASED LEARNING TERHADAP KARAKTER KREATIF DAN BERPIKIR KRITIS DALAM PEMBELAJARAN MATEMATIKA. *Jurnal Pendidikan Karakter*, *7*(1), 104–115. https://doi.org/DOI: https://doi.org/10.21831/jpk.v0i1.10736

Dewi, E. H. P., Akbari, S., & Nugroho, A. A. (2019). Peningkatan Aktivitas dan Hasil Belajar Biologi melalui Model Problem Based Learning (PBL) pada Materi Pencemaran Lingkungan Siswa Kelas X SMA Negeri 1 Jatisrono. *Journal of Biology Learning*, *1*(1), 53–62. https://doi.org/10.32585/.v1i1.251

Fauzan, M., Gani, A., & Syukri, M. (2017). PENERAPAN MODEL PROBLEM BASED LEARNING PADA PEMBELAJARAN MATERI SISTEM TATA SURYA UNTUK MENINGKATKAN HASIL BELAJAR SISWA. *Jurnal Pendidikan Sains Indonesia*, *5*(1), 27–35. https://jurnal.usk.ac.id/JPSI/article/view/8404/6797

Hartati, R. (2016). PENINGKATAN ASPEK SIKAP LITERASI SAINS SISWA SMP MELALUI PENERAPAN MODEL PROBLEM BASED LEARNING PADA PEMBELAJARAN IPA TERPADU. *EDUSAINS*, *80*(1), 90–97. https://doi.org/DOI: http://dx.doi.org/10.15408/es.v8i1.1796

Haryanti, Y.D. Febrianto, B. (2017). MODEL PROBLEM BASED LEARNING MEMBANGUN KEMAMPUAN BERPIKIR KRITIS SISWA SEKOLAH DASAR. *Jurnal Cakrawala Pendas*, *3*(2), 57–63. https://doi.org/http://dx.doi.org/10.31949/jcp.v3i2.596

Herlina, M., Syahfitri, J., & Oktariani, Y. (2020). Pengaruh Model Pembelajaran Pbl Menggunakan Media Audio Visual Terhadap Minat Dan Hasil Belajar Biologi. *Jurnal BIOEDUIN : Program Studi Pendidikan Biologi*, *10*(1), 46–53. https://journal.uinsgd.ac.id/index.php/bioeduin/article/view/8164

Ilmiyah, N.H., & Sumbawati, M. . (2019). Pengaruh Media Kahoot dan Motivasi Belajar Terhadap Hasil Belajar Siswa. *Journal Information Engineering and Educational Technology*, *3*(1), 46–50. https://doi.org/https://doi.org/10.26740/jieet.v3n1.p46-50

Karan, E. Brown, L. (2022). Enhancing Student's Problem -solving Skills through Project-based Learning Ebrahim Karan and Lisa Brown *. In *ojs.jpblhe* (Vol. 10, Issue 1, pp. 74–87). JPBLHE is Elsevier Scopus indexed. https://doi.org/10.5278/ojs.jpblhe.v10i1.6887

Karyatin, K. (2016). Penerapan modified Problem Based Learning (PBL) dengan gallery walk (GW) untuk meningkatkan keterampilan. *JPPIPA (Jurnal Penelitian Pendidikan IPA)*, *1*(2), 42–51. https://doi.org/https://doi.org/10.26740/jppipa.v1n2.p42-51

Kasuga, W., Maro, W., & Pangani, I. (2022). Effect of Problem-Based Learning on Developing Science Process Skills and Learning Achievement on the topic of Safety in Our Environment. *Journal of Turkish Science Education*, *19*(3), 872–886. https://doi.org/10.36681/tused.2022.154

Komariyah, S., & Laili, A. F. . (2018). Pengaruh kemampuan berpikir kritis terhadap hasil belajar matematika. *Jurnal Penelitian Pendidikan Dan Pengajaran Matematika*, *4*(2), 55–60. https://doi.org/DOI: https://doi.org/10.37058/jp3m.v4i2.523

Malasari, E. Y. U., Rasiman., & S. (2018). EFEKTIVITAS MODEL PEMBELAJARAN PROBLEM BASED LEARNING DAN SCRAMBLE TERHADAP KEMAMPUAN BERPIKIR KREATIF SISWA. *Media Penelitian Pendidikan*, *8*(2), 169–176. https://doi.org/DOI: https://doi.org/10.26877/mpp.v12i2.3835

Maulidiyahwarti, G., Sumarmi., &Amirudin, A. (2016). PENGARUH MODEL PROBLEM BASED LEARNING BERBASIS OUTDOOR STUDY TERHADAP HASIL BELAJAR SISWA KELAS XI IIS SMA. *Jurnal*

Pendidikan: Teori, Penelitian, Dan Pengembangan, *1*(2), 94–100. http://journal.um.ac.id/index.php/jptpp/article/view/6101

Maulidya, H. Z., Aprilia, N., & Hanafi, Y. (2021). Studi Literatur Peningkatan Kemampuan Analisis Siswa Melalui Model PBL Pada Pembelajaran IPA Biologi. *Journal of Biology Learning*, *3*(2), 55. https://doi.org/10.32585/jbl.v3i2.1526

