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PRODUCTION OF BIOPLASTIC BASED ON PLANTAIN PEEL STARCH AND CHITOSAN WITH SORBITOL PLASTICIZER

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ABSTRACT
Bioplastic is an alternative to conventional plastic use. Bioplastics are made from natural polymer materials such as starch. In its production, the addition of other materials is required, namely chitosan as an adhesive and a plasticizer as a softening agent. The purpose of this study is to determine the optimum composition of bioplastic materials so that they have physical properties, mechanical properties, and biodegradability that meet applicable bioplastic standards. This study used starch extracted from Raja banana peel amounting to 4 g and varying the addition of chitosan (2, 3, 4, 5, g) with the addition of 6 ml of sorbitol. Characterization tests conducted included water absorption test, biodegradation test, tensile strength test, elongation test, and FTIR (Fourier Transform Infrared) test. The characterization data of the produced bioplastics showed water absorption values of 14-79%, Biodegradation values of 56-80%, tensile strength values of 0.26-0.87 MPa, and elongation percentages of 6.5-25.5%. Meanwhile, the FTIR test results showed the same functional groups from the constituent components, namely OH, CH, NH, and CO groups. The characterization data of bioplastics with the optimum composition was found in sample D because the water absorption value of 14% met ASTM D570-98, the biodegradability of 56%, tensile strength of 0.87 MPa, and elongation percentage of 25.5% met ASTM D882-12

Keywords: Bioplastic, Raja Banana Peel Starch, Chitosan, Sorbitol, Characterization

INTRODUCTION

The problem of environmental pollution caused by the use of conventional plastics remains a serious global issue. Petroleum-based plastics are non- biodegradable, making them difficult to decompose naturally, leading to the accumulation of waste that pollutes soil and water bodies. This situation has driven the development of environmentally friendly alternative materials, one of which is bioplastics. Bioplastics are a type of plastic made from natural polymers such as starch, cellulose, and proteins that can be biologically degraded by microorganisms, thus potentially replacing conventional plastics in various industrial and packaging applications.

One potential raw material source for bioplastics is plantain (Musa paradisiaca L.) peels. Plantain peel waste contains a high starch content, reaching approximately 59%, and contains fiber and minerals such as calcium and phosphorus. This high starch content makes it an economical and readily available material for locally sourced bioplastic production. However, starch-based bioplastics have the disadvantage of poor mechanical properties, brittleness, and a lack of elasticity, requiring the addition of additives to improve their quality.

Chitosan and sorbitol are two additives frequently used in bioplastic production. Chitosan acts as a binder and has antimicrobial properties that can increase the bioplastic's resistance to microbial degradation. Sorbitol, as a plasticizer, plays a role in increasing the flexibility and elasticity of the bioplastic by reducing the stiffness of the polymer structure.

The combination of these two materials is expected to improve the physical, mechanical, and biodegradability properties of plantain peel starch-based bioplastics.

The main problem in this research is how to determine the optimum characteristics and composition of bioplastics based on plantain peel starch and chitosan with sorbitol plasticizer to meet bioplastic quality standards. For this reason, this research was conducted using an experimental method through variations in the composition of chitosan and sorbitol, and characterization was carried out including water absorption tests, biodegradation, tensile strength, percent elongation, and functional group analysis using Fourier Transform Infrared (FTIR).

This study aims to determine the optimum formulation of a bioplastic based on plantain peel starch and chitosan with the addition of sorbitol to produce a bioplastic with physical, mechanical, and biodegradable properties that meet ASTM and SNI standards. In addition to providing an alternative to conventional plastics, this research is also expected to contribute to the management of organic waste into products with high utility value and environmental sustainability.

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RESEARCH METHOD

Research Tools

This research is a laboratory experiment with a quantitative approach. The research was conducted to produce bioplastic films from plantain peel starch with varying chitosan and sorbitol plasticizer content and then characterized its physical, mechanical, and functional group properties. The main stages include: starch extraction from plantain peel, preparation of chitosan solution (1% acetic acid), starch-chitosan-sorbitol mixing, film printing on a 20×20 cm² glass plate, drying (oven at 70 °C for 12 hours), and sample characterization.

