JURNAL PENDIDIKAN KIMIA (JPKIM)
ISSN: 2085-3653| e-ISSN: 2549-3116

J. Pendidik. Kim 2023, 15(3), 198 – 207
DOI 10.24114/jpkim.v15i3.48864

Research Article

Practicum design for making bioplastics from uli banana peel (*Musa paradisiaca S.*) to grow the character of the pancasila student profile in polymer chapter

Alfandi Ahmad, and Retno Aliyatul Fikroh

Department of Chemistry Education, Faculty of Education and Teacher Training, Islamic State University Sunan Kalijaga, Yogyakarta- 55281, Indonesia

Received 17 July 2023 ♦ **Revised** 14 November 2023 ♦ **Accepted** 16 November 2023

Citation: Ahmad, A., & Fikroh R. A. (2023). Practicum design for making bioplastics from uli banana peel (Musa paradisiaca S.) to grow the character of the pancasila student profile in polymer chapter. Jurnal Pendidikan Kimia (JPKIM), 15(3), 198–207. https://doi.org/10.24114/jpkim.v15i3.48864

Keywords

Bioplastic
Merdeka curriculum
Pancasila
Polymer
Uli banana

Corresponding author:
Email: alphandiahmad13@gmail.com
(Alfandi Ahmad)

Abstract

The change from the 2013 curriculum to the Merdeka curriculum emphasizes the importance of experiential learning and the Pancasila student profile. However, polymers, a crucial macromolecular sub-material, often lack experimental support in education. This study focuses on selecting polymer materials through practical activities, specifically the creation of bioplastics from uli banana peels (*Musa paradisiaca* S), to foster the development of Pancasila Student Profile characteristics: collaborative teamwork, critical thinking, and innovation. Using a qualitative descriptive method, the study involves curriculum analysis, practical design, and feasibility assessment. The research revealed that the practical design aligns with the characteristics of high school experiments and produces high-quality bioplastics in terms of absorbency, tensile strength, elongation percentage, and biodegradability. Teacher and student interviews further confirmed the alignment with the Pancasila phase F student profile (class XII), emphasizing cooperation, objective-oriented learning, critical thinking, and innovation. This study establishes a strong connection between curriculum, learning outcomes, and experimental design in uli banana peel starch bioplastics production. Not only does it promote the development of Pancasila student profiles, but it also yields high-quality bioplastics.

Introduction

In the Merdeka Curriculum, polymers are one part of the macromolecular material taught in class XII of Senior High School (Rachmawati et al. 2022). The flow of Learning Objectives (ATP) contained in polymer materials includes ATP 12.23 by analyzing the structure and names of organic compounds and macromolecules (carbohydrates, proteins, fats) based on IUPAC and trivia/market. ATP 12.24 analyzes the properties, characteristics, and use of organic compounds and macromolecules (carbohydrates, proteins, fats) in everyday life. Based on the flow of learning objectives, it can be said that students should not only be introduced to theoretical concepts about polymers but also direct experience through experimental activities that aim to build the characteristics of Pancasila student profiles in terms of cooperation, objectivity, critical reasoning, and innovation (Irawati et al. 2022; Makarim, 2022).

Polymer is a concept that is often related to human life. One of the synthetic polymer products is plastic. Plastic is a primary need for human life. Such as cables, school supplies, children's toys, computer devices, food wrappers, and household supplies (Alawiyah, 2020). Plastic is one of the widely used synthetic polymers because it has stable, waterproof, lightweight, transparent, flexible, and solid properties but is not easily decomposed by microorganisms. The decomposition of plastic waste by incineration will produce dioxin compounds that are harmful to health. Currently, most people need an understanding of the use and dangers of using plastic packaging. In addition, the need for more public knowledge and awareness about handling plastic waste causes many environmental problems. The plastic problem is also a concern for the world of education because students should be introduced to problems that occur in the surrounding environment from an early age (Ningsih, 2018).

An effort to overcome this problem is to use bioplastics. Bioplastics are plastics made from natural materials that can be broken down using microorganisms, making them more environmentally friendly and cost-effective when compared to commercial plastics. Materials that are often used in the synthesis of bioplastics are starch and chitosan (Agustin and Padmawijaya, 2016). Starch is one of the most abundant and widespread preparation materials found in nature, which is a carbohydrate food reserve in plants (Kalsum et al. 2020).

Bioorganic waste that can be used as bioplastic because it contains starch is banana peel. The banana peel waste can be used to make bioplastics (Purbasari et al. 2020). Banana peel can be used as raw material for making bioplastics because banana peel contains starch of 0.98%. Banana peel is waste from the rest of snack food production (such as banana chips and banana hydrated), which is usually only used as animal feed (Munawaroh, 2015).

