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VARIATION OF POTATO STARCH AND BAGASSE CELLULOSE ON THE PHYSICAL AND MECHANICAL PROPERTIES OF BIOPLASTICS

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ABSTRACT
Bioplastics are ordinary plastics that can be used, but can be decomposed by microorganisms, so they are environmentally friendly. This research aims to determine the characteristics of potato starch and bagasse cellulose bioplastics and to determine variations that produce compositional attristics with the best quality for making bioplastics using potato starch and bagasse cellulose as basic ingredients. Samples A (75% : 25%), B (50% : 50%), and C (25% : 75%) have different compositions of potato starch and bagasse cellulose. To make bioplastic, magenectic is used for one hour at a speed of 500 rpm and a temperature of 80 °C. The mould size is 20 x 20 x 1 cm3, and drying is carried out in an oven at 50°C for 12 hours. This research has several tests, namely physical tests including water absorption tests refers to ASTM D570-98, and the biodegradable test follows SNI 7188.7:2016. Test The mechanism includes the tensile strength test of the SNI 06-1315-2006 testing standard.

Keywords: Bioplastics, Potato Starch, Sugarcane Bagasse Cellulose, Glycerol, Chitosan

INTRODUCTION

Plastic is an item that cannot be released in daily needs because it is light and cheap, but if plastic is used continuously it will endanger the environment because plastic is very difficult to be decomposed by microbes in the soil, this is what causes plastic to not be environmentally friendly because it can pollute the environment and damage the environment (Sinda Intandiana, 2019). It is estimated that nearly 28.4 thousand tonnes of plastic waste when calculated in 189,000 tonnes of waste per day in Indonesia (Etyka Rahmasari, 2022). Where conventional plastics currently include environmental problems and the time it takes to decompose is very long. Bioplastics are a solution to overcome this conventional plastic problem. Bioplastics are used materials that are able to degrade well so that they do not cause toxins and are very good for the environment.

Bioplastics have many advantages, one of which is their affordable price and wide availability. Bioplastics made from starch, such as potatoes, have been the subject of several studies (Ria Nurwidiyani, 2022). Due to the low hydrophilic properties of starch, bioplastics are not able to withstand the weight of ordinary plastics. As a result, bioplastics cannot retain water well. This weakness can be overcome by mixing starch with cellulose (Sinda Intandiana, 2019). Potato in the form of starch is innovated to be a good result to overcome the shortcomings of previous capabilities. In the process of starch is produced by filtering plant filtration, which can be in the form of tubers or seeds. Potatoes have a starch content of 22%-28% (Kurnia Eva Maulida, 2018). Solid waste derived from sugarcane stalks is bagasse. Even if bagasse is mostly used the rest of the bagasse is generally used for boilers, because the stock of bagasse exceeds the capacity of the boiler to burn it. Bagasse cane is still underused at this time (Marwah Anisya, 2020).

The use of bagasse has been limited, but there are still opportunities to benefit from its use. There is evidence that 42.50% cellulose can increase the quality of more valuable materials, which allows it to present a variety of valuable product innovations, such as as a raw material for making bioplastics. (Febri Aris Munandar, 2022). By increasing the concentration of cellulose reinforcing agent when making bioplastics, the bond will be stronger. This also affects the percentage factor of amylopectin present in starch. The presence of cross-linked polymer chains is due to the properties of cellulose during the gelatinisation process. This makes the resulting bioplastics tighter and more homogeneous (Edwin Permana, 2021).

To determine the physical and mechanical properties of bioplastics, researchers will make bioplastics made from potato starch and bagasse cellulose with various compositions.

RESEARCH METHODS

In this study, an experimental research method was used by making a quantitative approach. The raw material used in the manufacture of bioplastics is potato starch using bagasse cellulose and will be tested for physical and mechanical properties.

Tools and Materials

The tools used are: Digital balance, Blander, pH indicator, Filter paper, Oven, 100 mesh sieve, Beaker cup, Magnetic stirrer, Hot plate, Square mould measuring 20 × 20 × 1 cm3, Pot, Soil, Water, UTM RTF 1350. Materials used are: Potato starch, bagasse cellulose, glycerol, chitosan, acetic acid solution, sodium hydroxide solution, hydrochloric acid solution, distilled water, hydrogen peroxide solution.

1. Research Procedure

Raw Materials Preparation

Potato starch, potatoes were cleaned, peeled, sliced, then mashed with a blander in the ratio of 1 kg of potatoes: 500 ml water, squeezed and precipitated, for 24 hours. The precipitate was oven dried for 4 hours at 50°C, then sieved with a 100 mesh sieve.

Sugarcane bagasse cellulose, cleaned and dried. Sugarcane bagasse was delignified with 400 ml of 6% NaOH at 80°C for 4 hours. Next, hydrolysis process with 0.1 M HCl as much as 200 ml at 80°C for 1 hour. Blanching with 30% H2O2 as much as 200 ml at 80°C for 1 hour. Oven at 105°C for 1 hour, then blended until smooth then sieved with a 100 mesh sieve. Solution of 3 g chitosan dissolved with 1% acetic acid as much as 150 ml at 50°C for 1 hour.

