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Effect of Sorbitol and Chitosan Addition on Tensile Strength and Degradation Rate of Biodegradable Plastic from Rice Bran Starch

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ABSTRACT

The increasing use of plastic can cause enviromental pollution because plastic takes a very long time to decompose in the soil. Solutions that can be used to accelerate the process of plastic decomposition in the soil by replacing plastic making materials with natural polymer materials. Natural polymers are polymers produced from organic monomers, one of which is starch. Starch is one of the natural polymer materials used in the manufacture of biodegradable plastics, one of the natural materials containing starch is rice bran waste. From rice bran waste starch, bioderadable plastic can be made by adding chitosan and sorbitol by varying then succesively, namely 5:2:8, 5:3:7, 5:5:5, 5:7:3, 5:10:0, then making samples, then the samples are printed and tensile strength testing and degradation testing are carried out. From the tensile strength test results, the values obtained were 0.69 Mpa, 0.74 Mpa, 1.50 Mpa, 1.98 Mpa and 2.28 Mpa, respectively. The finel weight of the sampel after degradation is 0 gram, 0 gram, 0.0189 gram, 0.0226 gram, 0.1017 gram. It is concluded that biodegardable plastic with good tensile strength is in the variation of starch 5 grams, without sorbitol and chitosan 10 grams and for good degradation test in the variation of starch 5 grams, sorbitol 8 ml, chitosan 2 grams and variation of starch 5 grams, sorbitol 7 ml, chitosan 3 grams.

Keywords: *Rice Bran; Chitosan; Sorbitol; Tensile Strength; Degradation.*

INTRODUCTION

Plastic is widely used for various needs, starting from household needs to industrial needs. Plastic is usually used for packaging because plastic materials are elastic and not easily brittle [1]. Conventional plastics hurt long-term sustainability. Plastic waste can cause environmental damage because the decomposition process in the soil is very long. Plastic produces toxic compounds such as dioxins when burned [2]..

The plastics used today are plastics made from synthetic polymers from petroleum which are limited in number and non-renewable. Therefore, alternative plastic materials that are available in nature and easily obtained in large quantities and cheap but able to produce the same product, namely biodegradable plastics or bioplastics are needed [3]. Biodegradable plastics are plastics that can be decomposed in the soil with the help of microorganisms. The basic material widely used for the manufacture of biodegradable plastics is starch derived from plants. Starch is one of the natural polymers derived from plant extracts that can be used to produce biodegradable plastic materials [4]. One that can be utilized is rice bran waste, rice

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bran contains 39.8 - 48.1% starch [5]. The high starch content in rice bran can be utilized as a material for making biodegradable plastics and can provide added value to rice bran waste.

Many studies have been conducted to develop biodegradable plastics, including the manufacture of bioplastics by varying glycerol on the physical properties of biodegradable plastics made from cassava starch [6]. Research on the manufacture of edible film from breadfruit starch with the addition of sorbitol as a plasticizer [7]. Making biodegradable plastic by utilizing aking rice starch waste with a mixture of glycerol and chitosan composition [8]. Bioplastic research by varying the temperature and time of gelatinization [9].

The author is interested in conducting research on the manufacture of biodegradable plastics by utilizing milling waste, namely starch from rice bran waste with the addition of sorbitol plasticizers and additives in the form of chitosan with variations in the starch ratio between starch, sorbitol and chitosan to determine the tensile strength value and degradation rate of biodegradable plastics.

Based on the description above, researchers are interested in researching making biodegradable plastics from starch materials. So the researcher conducted a study on **"The Effect of Sorbitol and Chitosan Addition on Tensile Strength and Degradation Rate of Biodegradable Plastic from Rice Bran Starch".**

MATERIALS AND METHODS

This research was conducted at LLDIKTI Region X West Sumatra to make biodegradable plastic samples and degradation tests and at the UNAND Metallurgical Laboratory to conduct tensile strength testing. The research time was from March to July 2023.

For the variables of this study, the independent variables in this study are the variation of sorbitol and chitosan with the ratio being 10:0, 7:3, 5:5, 3:7 and 0:10 respectively. The control variables in this study were starch of as much as 5 grams and soil pH of 7. The dependent variables of this study were tensile strength analysis and degradation rate. The tools used in this research include an oven, blender, 200 mesh sieve, beaker glass, measuring cup, magnetic stirrer, petri dish, dropper pipette, stirring rod, analytical balance, mold and universal testing machine. The materials used were starch from rice bran, sorbitol, chitosan and 2% acetic acid.