The relationship between polymer materials and existing problems is a critical success factor in developing character. This concern is reflected in the chemistry learning process, especially in class XII polymer materials. The use of banana peel waste in bioplastics has been widely carried out, such as Agustin and Padmawijaya (2016) research which synthesizes bioplastics from the starches of kepok banana peels, increasing the characteristics of biodegradable plastics from temple banana peels with the addition of calcium silicate fillers and clay (Udjiana et al. 2020), the effect of adding glycerol and chitosan concentrations on mechanical properties in making jackfruit plantain peel bioplastics (*Musa paradisiaca* forma typica) (Rinaldi, 2019), and the utilization of ambon banana peel waste (*Musa paradisiaca* L.) in the manufacture of biodegradable plastics (Hikmah, 2015; Huzaisham and Marsi, 2020).

However, research on the use of uli banana peel waste as a practicum design for making bioplastics to grow the character profile of Pancasila students has yet to be carried out. Pisang uli, with the Latin name *Musa paradisiacal* sapientum, is a tropical banana fruit widely produced in Indonesia. The high production of uli bananas in Indonesia is different from the level of public consumption, resulting in many bananas that are not used because of their relatively short shelf life (Alhabsyie et al. 2020). In addition, Uli bananas are only used as raw materials for making banana chips, so the skin is not used and is only used as production waste. Uli banana chips are a snack commodity widely produced by household industries. Utilize the large amount of uli banana peel waste produced by utilizing it in bioplastic materials.

The selection of a polymer chapter through practicum activities for making bioplastics from uli banana peels (*Musa paradisiaca* S.) is expected to build the character of the Pancasila Student Profile, who can work together, think critically, and innovatively. This is the core of the Merdeka Curriculum, which aims to improve the quality of education in Indonesia by the demands of the times, producing intelligent students and having a character by values as a manifestation of the Pancasila Student Profile. The success of this research is that it can help reduce the condition of environmental problems. Namely, the problem of never-ending plastic waste grows the character of the Pancasila student profile. It achieves the flow of learning objectives in the class XII polymer chapter of the Merdeka curriculum.

Method

The method used in this study is the descriptive qualitative method. Descriptive qualitative research is conducted to explain existing research without providing manipulation of variable data under study by conducting direct interviews (Bahri, 2017). According to Sugiyono (2013), the Qualitative method is used to examine natural object conditions where researchers are the key instrument. Data collection techniques are carried out by triangulation (combined observation, interviews, documentation), the data obtained tend to be qualitative, data analysis is inductive, and qualitative research results emphasize meaning rather than generalization (Abdussamad, 2022). Qualitative research aims to understand individual views, find and explain processes, and explore in-depth information about limited research subjects or backgrounds (Hidayah and Fikroh, 2023).

Materials

The tools used in this experimental design are knives, analytical balances, 60 mesh sieves, stirring rods, magnetic stirrers, Petri dishes, 250 ml beakers, 1ml and 5 ml measuring cups, desiccators, ovens, hot plates, thermometers, spatulas, sieve shakers, 5 ml and 1 ml measuring pipettes, incubators, 500 ml measuring flasks. While the ingredients used are uli banana peel starch, aquadest, citric acid, acetic acid, glycerol, and chitosan.

Curriculum Analysis and Indicators of Competency Achievement of Polymer Chapter

The method used for curriculum analysis and competency achievement indicators is a literature study of polymer material class XII SMA / MA. Literature studies are conducted using the syllabus and ATP in the Merdeka curriculum.

Experimental Design for Making Bioplastics from Uli Banana Peel

Making Starch Flour from Uli Banana Peel. Make banana peel starch by cutting it into small parts using a knife and soaking it in 50% citric acid solution (w/v) for 60 minutes. Pieces of banana peel that have been soaked are then drained and mashed using a blender; when smoothing, add water until smooth, then the banana peel pulp is squeezed using a cloth until the pulp of the banana peel does not release water. Do these steps until the juice is colorless. The Uli banana peel filtrate is deposited for approximately 1x24 hours until the starch settles to the maximum; after that, remove the supernatant and take the starch precipitate. The starch deposits that have been obtained are then dried in the sun.

Moisture Content Testing of Uli Banana Skin Starch Flour. Clean the aluminium dish, heat it in the oven for 1 hour, cool it in a desiccator for 15 minutes, weigh the aluminium dish, and record the weight. Repeat the above procedure until the aluminium cup reaches a constant weight. After the constant aluminium cup, weigh the aluminium cup and banana peel starch as wet weight, record the weighing results obtained, then reheat the aluminium cup containing banana peel flour for 1 hour in the oven. After that, put it in the desiccator for 15 minutes, then weigh it. Do it until a constant weight is obtained, and calculate the percent moisture content.