2. Bioplastic Manufacturing Process

Preparation of bioplastics 6 grams of starch: cellulose with variations A (75%: 25%), B (50%: 50%), and C (25%: 75%) then dissolved with 150 ml of 1% acetic acid at 80 ° C speed 500 rpm for 1 hour. Then 1.5 ml of glycerol solution and 150 ml of homogenised chitosan solution were added. After homogeneous, the solution was poured into a square mould with a size of (20 × 20 × 1 cm3) and then in the oven at 50°C for 12 hours. The sample is ready for analysis.

3. Bioplastic Testing

Physical tests include water absorption and biodegradable tests and mechanical tests include tensile strength tests.

Water Absorption Test

The sample was cut with a size of 7.6 cm × 2.5 cm, after which the sample was weighed, then put into a glass beaker for 24 hours, then the sample was cleaned and weighed and then the calculation of water absorption was carried out with the equation:

$$DSA = \frac{m_1 - m_0}{m_0} \times 100\%$$

Description :

DSA = Water absorption (%)

m_0 = Mass of sample before testing (g)

m_1 = Mass of sample after testing (g)

Biodegradable Test

The sample was cut with a size of 3 cm × 1 cm, then the sample was weighed, then the sample was planted in the soil with a depth of 3 cm for 1 week, after which the sample was cleaned and weighed again and calculated with the equation :

$$Weight\ loss = \frac{W_0 - W_f}{W_0} \times 100\%$$

Description :

Weight loss = Weight reduction of biodegradeble plastics (g)

W_0 = Initial weight of biodegradable plastic (g)

W_f = Final weight of biodegradable plastic (g)

Tensile Strength Test

The sample was cut into 7 cm × 2 cm pieces, the sample was clamped on the UTM RFT 1350 with the load applied at the bottom, and then calculated with the equation :

$$\sigma = \frac{F_{max}}{A}$$

Description :

σ = Tensile strength (Pa)

F_{max} = Maximum load (N)

A = Cross section area (mm^2)

RESULT AND DISCUSSION

1. Effect of Variation of Potato Starch and Sugarcane Bagasse Cellulose on Water Absorbency

An important factor in the sample is absorbency. The higher the absorbency, the more water-resistant the bioplastic, which means that the rate of breakage and solubility in water is higher, resulting in faster deterioration.

Table 1. Water absorption test results

Sampel	m_0 (g)	m_1 (g)	Daya Serap Air (%)	ASTM D570-98 (%)
A	0,43	0,73	70	
B	0,44	0,59	34	≤16,63
C	0,63	0,73	16	

Therefore, the higher the absorbency, the more water-resistant the bioplastic. (Edwin Permana 2021). So, the calculation of water absorption aims to determine the ability or power to absorb the sample when exposed to water.

Based on the results, sample A has a maximum water absorption value of 70%, sample B of 34%, and sample C of 16%. The maximum value of sample A is 70% with a variation of starch and cellulose ratio of 75%: 25%, and the minimum value of sample C is 16% with a variation of starch and cellulose ratio of 25%: 75%. The diagram of the water absorption test is shown in Figure 1.

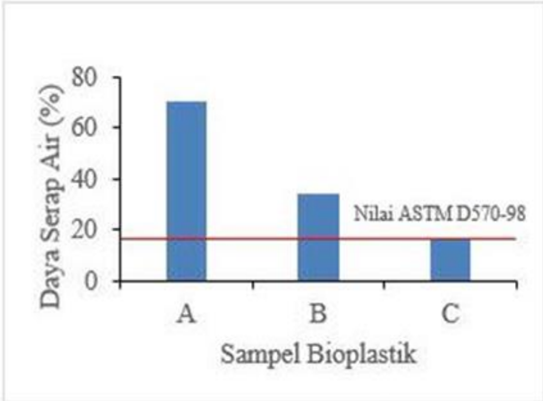

Figure 1. Water absorption test result

Due to the hydrophilic nature of starch rather than cellulose, the addition of bagasse cellulose to bioplastics improves bioplastics so that they do not absorb water, as shown in Figure 1. The characteristics of cellulose are difficult to bond with water because of its strong hydrogen bonds (Sindia Intandiana, 2019). In addition, the size of cellulose affects water absorption to decrease because the micro-size cellulose, the better the water absorption (Aulia Fadilla, 2023). Based on ASTM D570-98, sample A has the best absorption with a starch ratio of 75%: 25% cellulose and 70% absorption value.

2. Effect of Variation of Potato Starch and Sugarcane Bagasse Cellulose on Biodegradeble

In biodegradable plastics, biodegradable plastics can be decomposed by bacteria in a short time by bacteria or by nature due to the interaction of microorganisms (Thofanda Muharam, 2022). To find out how well bioplastics can decompose in the soil of Table 2.

