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The addition of tobacco stem powder in the cassava peels biodegradable plastic

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Abstract. Plastic waste has become an environmental problem for all countries. People dispose goods made of plastic causing a build-up of waste because it is difficult to degrade. For this reason, it is necessary to develop environmentally friendly plastics known as biodegradable plastics. This study used starch extracted from cassava peel as base material and tobacco stem powder as a natural reinforcement. Beside the cassava peel starch and tobacco stem powder, glycerol is needed as plasticizer. The purpose of this study was to determine the effect of tobacco stem powder and glycerol addition variations on the mechanical properties. This study is designed using a completely randomized design with two factors and three replication. The parameters observed were mechanical properties (thickness, tensile strength, elongation, modulus young) and the morphology of thickness. The results show that the addition of tobacco stem powder and glycerol had a significant effect on mechanical properties. The addition of tobacco stem powder and glycerol could increase the thickness value of biodegradable plastic between 0.173-0.283 mm. The elongation value obtained were inverse with the tensile strength value. The modulus young value was between 0.08-0.81 MPa.

1. Introduction

Plastic waste has become an environmental problem for all countries including Indonesia which is placed in the second rank as the producer of plastic waste to the sea after China, with 187, 2 tons [1]. As a result, it is found that several types of fish in the Market Makassar Paotere have been shown to contain microplastic in their intestine [2]. People who like disposable goods especially from plastic cause a build-up of plastic waste because plastic waste is difficult to degrade which then gives the impact on environmental pollution such as decreasing water and soil quality. Plastic burning is also not a good choice because it can pollute the air. To overcome this problem, the development of environmentally friendly plastic is needed. Biodegradable plastic is one of the efforts to overcome the problem of synthetic plastics made from petroleum whose raw materials are limited and cannot be renewed.

This study used agro-industrial waste; cassava peel as a source of starch and tobacco stem powder as a natural reinforcement. The high starch content in cassava peel allows it to be used as a raw material for making sustainable biodegradable plastics. Cassava peel contains 51.93 % of starch [3]. The use of fibre as a reinforcement in biodegradable plastic has not widely developed. Beside the cassava peel starch and tobacco stem powder, glycerol as plasticizer is needed in the biodegradable plastic production. The purpose of this study is to determine the effect of tobacco stem powder and glycerol addition variations on the mechanical properties.

2. Methods

2.1. Materials
The materials used in this study include: freshly cassava peel, TBN H382 tobacco stem powder, glycerol, Carboxyl Methyl Cellulose (CMC), glacial acetic acid, demineralised water, soil, dichromate, sulfuric acid, and silica gel.

2.2. Design of experiment
The experiment used completely randomized design with 2 factors. The first factor was the volume of glycerol with 3 levels, namely 25 % w/w (G1), 30 % w/w (G2), and 35 % w/w (G3). The second factor was the variation of tobacco stem powder addition, which had 4 levels, namely 0 % w/w (P0), 10 % w/w (P1), 20 % w/w (P2), 30 % w/w (P3).

2.3. Production of biodegradable plastics
The production of biodegradable plastics used solving casting method. 10 gram of mixed powder (cassava peel starch, CMC, and tobacco stem powder based on experimental design) was placed in to a 250 mL beaker glass and 100 ml demineralised water was added. Then the slurry was heated on a hot plate magnetic stirrer at the temperature of 70 °C for 5 minutes and 60 rpm. Glycerol was added based on experimental design with 1 % acetic acid, into the beaker glass and continue heated on a hot plate at 90 °C for 10 minutes and 60 rpm. Then the gel is poured on to a 20 cm x 15 cm plate and dried in drying oven at 60 °C for 24 hours. After drying and forming sheets, then it is cooled for 24 hours at room temperature then cut based on the test and stored into silica gel jars.

2.4. Analysis procedure
Thickness testing was done using the thickness gauge tool (Mitutoyo) [4]. Tensile strength and elongation tests were carried out using a universal testing machine (Shimadzu SM-500N-158) [4]. Modulus young was obtained from the comparison between tensile strength and elongation. Morphological analysis using a scanning electron microscope (Hitachi TM3030Plus).

3. Results and discussion

3.1. Visual of biodegradable plastics
Visual appearance of biodegradable plastic can be seen in Figure 1. The visual appearance of the biodegradable plastic produced shows that the more tobacco stem powder added, the darker the biodegradable plastic color. This is influenced by the brown color of tobacco stem powder added.

3.2. Thickness
Based on Figure 2, it can be seen that the thickness of biodegradable plastic film increases as glycerol and tobacco stems have increased. The results of the significance level variance (α) of 5 % show that the treatment of glycerol and tobacco stems significantly affect the thickness of biodegradable plastic films. The thickness of the biodegradable plastic produced ranges from 0.173 to 0.283 mm. The highest thickness results from the treatment with addition of tobacco powder 30 % and glycerol 35 % and the lowest thickness from the treatment with addition of tobacco powder 0 % and glycerol 25 %. The higher the concentration of dissolved solids, the higher the thickness of biodegradable plastic produced. The addition of tobacco stem powder increases the total dissolved solids of the film solution, thus it increases the thickness of the film. The addition of glycerol as plasticizer increases the gel viscosity of biodegradable plastics, and is considered to have a role in increasing film thickness.

