Use of biopolybag from tapioca starch and sawdust waste

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Abstract. One alternative to overcome the weakness of polybags, namely creating plastic waste, is the use of biodegradable polybags (biopolybags) that are easily degraded so that they can be planted directly without having to be opened and disposed of. Therefore, the purpose of this study was to determine the effect of comparison between tapioca starch and sawdust pulp on mechanical properties, plant height and diameter growth, and soil chemical properties. The analysis used in this research is a tensile test using ASTM D638 2005 standard, elongation (elongation at break), elasticity (young's modulus), and water absorption using SNI. The comparison of tapioca starch and sawdust pulp had a significant effect on the mechanical properties of the tensile strength and elongation tests, and had no significant effect on the elasticity.

1. Introduction
Polybags are used as a medium for growing plant seeds in the nursery process until the plants are ready to be planted and transferred to the land. Some of the advantages of using polybags include more efficient watering and fertilization, media composition can be adjusted, plants can be moved, and do not require large areas of land [1]. Polybags are waterproof and lightweight, and the price is relatively cheap so that they can be reached by various levels of society. However, polybags are not easily destroyed or degraded by microorganisms that live in the soil or environmental influences such as rain and heat from the sun, so the use of polybags will result in the accumulation of plastic waste [2].

As a solution to these problems, many bioplastics or biodegradable plastics have been developed, namely plastics made from renewable materials and are easily decomposed by microbes. Bioplastics are plastics that can be decomposed naturally by microorganisms. These bioplastics can be made from organic materials such as cellulose, collagen, starch, casein, protein, or lipids [3,4]. The degradable nature of biopolybags will increase efficiency in the process of transferring plants to land because biopolybags can be planted directly into the soil without having to be opened and disposed of like synthetic polybags so that they will not cause plastic waste [5].
2. Materials and Methods
The materials used in this study were wood pulp, cassava starch, glycerol, 25% acetic acid, distilled water. The manufacture of bioplastics begins with mixing starch and sawdust pulp in a ratio of 10:0, 9:1, 8:2, 7:3, 6:4 and 5:5 grams with 250 ml of distilled water for 15 minutes at a temperature of 100°C. Furthermore, glycerol and acetic acid were added at a temperature of 100°C for 25 minutes, the solution was stirred using a magnetic stirrer until homogeneous or formed a gel. Gelatinization causes amylose bonds to tend to be close to each other because of hydrogen bonds. After the gelatinization process occurs, then the solution is poured into the mold. Then the solution was dried in an oven at 60°C for 2 days. The last stage is the bioplastic is conditioned at room temperature for 2 days and the plastic is ready to be formed and tested. Characterization of mechanical properties (tensile strength, tensile modulus, and elongation at break) of composite films was carried out based on ASTM D 638 2005. Soil sample analysis includes c-organic content, base saturation, cation exchange capacity and soil pH.

3. Result and Discussion

3.1. Properties of Bioplastic
The visual appearance of bioplastics in various comparisons can be seen in Figure 1 which shows the comparison of tapioca starch and wood pulp. Bioplastic (a) has a lighter color, tends to be transparent and has a smoother texture because of the absence of a mixture of sawdust pulp. Bioplastics (b) and (c) still look slightly transparent, but are dark in color and have a rough texture. Meanwhile, bioplastics (d), (e) and (f) are dark in color and have a rough texture. The more comparisons of sawdust pulp used in the manufacture of bioplastics, the darker and coarser the visual appearance of the bioplastics will be.

![Figure 1. Visual appearance of tapioca starch bioplastic: sawdust pulp (a) 10:0; (b) 9:1; (c) 8:2; (d) 7:3 (e) 6:4 (f) 5:5](image-url)
3.2. Mechanical Properties of Bioplastic

Bioplastic with a ratio of 10:0 has the highest tensile strength value compared to other comparisons, which is 2.39 MPa. The high tensile strength value in this comparison is because tapioca starch contains amylopectin and amylose. The content of amylose and amylopectin affected the crystallinity and mechanical strength of the bioplastics produced [6]. Starch with high amylopectin content with the addition of plasticizer can increase its mechanical strength.

![Graph showing tensile strength comparison](image)

**Figure 2.** Visual appearance of tapioca starch bioplastic: sawdust pulp (a) 10:0; (b) 9:1; (c) 8:2; (d) 7:3 (e) 6:4 (f) 5:5

The lowest value of bioplastic tensile strength is found in a ratio of 5:5, which is 0.32 Mpa (Fig. 2). Due to the balanced ratio of tapioca starch as a thickener and sawdust pulp as a polysaccharide. The use of plasticizers affects the measurement of the tensile strength [7]. The results of the tensile strength measurement are related to the concentration of plasticizer added to the film making process.

Figure 3 shows The highest elongation value is at 10:0 plastic, which is 8.19%. The high elongation value in this comparison is because tapioca starch contains amylopectin and amylose. The crystallinity and mechanical strength of the bioplastics produced affected by amylose and amylopectin content. Starch with high amylopectin content with the addition of plasticizer can increase its mechanical strength. Meanwhile, the lowest elongation value is at a ratio of 6:4 with a value of 2.85%. This difference in elongation values can occur because the ratio of starch is almost comparable to cellulose.