Table 2. Biodegradeble test results

Sampel	w0 (g)	wf (g)	*Biodegradable* (%)
A	0,06	0,01	83
B	0,07	0,02	71
C	0,08	0,03	63

According to the biodegradable test, the value of sample A is 83%, sample B is 71%, and sample C is 63%. The highest value of sample A was 83% with a variation in the ratio of starch and cellulose of 75%: 25%, and the smallest value of sample C was 63% with a variation in the ratio of starch to cellulose of 25%: 75%. The biodegradable testing diagram can be seen in Figure 2.

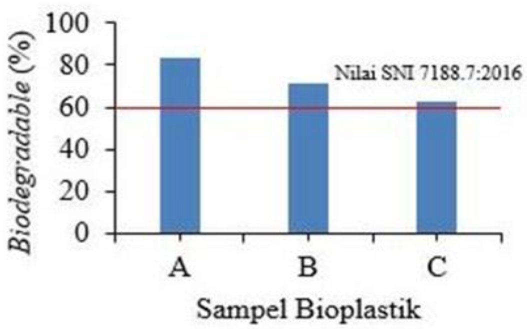

Figure 2. Biodegradable testing result

Bioplastic samples can be degraded in the soil, as shown in Figure 2. This is in accordance with SNI 7188.7:2016, describing that the weight of the sample will decrease by more than >60% after one week in the soil. A contributing factor is the fact that starch has hydrophilic properties than cellulose. As a result, the variation of starch composition that is greater than bagasse cellulose makes bioplastics easier to degrade than the variation of bagasse cellulose composition due to the bonds of bagasse cellulose that are difficult to be destroyed by microbes (Sunny Nafisah, 2022). Sample A had a cellulose starch ratio of 75%: 25% and a biodegradable value of 83%, according to SNI 7188.7:2016.

3. Effect of Variation of Potato Starch and Sugarcane Dreg Cellulose on Tensile Strength

Tensile strength is the division of force by cross-sectional area, which means that tensile strength will experience a pull on a material due to force. The tensile strength is done to determine the ability of the sample to maintain its shape when given a tensile force. The results of the tensile strength are shown in Table 3. Tensile strength is the division of force by cross-sectional area, which means that tensile strength will pull on the material due to force.

Table 3. Tensile strength test result

Sampel	F_{max} (N)	A (mm^2)	σ (MPa)
A	4,6359	1,4	3,3114
B	11,7358	1,4	8,3827
C	15,1643	1,4	10,8316

The tensile strength test results of bioplastics show that sample A has a tensile strength of 3.3114 MPa, sample B 8.3827 MPa, and sample C has the highest tensile strength of 10.8316 MPa. It can be seen that the addition of cellulose to bioplastics affects the tensile strength value of the sample, where sample C gets the largest tensile strength value of 10.8316 MPa and the smallest tensile strength value in sample A with 3.3114 MPa. Shown in Figure 3.

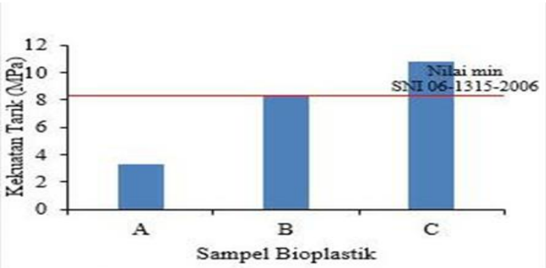

Figure 3. Tensile strength test result

The addition of bagasse cellulose had a greater effect on each type of bioplastic, as shown in Figure 3. The amount of bagasse cellulose used increased the resulting tensile strength values. The plastic is stronger due to the straight and long polymer chains of cellulose. In addition, because the groups in starch and cellulose are very strongly intertwined. When cellulose fibres are reduced, these pores make it less strong to resist pulling (Aulia Fadilla, 2023). This research is linear with the opinion of Sunny Nafisah (2022). It was found that adding bagasse cellulose increased the tensile strength. According to SNI 06-1315-2006, the optimal tensile strength is sample C 10.8316 MPa with a starch and cellulose ratio of 25%: 75.

CONCLUSION AND SUGGESTION

The results of research on the manufacture of environmentally friendly bioplastics made from potato starch with various compositions of bagasse cellulose show that there are several characteristics resulting from these bioplastics. They achieved absorbency values of 16% to 70%, biodegradable values of 61% to 77%, and tensile strength values between 3.3114 to 10.8316 MPa. The composition variation with the best quality in the manufacture of potato starch and bagasse cellulose bioplastics is found in sample C with a variation of starch and cellulose of 25%: 75% with a water absorption value of 16% reaching ASTM D570-98, a biodegradable value of 63% reaching SNI 7188.7: 2016, a tensile strength value of 10.8316 MPa reaching SNI 06-1315-2006.

The results show that researchers can improve the mechanical properties of bioplastics by using other cellulose substitutes or other variations of this study. Because glatinisation did not occur, future researchers should dissolve cellulose and starch first before mixing acetic acid and starch.

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