The implementation of this research refers to the journal Selpiana, et al (2015) [10] which has been modified. The initial stage in the implementation of this research is to make starch from rice bran. Rice bran was soaked overnight with a ratio of rice bran and water of 2:1, after which the soaking water was discarded and the rice bran was dried in an oven at 85ºC for 2 hours. The dried rice bran was blended until smooth, then sieved using a 200 mesh sieve to obtain a uniform size.

The next step is to make a chitosan solution. The preparation of this chitosan solution uses acetic acid with a concentration of 2% as a solvent. Dissolving chitosan powder of all variations with 100 ml of acetic acid, stirred using a magnetic stirrer for 25 minutes at 80ºC.
The next step is to make biodegradable plastic film. Starch as much as 5 grams was dissolved using 2% acetic acid as much as 50 ml at 80ºC for 10 minutes using a magnetic stirrer. After 10 minutes, mix the chitosan solution with the starch solution in a stirrer for 15 minutes. After 15 minutes, add sorbitol and stir again for 10 minutes to make it homogeneous. Then transfer the sample to the mold and oven for 6 hours at 80ºC, after 6 hours remove the sample from

the oven and let it stand at room temperature overnight. After overnight the sample can be tested.

Testing and characterization.

1. The tensile strength test is the maximum pull that can be achieved until the film can remain before breaking. The tensile strength test uses ASTM D-882 with a sample size of 10 cm long and 2 cm wide. To calculate the tensile strength test results using the formula

$$\tau = \frac{F_{max}}{A} \qquad (1)$$

With information: τ = tensile strength (MPa), Fmax = maximum stress (N), A = cross-sectional area (mm^2)

2. In the biodegradation test with the method of planting samples in the soil (soil burial test). This test uses samples with a size of 2x2 cm, measured weight before planting and planted in the ground for 14 days. Then the final weight of the sample was after planting and calculated using the following formula

$$\%W = \frac{W_0 - W_1}{W_0} \times 100\% \qquad (2)$$

With Notes %W = Weight loss (%), W_0 = Initial weight before burial (gr), W_1 = Final weight after burial (gr)

Table 1. Biodegradable plastic film-making formulation

Material	Amount				
	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5
Pati (gr)	5	5	5	5	5
Sorbitol (ml)	8	7	5	3	0
Kitosan (gr)	2	3	5	7	10
Asam Asetat (ml)	150	150	150	150	150
Total Volumes (ml)	165	165	165	165	165

RESULTS AND DISCUSSION

Effect of starch, sorbitol, and chitosan ratio on tensile strength test of biodegradable plastic

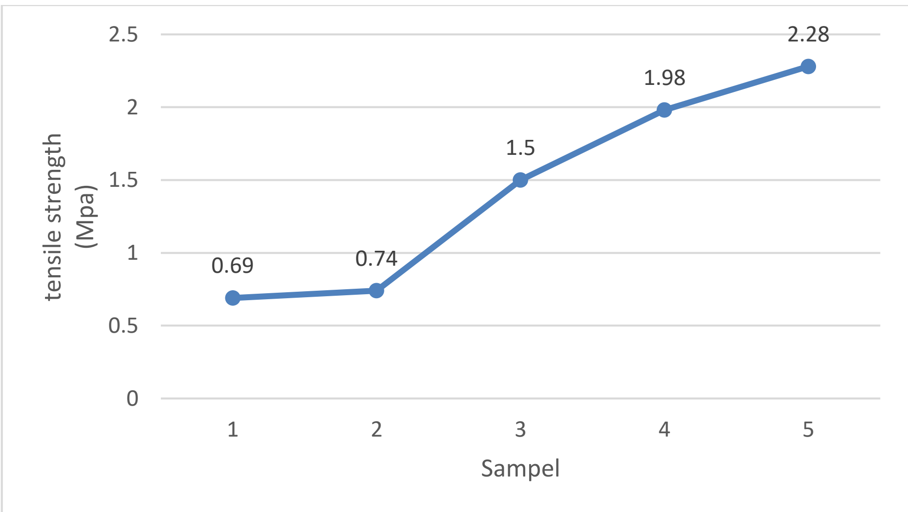

Figure 1: Effect of starch, sorbitol and chitosan ratio on tensile strength test of biodegradable plastics