Making Bioplastics from Uli Banana Skin Starch. The manufacture of bioplastics refers to research conducted by Pulungan et al. (2020), which has been modified. Making bioplastics is done by preparing two solutions: starch and chitosan. Making starch solution is done by dissolving 3.5 grams of starch, with equates to as much as 44 grams, then stirring using a magnetic stirrer for 10 minutes until it becomes a starch suspension. Chitosan is made later by dissolving 1.5 grams of chitosan in 1% acetic acid, as much as 50 grams, and stirring for 15 minutes at 100°C until chitosan gel is obtained. After that, the starch suspension is stirred and heated at 65°C for 5 minutes. The thickened starch solution is added to the chitosan solution prepared earlier, stirring and heating at 65°C for 5 minutes. After adding chitosan, 1 gram of glycerol is inserted and stirred at 65 ° C for 10 minutes. The finished bioplastic solution is poured into a 20x20 cm acrylic mold and flattened on the surface. The wet bioplastic is then dried in an oven at 50°C for approximately 2 hours.

Implementation of the Feasibility of Bioplastics from Uli Bananas as Polymer Teaching Materials to Grow the Character of the Pancasila Student Profile

Quality Aspects of Bioplastics

Test of Tensile Strength and Percent Elongation. Tensile strength testing is a form of testing carried out to determine the response of a material when subjected to force so that its mechanical properties can be analyzed with tensile strength and percent elongation.

Water Absorption Test. Water absorption testing. Cut samples measuring 2×2 cm, then weighed and recorded as (W0). The plastic pieces are then immersed in 10 mL aquadest into a 50 mL beaker. Let the plastic stand for up to 10 minutes. Then the sample is taken and removed water on the sample surface using a tissue, then weighed and recorded as (W1) until the weight is constant. Its water absorption ability is calculated using the formula:

$$Wc\ (\%) = \frac{W1 - W0}{W0} \times 100\%$$

Description: Wc = Water absorption ability; W0 = Initial weight; W1 = Weight after soaking

Biodegradability Test. A sample of 10% fermipan solution was prepared. The sample that has been prepared is cut into a size of 3x3 cm and then stored in a desiccator, after that put the plastic sample is placed into a petri dish, pipette 10 mL of 10% fermipan solution, then put into a petri dish containing.

Aspects of Suitability of Practicum Design with the Characteristics of the Pancasila Student Profile
The suitability of the practicum design for making bioplastics from uli banana peel starch in polymer learning with the characteristics of the Pancasila student profile was carried out by semi-structured interviews with five teachers and five high school / MA students. Then the results of the interview were used to determine whether or not the manufacture of bioplastics from skin starch was appropriate as an effort to grow the character profile of Pancasila students.

Results and Discussion

Curriculum Identification and Learning Achievement Indicators of Polymer Chapter
The syllabus published by the Ministry of Education and Culture through their official website in, www.guruberbagi.kemendikbud.go.id, is used as a reference to analyze learning achievement indicators. In this analysis, the reference refers to the reference learning objectives listed in the syllabus. Thus, several relevant learning indicators can be identified. This analysis considers the relationship between the results of experiments conducted during the learning process with previously established learning achievement indicators.

The purpose of curriculum analysis and learning outcome indicators in developing practicum design is to ensure that the practicum is designed appropriately by the applicable curriculum and meets the set learning objectives (Hidayah and Fikroh, 2023). Curriculum analysis involves an in-depth understanding of curriculum content, learning standards, and competencies expected to be achieved by students. Learning achievement indicators are used as guidelines in designing practicum activities that can measure the achievement of student competencies concretely. By conducting this analysis, practicum design can be tailored to the needs of students and facilitate the achievement of desired learning objectives. The relationship between practicum design and learning outcome indicators can be seen in Table 1.

Table 1. The relationship between practicum design and learning outcome indicators

No	Experiments section	Learning Outcomes	Pancasila Student Profile
1.	Making uli banana skin starch flour	Analyzing the structure and names of macromolecular organic compounds	Cooperative, objective, critical reasoning, and innovation
2.	Water content testing of uli starch flour banana peel	Analyze the properties and characteristics of macromolecular organic compounds	
3.	Bioplastic manufacturing	The use of macromolecular organic compounds in everyday life	

Based on the results of curriculum analysis and learning achievement indicators, it was found that the practicum design for making bioplastics from uli banana peels was by the Merdeka curriculum and met the learning achievement indicators according to the learning objectives flow (ATP).