Found the highest elasticity in the ratio of 10:0, 8:2 and 6:4 with 0.05, 0.05 and 0.05, respectively. And the lowest values are in the ratio 9:1, 7:3 and 5:5 with values of 0.04, 0.04 and 0.04, respectively (Fig. 4).
3.3. Biodegradability of Bioplastic

The biodegradability test is a test that aims to analyze the ability of plastic to decompose by a two-week burial process so that the value of its weight loss is obtained. Figure 5 shows the highest biodegradability value is found in a ratio of 9:1 with a value of 51.48%. Meanwhile, the lowest biodegradability value was found in a ratio of 7:3 with a value of 32.43%.
Figure 5. Biodegradability of bioplastic

Figure 6 shows the application of containerized bioplastics with various ratios on Sengon plants for 8 weeks. All comparisons used the same treatment, which was watered every day and under the shade. Conventional polybags were used as controls for plant testing.

![Figure 6](image)

**Figure 6.** Application of bioplastic as a planting medium (biopolybag) Sengon for 8 weeks with a ratio of tapioca starch: sawdust pulp (a) 10:0 (b) 9:1 (c) 8:2 (d) 7:3 (e) 6:4 (f) 5:5

After 8 weeks of observation, disassembly was carried out to see the degradation process in biopolybags. Figure 7 shows that the entire ratio of biopolybags is completely decomposed in the 8th week. This can happen because the materials used for the manufacture of biopolybags are materials that can be destroyed in the soil, such as the use of acetic acid and glycerol which are soluble in water and alcohol. Insoluble in substances containing cyclic carbon. Water content, soil pH and soil organisms also affect the process of soil decomposition.
3.4. Analysis of degradation with differential scanning calorimetry

Figures 8a and 8b show almost the same trend, which indicates that the addition of sawdust pulp has no effect on heat transfer. In Figure 8a, the first peak is 138.26°C with a heat absorption value of 1.11 j or 126.09 j/g, and meanwhile, in Figure 8b, the first peak is 130.98°C with a heat absorption of 1.67 j or 201.18 j/g. The temperature reaches more than 100°C, which means there is excess evaporation. This is presumably due to the addition of other chemicals such as glycerol and acetic acid. In Figure 8a it can be seen that the addition of sawdust causes the temperature to shift higher. This is presumably because the sawdust used is dry. The presence of water is bound in the sawdust, so it takes longer to evaporate. In the second peak, the temperature decreases (endothermic) so that it is identified as the melting temperature.

Figure 8a shows the melting temperature is 287.28°C with heat absorption as much as 326.47 j or 37.53 j/g. While in Figure 8b, the melting temperature is 286.26°C, with the absorption of heat as much as 476.90 j or 57.70 j/g. The third peak experiences an increase in temperature (exothermic). That is, the material begins to burn or decompose. Figure 8a shows the decayed material is 371.03°C with a heat release of 6.07 j or 769.76 j/g. While in Figure 8b, the decayed material is 351.72°C with a heat release of 183.19 mj or 22.07 j/g.

Figure 7. The remaining biopolybag after 8 weeks of Sengon planting with the ratio of tapioca starch: sawdust pulp (a) 10:0 (b) 9:1 (c) 8:2 (d) 7:3 (e) 6:4 (f) 5:5
Figure 8. Differential Scanning Calorimetry Testing: a) Comparison of Tapioca Starch And Wood Pulp are 9:1 and b) Comparison of Tapioca Starch And Wood Pulp are 10:0

3.5. Plant test and soil test

The analysis results showed that bioplastics had no significant effect on the parameters of plant height, plant diameter, root crown ratio, and plant dry weight. This is presumably because the biopolybag material used does not have a negative impact on plants becoming stunted or dead or positive impacts such as adding nutrients to plant growth. So biopolypbags are safe for the environment and plants. Table 1 shows the results of soil sample analysis using conventional polybags and biopolybags. Biopolybags from tapioca starch and sawdust pulp have no significant effect on soil chemical properties, so bioplastics do not provide additional nutrients for soil chemical properties.

Table 1. Soil Analysis Results

| Sample     | pH H2O | C (%) | K (% e/100g) | Ca (%) | Na (%) | Mg (%) | JKB (%) | KTK (%) | KB (%) |
|------------|--------|-------|-------------|--------|--------|--------|---------|---------|--------|
| Polybag    | 6.1    | 3.65  | 3.18        | 6.41   | 0.09   | 2.13   | 11.81   | 24.61   | 48     |
| Biopolybag | 5.7    | 4.09  | 2.15        | 5.2    | 0.19   | 1.61   | 9.15    | 30.95   | 30     |

4. Conclusion

Comparison of tapioca starch and sawdust pulp significantly affects the mechanical properties of tensile strength and elongation tests and has no significant effect on elasticity. Comparison of tapioca starch and sawdust pulp had no significant impact on plant growth and diameter. The comparison of tapioca starch and sawdust pulp also did not significantly affect the chemical properties of the soil, so bioplastics did not provide additional nutrients for the chemical properties of the earth.

Acknowledgment

The authors would like to thank the Research Institutions, University of Sumatera Utara for its financial support by the TALENTA Research Implementation Contract of the University of Sumatera Utara, 2018 (Grant No: 2590 / UN.1.R / PPM / 2018 March 16, 2018).

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