Based on Figure 1, it can be seen that variation 1 to variation 5 with the ratio of starch, sorbitol, and chitosan respectively 5:8:2, 5:7:3, 5:5:5, 5:3:7, 5:0:10 experienced an increase in tensile strength, the lowest tensile strength value in the first variation with 5 grams of starch, 8 ml sorbitol and 2 grams of chitosan with a tensile strength value of 0.69 Mpa. The highest dance strength value is found in the variation of 5 grams of starch, without sorbitol and 10 grams of chitosan with a tensile strength value of 2.28 Mpa. This shows that the more chitosan used in the mixing, the higher the tensile strength produced. Chitosan is added to the starch solution to fill and increase the density of the bioplastics formed, thereby increasing the durability of the bioplastics during the tensile strength test. When chitosan is added, there is an interaction between chitosan and starch suspension, where chitosan hydrogen bonds with starch molecules when the mixture is heated. The more chitosan that is mixed, the more hydrogen bonds are formed in bioplastics resulting in stronger bioplastics and difficult to break [11]. In samples with more sorbitol variations, the tensile strength is weak, this is because plasticizers can reduce the energy required for molecules to move, so the molecules become stiffer and have lower tensile strength values. The addition of plasticizers also causes the internal hydrogen bonds of the molecules to become weaker [12]. The tensile strength of the bioplastic film in Fatnasari, et al. (2018) the tensile strength of the sample has met the JIS 1975 standard which is at least 0.39226 MPa [13]. The results of the tensile strength test showed that the bioplastic film had met the JIS requirements.

Effect of starch, sorbitol and chitosan ratio on biodegradable plastic degradation test

Table 2: Effect of starch, sorbitol and chitosan ratio on biodegradable plastic degradation test

Variasi	Starting Weight (gr)	Weight After 14 Days (gr)	Weight Loss (%)
Pati 5 gr Sorbitol 8 ml Kitosan 2 gr	0,5392 gram	0	100%
Pati 5 gr Sorbitol 7 ml Kitosan 3 gr	0,5641 gram	0	100%
Pati 5 gr Sorbitol 5 ml Kitosan 5 gr	0,8205 gram	0,0189 gram	97,69%
Pati 5 gr Sorbitol 3 ml Kitosan 7 gr	0,8251 gram	0,0226 gram	97,26%
Pati 5 gr Sorbitol 0 Kitosan 10 gr	0,8514 gram	0,1017 gram	88,05%

Based on Table 2, it can be seen that within 14 days the biodegradable plastic samples that were buried experienced weight reduction, in the 8 ml and 7 ml sorbitol variation samples the samples were completely degraded within 14 days while for 5 ml sorbitol, the weight loss was 97.69%, the sample with 3 ml sorbitol lost weight by 97.26%, and without sorbitol lost weight by 88.05%. This is to the theory that the more sorbitol used the less the remaining undecomposed sample, this is because the addition of large amounts of plasticizers can reduce the density of biodegradable plastics, which creates larger pores and causes bacteria to enter and multiply and break down biodegradable plastics [12]. Sorbitol has hydrophilic properties and is easily soluble in water. Sorbitol will absorb water in the soil thus encouraging microbial growth on the decomposing bioplastic film [14]. But the sample with 10 grams of chitosan experienced the longest degradation process, this is due to the slower water absorption process due to high chitosan levels [15]. Chitosan has hydrophobic properties that can inhibit the rate of water absorption which makes it easier for bacteria to decompose the sample, and the addition of high chitosan levels causes the density between biodegradable plastic molecules so that the water absorption process is slow [10]. Based on ASTM D638 standards for PLA plastic from Japan and PLC from the UK, it takes 60 days to degrade completely (100%) [16]. In this study, the length of time the sample degraded in the soil was almost entirely (above 80%), namely for 14 days, this proves that this study meets the criteria for degradation of bioplastic films based on ASTM D638.

CONCLUSION

From the results of data analysis, discussion and objectives, the following conclusions can be drawn (1) the highest tensile strength value is obtained with the highest amount of chitosan, namely 10 grams with a tensile strength value of 2.28 Mpa, while the lowest tensile strength with the least amount of chitosan is 2 grams with a tensile strength value of 0.69 Mpa. (2) For the level of degradation, the sample with the amount of sorbitol 8 ml and 7 ml experienced a weight loss of 100%, which means that the sample was completely degraded in the soil, while the sample without sorbitol experienced the lowest weight loss of all variations, which was 88.05%. So, the best tensile strength is in the variation of starch 5 grams, sorbitol 0, and chitosan 10 grams, while the best degradation rate is in the variation of starch 5 grams, sorbitol 8 ml, chitosan 2 grams and variation of starch 5 grams, sorbitol 7 ml, chitosan 3 grams.

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