Experimental Design for Making Bioplastics from Uli Banana Peel
In creating an experiment design, paying attention to several key factors is essential. First, the experimental design must be by the results of curriculum analysis and predetermined learning outcome indicators. This is so that the practicum can effectively meet the learning objectives set in the curriculum. Practicum procedures must be adjusted to the availability of tools and materials in schools (Assunção Flores and Gago, 2020). Each school has limitations in terms of laboratory facilities and available inventory. Therefore, it is essential to ensure that the designed procedures can be carried out using the tools and materials available in the school. Thus, practicum can be done well, and students can experience relevant learning with available resources.

Bioplastic formulations used in lab work should be based on the results of literature studies and previous experiments. Through analysis of previous research, the best formula that gives the desired results can be found. In this context, the best formula combines raw materials, solvents, and additives that produce bioplastics with optimal physical and mechanical properties. Using the best formula, a practicum can provide consistent results and enrich students' understanding of bioplastic manufacturing.

The initial stage in the manufacture of bioplastics is starch extraction. Uli banana skin can experience browning if left too long. Prevention is done to overcome browning by soaking uli banana skin in a 50% citric acid solution. If soaking is not done with citric acid, the resulting starch will be dark brown, damaging the aesthetic value. Starch extraction from the uli banana peel is done by blending the banana peel in a water solvent. In this process, the starch contained in the banana peel will dissolve into the liquid phase to separate it from the crude fiber, fat, and other water-insoluble impurities (Husaini and Widiarti, 2017). The effectiveness of starch extraction is affected by the solubility of the compound to be extracted using a suitable solvent, according to the principle of "like dissolves like" (Liu, 2023), where compounds with similar solubility properties with the solvent will dissolve (Ereifej et al. 2016). Starch, which is polar, is extracted using water as a solvent which is also polar (Algariri et al. 2013). The results of separating the filtrate from the skin dregs were left for 24 hours to separate the starch and water, then dried in the sun and obtained banana peel starch flour.

Table 2. Formulations used in making designs

Materials	Quantity (g)
Uli banana peel starch	3.5
Aquadest	44
Chitosan	1.5
Acetic acid 1%	50
Glycerol	1

Fig.-1. Uli banana peel starch bioplastic

Testing the starch water content aims to determine the amount of water contained in starch. Good starch has a maximum water content of 14% (w/w) (BSN, 2011). Starch with a highwater content can damage the starch because it can quickly be grown by microbes (He et al. 2020). Based on the test results, it was found that the water content of banana peel starch flour was 10.61%. Based on these results, starch has a water content that meets the standard. The manufacture of bioplastics refers to the formula made by (Utomo et al. 2013), which was later modified by researchers with the formula as shown in the Table 2. Bioplastic results from uli banana starch can be seen in Fig.-1. The quality of the bioplastics produced is then tested for quality to be considered as to whether this practicum design can be implemented.

Implementation of Feasibility of Bioplastics from Uli Bananas as Polymer Teaching Materials in Growing Pancasila Student Profiles

Quality Aspects of Bioplastics

Tensile Strength Test and % Elongation. Tensile strength and percent elongation tests were carried out at the Laboratory of the Faculty of Agriculture, Gajah Mada University, Yogyakarta. Tensile strength is the ability of a material or material to withstand external tensile or pressure forces without breaking or cracking. Tensile strength is usually measured in units of pressure such as megapascals (MPa) or psi (pounds per square inch) (Callister and Rethwisch, 2018). Tensile strength is one of the most important mechanical properties of biodegradable films (Domene-López et al. 2019) because biodegradable films with high tensile strength can protect the product they are packaged from mechanical disturbances (Gómez-Aldapa et al. 2020).

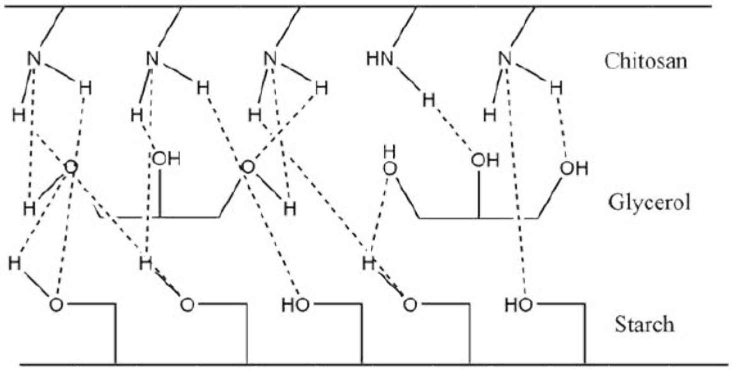

Fig.-2. Hydrogen interaction between chitosan, glycerol, and starch (Agustin and Padmawijaya, 2016)