Figure 1. Biodegradable plastic samples dimensions of 5 cm x 2 cm.

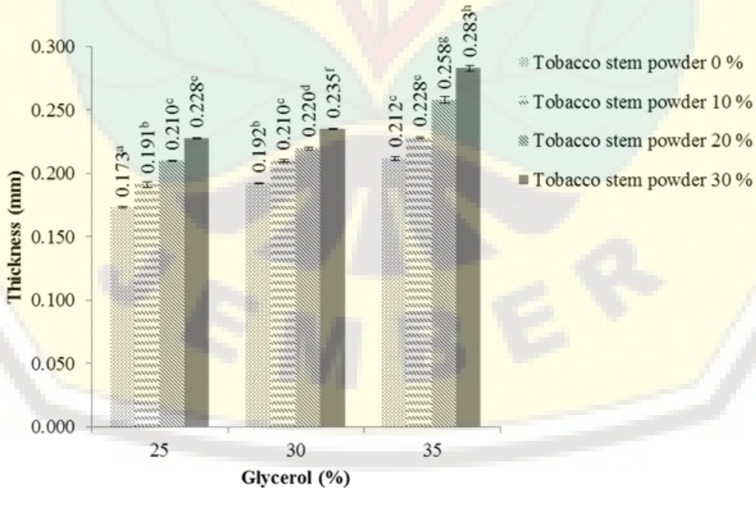

Figure 2. Thickness value of biodegradable plastic film.

3.3. Tensile strength

Based on Figure 3, the highest tensile strength occur from the treatment of 30 % tobacco stem powder and 25 % glycerol addition, the value is 2.91 MPa and the lowest can be obtained from the treatment of 0 % tobacco stem powder and 35 % glycerol, with 1.48 MPa. The results of the significance level variance (α) of 5 % shows that the treatment of glycerol and tobacco stems powder addition, significantly affects the tensile strength of biodegradable plastic. The addition of glycerol result in decrease of tensile strength while the addition of tobacco stem powder result in increase of tensile strength.

The dried tobacco stems powder contain relatively high cellulose at 36-38 % [5]. The presence of cellulose in tobacco powder can make the tensile strength of biodegradable plastic films increases. While the addition of glycerol causes tensile strength to decrease. Glycerol can reduce tensile strength due to the work of glycerol which infiltrates the space between the polymer matrices [6]. In addition, too much cellulose and glycerol causes the plastic film to become less homogeneous and the bonds that occur between starch-cellulose and glycerol are not strong.

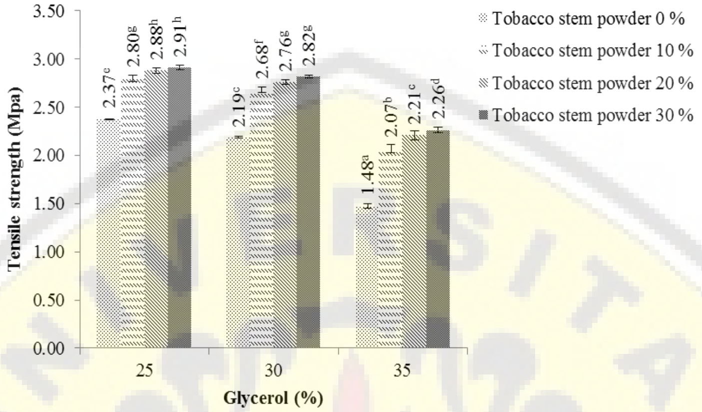

Figure 3. Tensile strength value of biodegradable plastic films.

3.4. *Elongation*

Figure 4 shows that the elongation value is inversely proportional to the tensile strength value. The results of the variance analysis at significance level (α) of 5 % showed that the variation of glycerol and tobacco stems powder addition significantly affects the value of elongation. The elongation value in the treatment of 0 % tobacco stem powder addition has increased from 12.24-17.99 % because of glycerol addition. Glycerol is an agent that can repair and accelerate the plasticization mechanism in the polymer matrix. The addition of plasticizer to starch films has a large effect on film mechanical properties, such as increasing film flexibility and resilience [7]. When the tobacco stem powder increases, the elongation value decreases. The increasing of tobacco stems powder causes stronger tensile strength and conversely, decreases elongation.

The same results are shown from the research of starch composites reinforced by bamboo cellulosic crystals (BCC), the elongation at break increases when BCC content decreases. With increasing BCC content, both tensile strength and Young's modulus increase [8]. This change in mechanical properties is related to the interaction of cellulose with starch and glycerol as plasticizers.

