Utilization of Cempedak Fruit for Biodegradable Plastic Production

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Abstract. The abundance of plastic waste that is difficult to decompose on the ground has a negative impact on the environment. Biodegradable plastic is a plastic film used as disposable item such as food service packaging that can be naturally degraded. In this research, biodegradable plastic was produced from flour of cempedak meat (Artocarpus champeden) and glycerin as plasticizer. Experimental results show that the biodegradable plastic could be produced from ordinary glycerin and flour of cempedak meat. Increasing the glycerin amount reduced the quality of biodegradable plastic as based on the tensile strength value, elongation and water resistance. The biodegradable plastics with glycerin amount of 1.5 mL resulted in a tensile strength value of 44.2 MPa; elongation of 40.8%; water resistance 88.36%. The plastics could be also degraded in soil during ten days.

Keywords: Biodegradable, mechanical strength, cempedak, glycerin

1. Introduction

Synthetic plastic is widely used in daily life such as such as packaging, construction, agriculture, etc. [1]. However, this synthetic plastic is still difficult to decompose in the environment. This long process of decomposing causes adverse impacts on the environment, such as the emergence of chemicals that can pollute the soil thereby reducing the level of benefits and fertility [2]. Biodegradable plastic is a type of plastic made from biopolymers. Biopolymers are polymers composed of renewable biomass. In addition to its constituents, the difference between biodegradable plastics and ordinary plastics is biodegradable decomposition grade which can be degraded more easily than ordinary plastics. This causes biodegradable plastic as an environmentally friendly alternative plastic [3].

Cempedak is a plant that has a unique fruit shape, taste and aroma such as jackfruit (Artocarpus heterophyllus), spread evenly in the regions of Sumatra, Java, Kalimantan, Sulawesi, Maluku and Papua [4]. Specifically in the South Kalimantan region, cempedak fruit is processed as traditional food through a fermentation process called cempedak, while fruit skin fermentation is called mandai [5]. Distribution data based on the 2003 agriculture census [6] show that the largest distribution of cempedak is found on the island of Kalimantan, with more than 200,000 trees and tilapia scattered throughout Indonesia and several countries but not processed as traditional food. This shows the existence of local wisdom of the local community which was developed from generation to generation in utilizing the living natural resources.

Glycerol is a polyol alcohol compound with three hydroxyl groups in one molecule (trivalent alcohol). The chemical formula of glycerol is \( \text{C}_3\text{H}_8\text{O}_3 \) with the chemical name 1,2,3-
propanetriol. The glycerol molecular weight is 92.10 and the boiling point is 204 °C. Glycerol has soluble properties in water, increases the viscosity of solutions and follows water, is hydrophilic, has a high boiling point, is polar and non-volatile. In addition, glycerol is also a humectant [7].

Due to the abundance of cempedak, this research aims to synthesize biodegradable plastic from cempedak by studying the effect of using glycerin plasticizer from transesterification of used cooking oil and from ordinary glycerin. This research was also conducted to determine the effect of the addition of glycerin concentration and to test the mechanical properties of biodegradable plastic produced.

2. Materials and methods
Cempedak meat was peeled from the outer skin and washed using water. Cempedak meat was chopped using a knife and put in 0.5% citric acid solution (w/v) for 10 minutes to prevent discoloration. Then, cempedak meat was dried using an oven at 60ºC for 12 hours. After drying, Cempedak meat was finely chopped using a blender to form flour. The result of coarse powder was sieved using a 100 mesh sieve. Biodegradable plastic was formed by mixing 5 grams of cempedak flour, 1.5 ml of glycerin, 1 ml of vinegar and 92.5 ml of distilled water into a beaker. The mixture of ingredients was heated using a hotplate stirrer at a temperature of 80 °C and 700 rpm. Heating and stirring was conducted for 40 minutes. Then, the mixture was cooled for 10 minutes and poured into a plastic mold. The biodegradable plastic mold was dried using an oven at 50ºC for 24 hours. Furthermore, the plastic was released from the mold. Biodegradable plastic samples are further made with basic ingredients of cempedak meat flour (5 grams) and glycerin from used cooking oil and glycerine (1.5 mL; 3 mL and 4.5 mL).

3. Results and discussion
Tensile strength test was carried out to determine the effect of glycerin concentration on the resistance or tensile strength of biodegradable plastic samples. Tensile strength test and elongation results can be seen in Figure 1 and Figure 2, respectively. Figure 1 shows that the greater concentration of glycerin added caused the tensile strength to decrease. The values of tensile strength at glycerin concentration 1.5 mL; 3 mL and 4.5 mL were obtained at 44.2 MPa; 19.6 MPa and 3.6 MPa, respectively. Tensile strength decreased while increasing the concentration due to the reduction in intermolecular interactions; hence, the sample matrix formed became less. It was possible because glycerin molecules as plasticizers would reduce intermolecular interactions and increase polymer mobility [8]. Intermolecular interactions could also weaken hydrogen bonds in biopolymer bonds, causing interaction between biopolymer molecules to decrease. Weak hydrogen bonds between these biopolymer molecules caused a reduction tensile strength [9]. This finding is in accordance to the research [10] where the tensile test strength also decreased with the increase in the volume of glycerin added to the biodegradable plastic mixture.