In bioplastic samples, with the addition of 1.5 grams of chitosan and 1 gram of glycerol or 30% by weight of starch (g/g), an average tensile strength value of 2.9744 MPa was obtained. The criteria for tensile strength (tensile strength) for the Moderate Properties group are 10-100 MPa. Meanwhile, according to SNI standards, the tensile strength of plastic is 24.7-302 MPa. Thus, when viewed from its tensile strength value, the bioplastics produced in this study still need to be categorized as plastics with moderate mechanical properties and are not by the tensile strength values based on SNI standards (Nurlita et al. 2017). The addition of chitosan significantly affects the tensile strength of bioplastics (Tan et al. 2022). According to Selpiana et al. (2016), the higher the chitosan composition, the tensile strength also increases because the hydrogen bonds formed in the plastic film in the presence of hydrogen bonds make the plastic film stronger and harder to break. This happens because it undergoes a physical change in the bioplastic particles. This tensile strength value is a result of the cross-linking between chitosan and glycerol, which consequently reduces the intermolecular forces among the polysaccharide chains, leading to smoother and more flexible plastic samples (Ardyansa et al. 2022; Priyadarshi and Rhim, 2020). Hydrogen interaction between chitosan, glycerol, and starch can be seen in Fig.-2.

Table 3. The results of the tensile strength test for bioplastic samples

Number	a^0 (mm)	b^0 (mm)	Lc (mm)	Fmax (N)	Tensile Strength (Mpa)	Strain at Fmax (%)
1	0.181	5	50	2.7258	3.0119	42.1020
2	0.214	5	50	3.1425	2.9369	35.6300

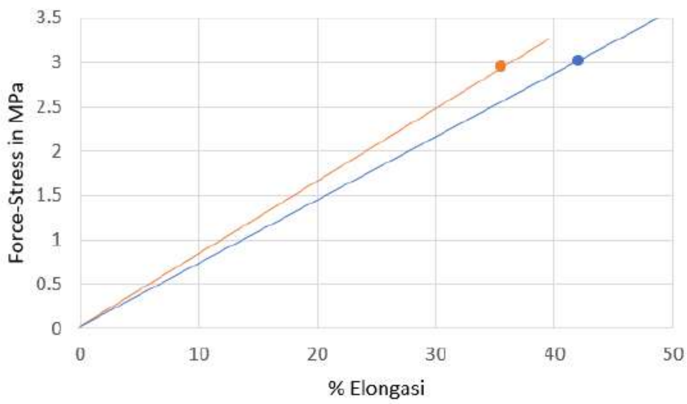

Fig.-3. Graph of tensile strength and elongation

Elongation or strain deformation is a quantity that measures changes in the shape of a material due to loading. Elongation is expressed as a percentage and is calculated as the change in length to the original length of the material (Sajjan et al. 2020). The higher the elongation, the more the material can withstand loads without breaking. Adding glycerol to the bioplastic formulation of 1 gram or 30% by weight of starch (g/g) is intended as a plasticizer. Plasticizers (softeners) are organic materials with low molecular weight added to a product to reduce the polymer's stiffness while increasing the polymer's flexibility and extensibility (Anita et al. 2013). So that the greater the amount of glycerol added, the tensile strength value of plastic tends to decrease. Adding glycerol can also reduce the intermolecular forces of polysaccharide chains which can cause decreased flexibility in plastic samples. From adding 1 gram of glycerol, the average percent elongation value of the bioplastic sample was 38.8660%. The tensile strength test results can be seen in Table 3 and Fig.-3.

Water Absorption Test. Testing the water absorption capacity of bioplastic samples aims to determine whether or not bioplastic samples absorb water quickly. A suitable bioplastic is a bioplastic that is difficult to absorb water and is characterized by having a lower water absorption value (Ningsih, 2018). To find out the water absorption capacity of the bioplastic sample, it was cut and weighed as W0, then the sample was soaked in distilled water and waited for 10 minutes (Fig.-4), then dried and weighed so that the sample weight after soaking was obtained as W1. The absorption capacity (Wc) can be determined by subtracting W1 from W0 and dividing by W0. From the tests carried out, it was found that the water absorption capacity of the banana peel bioplastic sample was 31.48%.