Noviyanti, E, Rusdi, Ristan, R. H. (2019). Guided Discovery Learning Based on Internet and Self Concept_ Enhancing Student's Critical Thinking in Biology _ Noviyanti _ Indonesian Journal of Biology Education.pdf. *Indonesian Journal of Biology and Education*, *2*(1), 7–14. https://doi.org/DOI10.31002/ijobe.v2i1.1196

Paradina, D. Connie, Medriati, . (2019). PENGARUH MODEL PEMBELAJARAN PROBLEM BASED LEARNINGTERHADAP HASIL BELAJAR SISWA DI KELAS X. *Jurnal Kumparan Fisika*, *2*(3), 169–176. https://doi.org/https://doi.org/10.33369/jkf.2.3.169-176

Phungsuk, R., Viriyavejakul, C., Ratanaolarn, T. (2017). Development of a problem-based learning model via a virtual learning environment. *Kasetsart Journal of Social Sciences*, *38*(3), 297–306. https://doi.org/https://doi.org/10.1016/j.kjss.2017.01.001

Purwanto, W., Djatmika, E. T., & H. (2016). PENGGUNAAN MODEL PROBLEM BASED LEARNING DENGAN MEDIA POWERPOINT UNTUK MENINGKATKAN MINAT BELAJAR SISWA. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(9), 1700–1705. http://journal.um.ac.id/index.php/jptpp/article/view/6721

Rosa, N. M., & Pujiati, A. (2016). Pengaruh Model Pembelajaran Berbasis Masalah Terhadap Kemampuan Berpikir Kritis dan Kemampuan Berpikir Kreatif. *Rosa, N. M., & Pujiati, A*, *6*(3), 175–183. https://journal.lppmunindra.ac.id/index.php/Formatif/article/view/990/926

Saharsa, U., Qaddafi, M., & B. (2018). EFEKTIVITAS PENERAPAN MODEL PEMBELAJARAN PROBLEM BASED LEARNING BERBANTUAN VIDEO BASED LABORATORY TERHADAP PENINGKATAN PEMAHAMAN KONSEP FISIKA. *Jurnal Pendidikan Fisika*, *6*(2), 57–64. http://journal.uin-alauddin.ac.id/indeks.php/PendidikanFisika

Schettino, C. (2016). A Framework for Problem-Based Learning: Teaching Mathematics with a Relational Problem-Based Pedagogy. *Interdisciplinary Journal of Problem-Based Learning*, *10*(2). https://doi.org/https://doi.org/10.7771/1541-5015.1602

Supiandi, M. I., & Julung, H. (2016). Pengaruh Model Problem Based Learning (PBL) terhadapKemampuan Memecahkan Masalah dan Hasil BelajarKognitif Siswa Biologi SMA. *Jurnal Pendidikan Sains Indonesia*, *6*(2), 60–64. https://doi.org/DOI: http://dx.doi.org/10.17977/jps.v4i2.8183

Tayeb, T. (2017). ANALISIS DAN MANFAAT MODEL PEMBELAJARAN. *AULADUNA: Jurnal Pendidikan Dasar Islam*, *4*(2), 48–55. https://doi.org/DOI: https://doi.org/10.24252/auladuna.v4i2a5.2017

Tyas, R. (2017). KESULITAN PENERAPAN PROBLEM BASED LEARNING DALAM PEMBELAJARAN MATEMATIKA. *TECNOSCIENZA*, *2*(1), 43–52. https://ejournal.kahuripan.ac.id/index.php/TECNOSCIENZA/article/view/26

Warabula, M; Papilaya, P.M., Rumahlatu, D. (2020). Pengaruh Model Pembelajaran Problem Based Learning Dan Inquiri Based Learning Terhadap Motivasi Dan Hasil Belajar Siswa. *Edubiotik*, *5*(1), 29–41. https://doi.org/doi.org/10.33503/ebio.v5i01.657

Webster, A., Metcalf, A., Kelly, L., Bisesi, A., Marnik-said, M., Colbeck, C., Marine, R., Vinces, M., Campbell, A., & Allen, T. (2022). Undergraduates ' lived experience of project- / problem-based learning in introductory biology. *Adv Physiol Educ*, *46*, 162–178. https://doi.org/10.1152/advan.00042.2021

Wulandari, N. I., Wijayanti, A., & Budhi, W. (2018). EFEKTIVITAS MODEL PEMBELAJARAN PROBLEM BASED LEARNING TERHADAP HASIL BELAJAR IPA DITINJAU DARI KEMAMPUAN BERKOMUNIKASI SISWA. *J. Pijar MIPA*, *13*(1), 51–55. https://doi.org/https://doi.org/10.29303/jpm.v13i1.538

Yew, E.H.J., Goh, K. (2016). Problem-Based Learning: An Overview of its Process and Impact on Learning. *Health Professions Education*, *2*(2), 75–79. https://doi.org/https://doi.org/10.1016/j.hpe.2016.01.004

ISSN 3026-5428

INCOBEST 2023

Universitas Muhammadiyah Surakarta

International Conference on Biology Education, Natural Science, and Technology