In the starch extraction process carried out, namely soaking banana peel pulp with 100 g $Na_2 S_2 O_5$ + 100 g citric acid; sedimentation for 24 hours then drying in an oven at 50 °C for 2 hours then sieving using a 100 mesh sieve.

In the manufacture of bioplastics, 4 g of starch per sample was used; variations of chitosan 2, 3, 4, 5 g; sorbitol 6 mL. Chitosan was dissolved in 100 mL of 1% acetic acid and starch was dissolved in 100 mL of distilled water and heated until gelatinization at 90 °C. Mixing for≈1 hour; cooling →molding →drying 70°C for 12 hours. The research samples used were four formulations selected/printed and analyzed, marked as Samples A–D. Sample A: 4 g starch, 2 g chitosan, 6 mL sorbitol, Sample B: 4 g starch,3 g chitosan, 6 mL sorbitol, Sample C: 4 g starch,4 g chitosan, 6 mL sorbitol, and Sample D: 4 g starch, 5 g chitosan, 6 mL sorbitol.

Main instruments/tools:

- Analytical balance (material weighing)
- Blender / mortar & pestle (to grind banana peel)
- Filter cloth (starch extraction)
- Oven (starch and film drying) — 50 °C & 70°C
- 100 mesh sieve
- Magnetic stirrer + magnetic bar (homogeneous stirring and heating)
- Beaker glass, spatula, syringe (processing & molding)
- 20×20 cm² glass plate (film print)
- Tensile strength testing machine (tensile tester) according to ASTM-E8M / ASTM
- FTIR Spectrometer (functional group analysis)
- Scales and dimensional measuring instruments (length, cross-sectional area)

- Stopwatch/thermometer for temperature & time control

Material:

- Plantain peel (raw material for starch)
- Chitosan (commercial)
- Sorbitol (plasticizer)
- Acetic acid 1%(solvent/catalys for chitosan)
- Sodium metabisulfite ($Na_2 S_2 O_5$) and citric acid ($C_6 H_8 O_7$) for starch extraction
- Aquadest (solvent)

Characteristic testing follows international/ national standards: ASTM D570-98 (water absorption), SNI 7188.7:2016 (biodegradation), ASTM-E8M (tensile strength), ASTM D882-12 (elongation). The use of standard methods increases the internal validity of the measurements. FTIR: identification of functional groups using the wavelength range 4000–500 cm⁻ 1as is common practice, and peak interpretation refers to relevant literature.

How to Analyze Data

1. Water absorption capacity (DSA, %)

$$\%DSA = \frac{m_b - m_k}{m_k} x100\% \quad (1)$$

where m_b = mass of sample after testing (g),m_k = mass of sample before testing (g).

2. Biodegradation (%)

$$\%Bio = \frac{m_0 - m_1}{m_0} x100\% \quad (2)$$

Where m_0 =initial mass of bioplastic sample(g). m_1 = final mass of the sample after burial (g)

3. Tensile strength (σ, MPa):

$$\sigma = \frac{F_{maks}}{A_0} x100\% \quad (3)$$

Where σ = Tensile strength of the sample (MPa). Fmax = Maximum load the object can withstand (N). A0 = Initial cross-sectional area (mm2).

4. Percent elongation (% elongation):

$$\%\varepsilon = \frac{I_1 - I_0}{I_0} x100\% = \frac{\Delta I}{I_0} x100\% \quad (4)$$

Where $\%\varepsilon$ = Percent elongation (%).ΔI = Increase, in length (mm). I_0 = Initial length of the measured material (mm). I_1 = Length after drawing (mm)

5. FTIR

Fourier Transform Infrared Spectroscopy (FTIR) analysis is used to identify chemical compounds contained in a polymer material (Kholisoh et al., 2024). Fourier Transform Infrared Spectroscopy (FTIR) was carried out to determine changes in functional groups in the resulting bioplastics

RESULT AND DISCUSSION

Reults

1. Results of Water Absorption Calculation (%)

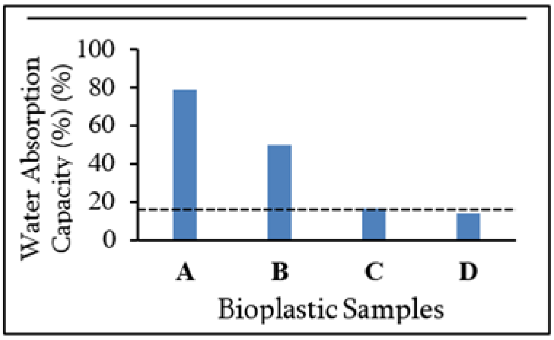

Figure 1. Diagram of Water Absorption Test Results

From Figure 1, it can be seen that in the water absorption test that was carried out, the addition of chitosan to the sample affected the water absorption value.