Fig.-4. Water absorption test

The value of water absorption can be influenced by several factors, one of which is starch. Naturally, hydrophilic compounds will increase the water absorption of the film. Starch molecules have a hydroxyl component that can interact with water, causing an increased ability to absorb water (Santana et al. 2018). In addition to the starch factor, glycerol also affects the percentage of water absorption. The greater the amount of glycerol, the greater the percentage of water absorption. The data is corroborated by research. This is due to the nature of glycerol, which dissolves in water and is naturally hygroscopic.

Biodegradability Test. Biodegradability tests were carried out to determine whether bioplastics from banana peel starch could be degraded appropriately in the environment so that the time needed to decompose completely can be estimated. The biodegradability test was conducted by immersing the bioplastic samples in 10% fermipan solution in a petri dish incubated at 36°C for 24-72 hours. Fermipan contains *Saccharomyces cerevisiae*, a type of yeast often used in the bread and cake industry. The fungus Saccharomyces cerevisiae found in fermipan can degrade starch compounds.

Fig.-5. After 24 hours (left), 48 hours (middle), 72 hours (right)

The results of the biodegradability test showed that bioplastic starch from banana uli peel had not been degraded within 24 hours and was characterized by no change in bioplastic structure or bacterial growth. Bioplastics on day two or at 48 start to show changes marked by the start of structural changes in bioplastic sheets. Bioplastics showed significant changes at 72 hours. The characteristic shown was the growth of fungi on bioplastics Biodegradability Test. The results of the biodegradability test can be seen in Fig.-5. Based on testing from the aspect of the quality of banana uli starch bioplastics, it was found that the practicum design made could produce bioplastics that had good quality from several parameters, namely, tensile strength test, % elongation, water absorption, and biodegradability test.

Aspects of Compatibility of Practicum Design with Characteristics of Pancasila Student Profiles

The suitability of the practicum design for making bioplastics from uli banana peel starch with the profile of Pancasila students can be seen through interviews involving five teachers and five students. According to the interview, this practicum is seen as by the profile characteristics of Pancasila in phase F (class XII), namely cooperation, objectivity, critical thinking, and innovation.

In this practicum, students are invited to work together in groups to design and carry out experiments. They can develop a cooperative attitude through collaboration and teamwork and learn to help each other, share ideas, and solve problems together. This practicum can also encourage students to have objective goals. They are expected to follow instructions carefully, accurately measure ingredients, and record results. In this case, students can develop skills in achieving goals based on facts and not prejudice. The practicum for making bioplastics from uli banana peel starch also triggers students to think critically. They need to analyze the bioplastics manufacturing process, identify the factors that influence the results, and evaluate the effectiveness and superiority of the resulting bioplastics. In this context, the practicum aims to develop students' critical thinking skills, where they learn to make decisions based on in-depth reasoning and analysis. In addition, this practicum can also stimulate innovation. Students are invited to design methods for making bioplastics as an alternative to synthetic plastics. In this process, they can develop their creativity and desire to find new or alternative solutions to their challenges.

Based on interviews with teachers and students, the practicum for making bioplastics from uli banana peel starch is considered by the profile of Pancasila students in phase F. By prioritizing cooperation, objectivity, critical thinking, and innovation. This practicum positively contributes to developing the character and competence of the participants educated by the values of Pancasila.

Conclusion

Based on the results of the discussion and research that has been done, it can be concluded that the results of identifying the curriculum and learning outcomes based on the Merdeka curriculum ATP show a close relationship between polymer materials and the experimental design of making bioplastics from uli banana peel starch. The analysis showed that the experimental design was by the characteristics of experiments in SMA/MA, and the bioplastics produced met good quality standards, including absorption, tensile strength, percentage of elongation, and biodegradability. The interviews with teachers and students also showed that the experimental design for making bioplastics from banana peel starch matched the profile characteristics of Pancasila students in phase F (class XII). This design involves student collaboration, has objective goals, encourages critical thinking, and stimulates innovation. Thus, this conclusion strongly links curriculum, learning outcomes, and experimental design in making bioplastics from banana peel starch. This practicum not only supports the development of the character profile of Pancasila students but also produces bioplastics that meet good quality.

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

Acknowledgment

The researcher would like to thank the Integrated Laboratory of UIN Sunan Kalijaga and the Laboratory of the Faculty of Agriculture, Universitas Gadjah Mada, for their invaluable assistance and cooperation in this research. The facilities, resources, and technical support provided by these two laboratories have greatly helped the smooth running of this research. Thanks to the opportunity and contribution given, researchers hope that this collaboration can continue for the development of research in the future.