Figure 1: Effect of Glycerin on Biodegradable Plastic Tensile Strength
Figure 2 shows that the greater concentration of glycerin added resulted in lower elongation value of biodegradable plastic. Elongation value at the glycerin concentration 1.5 mL; 3 mL and 4.5 mL was obtained to 40.8%; 32.1% and 2.9%, respectively. The value of biodegradable plastic elongation at glycerin concentration of 4.5 mL decreased significantly compared to concentrations of 1.5 mL and 3 mL. This was caused by an excessive plasticizer added thus leading the imperfectly formed matrix. This further affected the interaction between the matrices formed to be weaker and more easily torn [8]. The effect of the addition of glycerin to the elongation properties of biodegradable plastics can be seen in Figure 2.

![Figure 2](image)

**Figure 2.** Effect of Glycerin on Biodegradable Plastic Elongation

A good biodegradable plastic can be determined by the composition of biodegradable plastic at which the material weight does not change to water (does not absorb water), this can be determined by conducting a swelling test. The swelling test results can be seen in Table 1. Based on Table 1, the more glycerin added tends to increase water absorption in biodegradable plastics. The value of water resistance at glycerin concentration of 1.5 mL; 3 mL and 4.5 mL is 69.22%, 81.44% and 88.36%, respectively. It was observed that the greater the concentration of glycerin, the lower the percentage of water resistance. The highest percentage of water resistance was 88.36% with a glycerin concentration of 1.5 mL. The addition of plasticizer would cause a decrease in internal hydrogen bonds and an increase in the distance between molecules; thus leading to an increase in the permeability of biodegradable plastics [8]. In addition, the decreased molecular interactions and the increased mobility would also facilitate water transfer. Hence, the higher the concentration of glycerin, the greater the water absorbed in biodegradable plastic, this is because of hydrophilic character of glycerin [11].

| Glycerin Amount | Initial mass (g) | Final mass (g) | Hydrophobicity (%) |
|----------------|------------------|----------------|-------------------|
| 1.5            | 0.1228           | 0.1371         | 88.36             |
| 3              | 0.0797           | 0.0945         | 81.44             |
| 4.5            | 0.0614           | 0.0803         | 69.22             |

Table 1: The result of swelling test.

Biodegradation test is carried out to determine the time needed for a plastic sample to undergo degradation. The biodegradation test is carried out by utilizing soil microorganisms to the degradation process or commonly called as the soil burial test technique [12]. Figure 3 shows the results of biodegradation test on samples with a glycerin concentration of 1.5 mL. As shown in the figure, in the initial conditions the sample was still intact. The sample was buried in a pot filled with soil and the pot
was exposed to heat and rain. The observations are carried out once every two days. In the second day, the sample began to experience degradation where the size became smaller. In the fourth day, the sample size also decreased. In the sixth day, the sample narrowed and there was a hole form. In the eighth day, the sample remained small flakes and two pieces were separated from each other. In the tenth day, no more samples were found in pots containing soil. Thus, the biodegradable plastic took 10 days to degrade with soil. In a study conducted by Eko [13], biodegradable plastic samples made from raw yellow kapok banana weevil were degraded within a period of 13 days. On the other hand, a research conducted by Fibriyani et al. [14], the biodegradable plastic from cassava was degraded for 9 days.

The characteristics of biodegradable plastic sample were compared to the Indonesian National Standard. The characteristics of the samples produced meet the standard. Indonesian National Standard (SNI) values for plastics are shown in Table 2 [15]. For example of the mechanical properties for concentration of 1.5 mL, the properties values of tensile strength, percent elongation and water resistance were 44.2 MPa, of 40.8%, and 88.36%, respectively. For the tensile and elongation strength test results, the biodegradable plastic produced has met the SNI standard. The value of water resistance (hydrophobicity) did not meet SNI standards. However, biodegradable plastic produced has the advantage compared to the conventional plastic because the biodegradable one could be easily decomposed during about 10 days as compared to conventional plastic with decomposition period of 400-600 years.

**Table 2. Mechanical Plastic Properties According to Indonesian National Standard.**

| Characteristic            | Standard value | Value in this research |
|---------------------------|----------------|------------------------|
| Tensile Strength (MPa)    | 24,7 – 302     | 44.2                   |
| Elongation (%)            | 21 – 220       | 40.8                   |
| Hydrophobicity (%)        | 99%            | 88,36%                 |

4. Conclusion
The addition of glycerin concentration in the production of biodegradable plastics results in a decrease in the value of tensile strength test, elongation break and swelling test. The results of mechanical test showed that a biodegradable plastic sample from cempedak fruit flour with a glyceric concentration of 1.5 mL had a tensile strength value, elongation and water resistance of 44.2 MPa, 40.8% and 88.36%, respectively. The biodegradable plastic was completely degraded in the soil within ten days. These
results show that the biodegradable plastic can be possible used as alternative product to replace the synthetic plastic as a cause of environmental problems.

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