Table 1 Water Absorption Test Results Data

Sample	Water Absorption Capacity (%)	ASTM D570-98
A	79	≤ 16.63%
B	50	
C	18	
D	14	

In Table 1 it can be seen that the maximum value is in sample A at 79% and the minimum value is in sample D at 14%.

2. Biodegradation Calculation Results

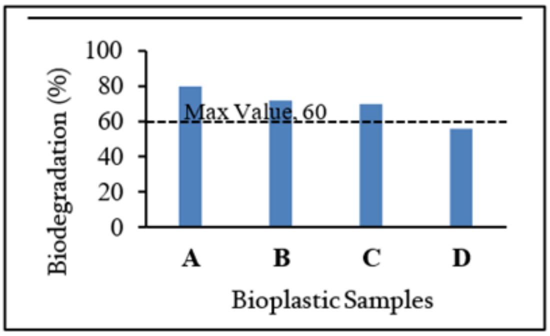

Figure 2. Diagram of Biodegradation Test Results

From Figure 2, it can be seen that in the biodegradation test that was carried out, the addition of chitosan to the bioplastic sample caused the biodegradation value to decrease and the bioplastic sample took longer to degrade.

Table 2 Biodegradation Test Results Data

Sample	Biodegradation Value (%)	SNI 7188.7:2016
A	80	*Min* 60%
B	72	
C	70	
D	56	

In Table 2, it can be seen that the maximum value of biodegradation is in sample A at 80% and the minimum value of biodegradation in sample D at 56%.

3. Results of Tensile Strength Calculation (Mpa)

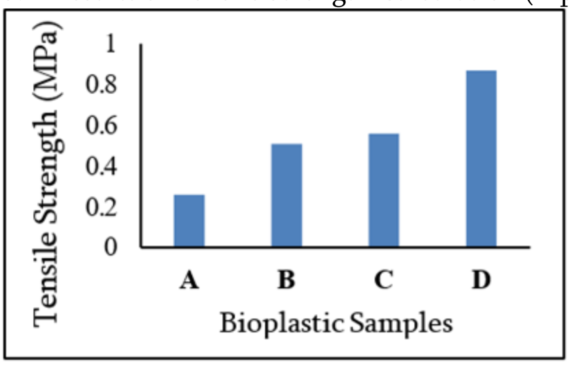

Figure 3. Tensile Strength Test Results Diagram

From Figure 4.3 it can be seen that the greater the chitosan composition in bioplastic, the greater the tensile strength value will be.

Sample	**Tensile Strength Value (MPa)**	**ASTM E8/E8M-13a**
A	0.26	≥ 1.35 MPa
B	0.51	
C	0.56	
D	0.87	

In table 3, it can be seen that the highest tensile strength value is in sample D, namely 0.87 MPa, and the lowest tensile strength value is in sample A, namely 0.26 MPa.

4. Results of Percentage Elongation Calculation

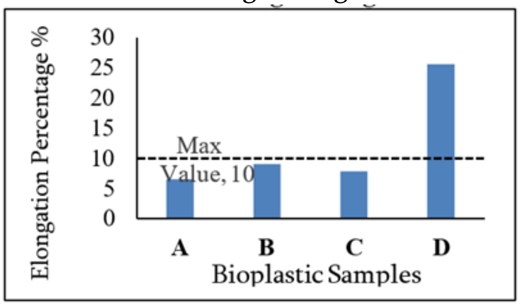

Figure 4. Diagram of Percentage Elongation Test Results

From Figure 4 it can be seen that the addition of chitosan can increase the percentage of elongation

Table 4 Data on Percentage Elongation Test Result

Sample	**Percentage Elongation Value (%)**	**ASTM D882-12**
A	6.5	≥ 10%
B	9.0	
C	7.8	
D	25.5	

From Table 4, it can be seen that the maximum value of the elongation percentage test is in sample D at 25.5%, and the minimum value is in sample A at 6.5%.