References

Abdussamad, Z. (2022). *Buku metode penelitian kualitatif*. Makassar: Syakir Media Press

Agustin, Y. E., & Padmawijaya, K. S. (2016). Sintesis bioplastik dari kitosan-pati kulit pisang kepok dengan penambahan zat aditif. *Jurnal Teknik Kimia*, 10(2), 43–51. http://eprints.upnjatim.ac.id/7034

Alawiyah, S. (2020). *Pengembangan lembar kerja berbasis proyek pada pemanfaatan limbah kulit pisang (Musa Paradisiaca) sebagai bioplastik*. UIN Sunan Gunung Djati Bandung. https://digilib.uinsgd.ac.id/38366/

Alhabsyie, M. I., Surya, A., & Domodite, A. (2020). Olahan pisang uli menjadi pisang crispy. *BEMAS: Jurnal Bermasyarakat*, 1(1), 33–38. http://dx.doi.org/10.37373/bemas.v1i1.40

Anita, Z., Akbar, F., & Harahap, H. (2013). Pengaruh penambahan gliserol terhadap sifat mekanik film plastik biodegradasi dari pati kulit singkong. *Jurnal Teknik Kimia*, 2(2), 37-41. https://doi.org/10.32734/jtk.v2i2.1437

Ardyansa, N. J., Ramadhon, A. S. P., & Santi, S. S. (2022). Effect of additional cellulose bacterial from nata de soya and chitosan in bioplastic manufacturing. *Journal of Applied Science, Engineering, Technology, and Education*, 4(2), 202–209. http://dx.doi.org/10.35877/454RI.asci1133

Assunção Flores, M., & Gago, M. (2020). Teacher education in times of COVID-19 pandemic in Portugal: National, institutional and pedagogical responses. *Journal of Education for Teaching*, 46(4), 507–516. https://doi.org/10.1080/02607476.2020.1799709

Bahri, S. (2017). Pengembangan kurikulum dasar dan tujuannya. *Jurnal Ilmiah Islam Futura*, 11(1), 15–34. http://dx.doi.org/10.22373/jiif.v11i1.61

Callister, W. D., & Rethwisch, D. (2018). *Mater. Science and Engineering: An Introduction, 10th ed.* John Wiley & Sons: New York, NY, USA.

Domene-López, D., García-Quesada, J. C., Martin-Gullon, I., & Montalbán, M. G. (2019). Influence of starch composition and molecular weight on physicochemical properties of biodegradable films. *Polymers*, 11(7), 1084. https://doi.org/10.3390/polym11071084

Gómez-Aldapa, C. A., Velazquez, G., Gutierrez, M. C., Rangel-Vargas, E., Castro-Rosas, J., & Aguirre-Loredo, R. Y. (2020). Effect of polyvinyl alcohol on the physicochemical properties of biodegradable starch films. *Materials Chemistry and Physics*, 239, 122027. https://doi.org/10.1016/J.MATCHEMPHYS.2019.122027

He, L., Wang, C., Xing, Y., Zhou, W., Pian, R., Chen, X., & Zhang, Q. (2020). Ensiling characteristics, proteolysis and bacterial community of high-moisture corn stalk and stylo silage prepared with Bauhinia variegate flower. *Bioresource Technology*, 296, 122336. https://doi.org/10.1016/j.biortech.2019.122336

Hidayah, M. A., & Fikroh, R. A. (2023). Potential analysis of boat lily leaf extract (Rhoeo spathaceae (Sw.) Stearn) as an alternative indicator in acid-base titration of acid-base learning. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7491–7502. http://dx.doi.org/10.29303/jppipa.v9i9.3306

Hikmah, N. (2015). Pemanfaatan limbah kulit pisang ambon (Musa Paradisiacal) dalam pembuatan plastik biodegradable dengan plasticizer gliserin. *Laporan Akhir*. Palembang: Politeknik Negeri Sriwijay

Huzaisham, N. A., & Marsi, N. (2020). Utilization of banana (Musa Paradisiaca) peel as bioplastic for planting bag application. *International Journal of Advanced Research in Engineering and Technology (IJARET)*, 11(4), 108-118. https://ssrn.com/abstract=3598064

Kalsum, U., Robiah, R., & Yokasari, Y. (2020). Pembuatan bioplastik dari ampas tahu dan ampas tebu dengan pengaruh penambahan gliserol dan tepung maizena. Jurnal Distilasi, 5(2), 34–37. http://dx.doi.org/10.32502/jd.v5i2.3031

Liu, Z. (2023). A review on the emerging conversion technology of cellulose, starch, lignin, protein and other organics from vegetable-fruit-based waste. *International Journal of Biological Macromolecules*, 124804. https://doi.org/10.1016/j.ijbiomac.2023.124804

Makarim, N. A. (2022). *Sekolah yang mengimpelmentasikan kurikulum merdeka*. https://pasjabar.com/2022/02/14/inilah-jumlah-sekolah-yang-telah-menerapkan-kurikulum-merdeka/

Munawaroh, A. (2015). *Pemanfaatan tepung kulit Pisang (Musa paradisiaca) dengan variasi penambahan gliserol sebagai bahan alternatif pembuatan bioplastik ramah lingkungan*. Universitas Muhammadiyah Surakarta. https://eprints.ums.ac.id/34048

Ningsih, A. R. (2018). *Pembuatan e-module polimer sintetis berbasis green chemistry*. UIN Sunan Gunung Djati Bandung. https://etheses.uinsgd.ac.id/16944

Nurlita, D., Wikanastri, H., & Yusuf, M. (2017). Karakteristik plastik biodegradable berbasis onggok dan kitosan dengan plastisizer gliserol. *Jurnal Pangan dan Gizi*, 7(2), 131–139. https://doi.org/10.26714/jpg.7.2.2017.131-139

Priyadarshi, R., & Rhim, J.-W. (2020). Chitosan-based biodegradable functional films for food packaging applications. *Innovative Food Science & Emerging Technologies*, 62, 102346. https://doi.org/10.1016/j.ifset.2020.102346

Ahmad & Fikroh Bioplastics from uli banana peel Pulungan, Marthalina & Kapita, R & Dewi, Ika Atsari. (2020). Optimisation on the production of biodegradable plastic from starch and cassava peel flour using response surface methodology. *IOP Conference Series: Earth and Environmental Science*, 475. 012019. https://doi.org/10.1088/1755-1315/475/1/012019

Purbasari, A., Wulandari, A. A., & Marasabessy, F. M. (2020). Sifat mekanis dan fisis bioplastik dari limbah kulit pisang: pengaruh jenis dan konsentrasi pemlastis. *Jurnal Kimia dan Kemasan*, 42(2), 66–73. http://dx.doi.org/10.24817/jkk.v42i2.5872

Rinaldi, A. S. (2019). *Pengaruh penambahan konsentrasi gliserol dan kitosan terhadap sifat mekanik pada pembuatan bioplastik kulit pisangraja nangka (Musa Paradisiaca Forma Typica)*. Universitas Brawijaya. http://repository.ub.ac.id/181422

Sajjan, A. M., Naik, M. L., Kulkarni, A. S., Rudgi, U. F.-E.-H., Ashwini, M., Shirnalli, G. G., Sharanappa, A., & Kalahal, P. B. (2020). Preparation and characterization of PVA-Ge/PEG-400 biodegradable plastic blend films for packaging applications. *Chemical Data Collections*, 26, 100338. https://doi.org/10.1016/j.cdc.2020.100338

Santana, R. F., Bonomo, R. C. F., Gandolfi, O. R. R., Rodrigues, L. B., Santos, L. S., dos Santos Pires, A. C., de Oliveira, C. P., da Costa Ilhéu Fontan, R., & Veloso, C. M. (2018). Characterization of starch-based bioplastics from jackfruit seed plasticized with glycerol. *Journal of Food Science and Technology*, 55, 278–286. https://doi.org/10.1007/s13197-017-2936-6

Selpiana, S., Patricia, P., & Anggraeni, C. P. (2016). Pengaruh penambahan kitosan dan gliserol pada pembuatan bioplastik dari ampas tebu dan ampas tahu. *Jurnal Teknik Kimia*, 22(1), 18–26. http://ejournal.ft.unsri.ac.id/index.php/jtk/article/view/530

Sugiyono, D. (2013). *Metode penelitian pendidikan pendekatan kuantitatif, kualitatif dan R&D*. Bandung: CV Alfabeta

Tan, S. X., Ong, H. C., Andriyana, A., Lim, S., Pang, Y. L., Kusumo, F., & Ngoh, G. C. (2022). Characterization and parametric study on mechanical properties enhancement in biodegradable chitosan-reinforced starch-based bioplastic film. *Polymers*, 14(2), 278. https://doi.org/10.3390/polym14020278

Udjiana, S. S., Hadiantoro, S., Takwanto, A., & Mustikarini, A. W. (2020). Peningkatan karakteristik biodegradable plastics dari kulit pisang candi dengan penambahan filler kalsium silikat dan clay. *Jurnal Teknik Kimia dan Lingkungan*, 4(2), 175–185. http://dx.doi.org/10.33795/jtkl.v4i2.135