5. FTIR Test Result

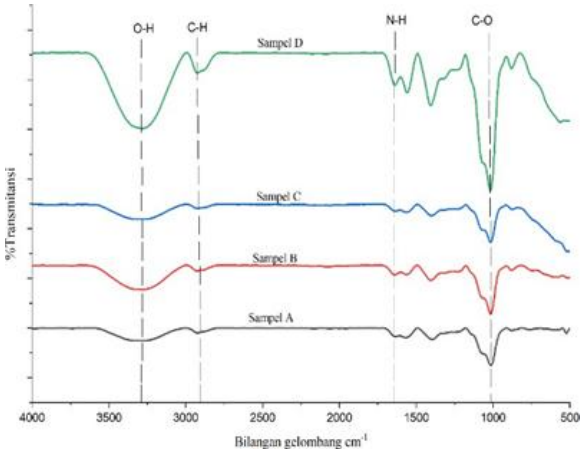

Figure 5. FTIR test results

Figure 5 shows that all the main functional groups were successfully detected according to the theoretical range.

Discussion

From the research that has been done, the highest physical property value was obtained in sample A, namely the water absorption value of 79% and the biodegradation value of 80%, which exceeds the SNI 7188.7:2016 standard (60%). This is due to the high hydrophilic nature of starch, so that bioplastics absorb water more easily and degrade quickly. On the other hand, the lowest value was found in sample D which showed a water absorption capacity of 14% and biodegradation of 56% which indicates that the addition of chitosan mass in the manufacture of bioplastics can reduce the hydrophilic properties of bioplastics while slowing down the degradation process.

In mechanical testing, the highest value was obtained in sample D, namely a tensile strength value of 0.87 MPa and a percentage elongation value of 25.5% which exceeds the ASTM D882-12 standard (10%). This shows that chitosan can form hydrogen bonds and stronger intermolecular interactions and the greater the composition of chitosan in bioplastic, the number of hydrogen bonds contained in the bioplastic increases, resulting in the bioplastic being difficult to break and can increase the flexibility of the material.

From this study, it was found that the addition of chitosan can reduce the water absorption capacity and reduce the biodegradation capacity, and the addition of chitosan can increase the tensile strength and elongation percentage. The optimum composition in the manufacture of bioplastics based on banana peel starch with sorbitol plasticizer with variations of chitosan is found in sample D because it is able to produce bioplastics with adequate mechanical properties while still having good water resistance, making it suitable for application as an environmentally friendly packaging material.

CONCLUSION AND SUGGESTION

Conclusion

From the results of research on plantain peel starch and chitosan with sorbitol plasticizer,

The data from the characterization of bioplastic production obtained water absorption test values of 14-79%, biodegradation test values of 56-80%, tensile strength test values of 0.26-0.87 MPa, elongation test values of 6.5-25.5%. The higher the chitosan content, the decrease in water absorption and biodegradation will occur, as well as an increase in tensile strength and percent elongation. While the results of the FTIR test obtained OH groups with a wave number range of 3288-3301 cm-1, in CH groups with a wave number range of 2860-2885 cm-1, in NH groups with a wave number range of 1553-1556 cm-1, and in CO groups with a wave number range of 1074-1075 cm-1.

The optimal composition in making bioplastics based on banana peel starch and chitosan with sorbitol plasticizer is found in sample D with starch variations. 4 g, chitosan 4 g, and sorbitol 6 ml because the water absorption test value has met ASTM D570-98, which is 16.13%, the highest tensile strength value is 0.87 MPa, the percentage elongation value is 25.5% and has met ASTM D882-12, and can be degraded and has good environmental friendly properties.

Suggestion

Based on the results of the research that has been conducted, the researcher suggests the following:

For further research on the production of bioplastic from plantain peel starch, it is recommended that oven drying be avoided, as this can affect the physical appearance of the bioplastic. Further research is recommended to include other characterization methods, such as modulus of elasticity and others. Further research is recommended to conduct biodegradation tests for bioplastics with longer burial times to produce more accurate data.

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