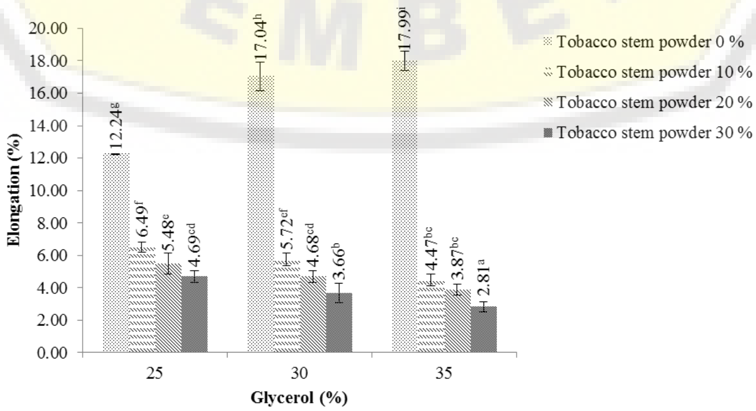

Figure 4. The elongation value of biodegradable plastic films.

3.5. *Young's modulus*

Based on Figure 5, the addition of tobacco stem powder causes the increasing of biodegradable plastic's modulus young. The reinforce structure resulted in strong and rigid tensile strength. The results of variance analysis with significance level (α) of 5 % showed that the treatment of glycerol and tobacco stems powder addition significantly affects on the modulus young value. The greatest modulus value was obtained from the treatment 30 % tobacco stem powder and 35 % glycerol addition, which is 0.81 MPa. While the smallest modulus value was obtained from the treatment 0% tobacco stem powder and 35 % glycerol addition, which is 0.08 MPa. This result is the opposite of elongation value but concomitant with tensile strength value.

Addition of glycerol to biodegradable plastic without the addition tobacco stem powder (0 % addition) decreases modulus young due to the role of glycerol as a plasticizer which increases the flexibility of the material. However, when the tobacco stem powder is added to the biodegradable plastic matrix, the glycerol addition increases modulus young. These probably because the increase in tobacco stem powder proportion will decrease the ratio of glycerol as plasticizer to starch so that the role of glycerol as plasticizer decreases. In addition, the hydroxyl group contained in cellulose allows it to form many hydrogen bonds. This causes high inter-chain stiffness and force [9].

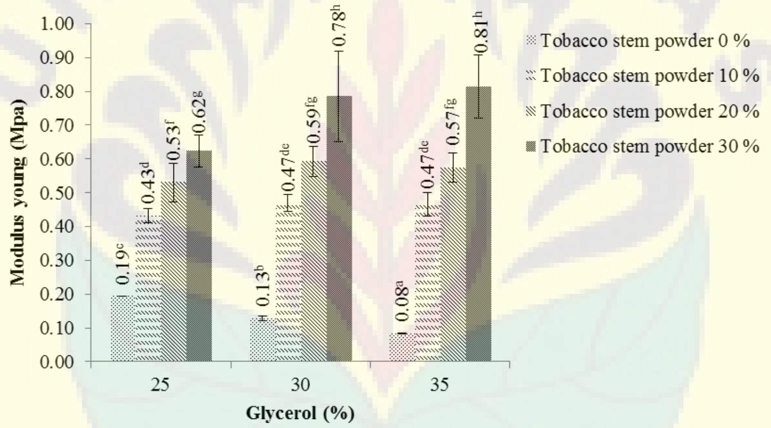

Figure 5. Modulus young value of biodegradable plastic films.

3.6. Scanning electron microscope (SEM)

Figure 6 and 7 shows the results of the SEM test in sample thickness with a magnification of 500, it is visible that there are the differences of the thickness form between the additional treatment of tobacco powder 0 % and glycerol 30 % (P0G2) with the additional treatment of tobacco powder 30 % and glycerol 25 % (P3G1). The P3G1 treatment shows that there are the presence of fibers which can increase the tensile strength of the biodegradable plastic film produced, but by the presence of cavities, it shows that the fiber between the other constituents has not been mixed well so that the strength of the fiber is not maximum. While the SEM image of the P0G2 treatment shows that the cassava shell starch composers are well mixed and do not show its fiber as found in the P3G1 biodegradable plastic treatment.

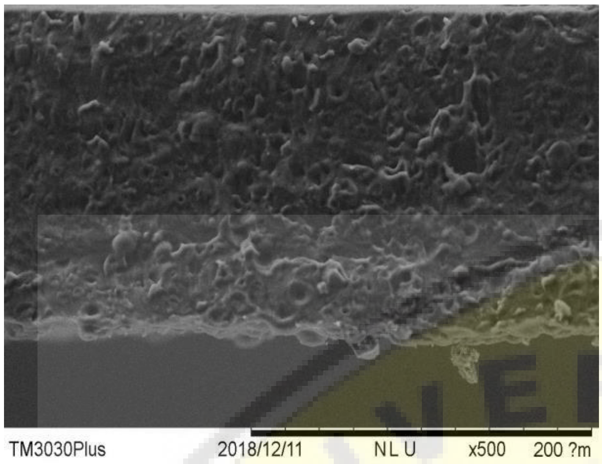

Figure 6. The SEM test of tobacco stem powder 0% glycerol 30%.

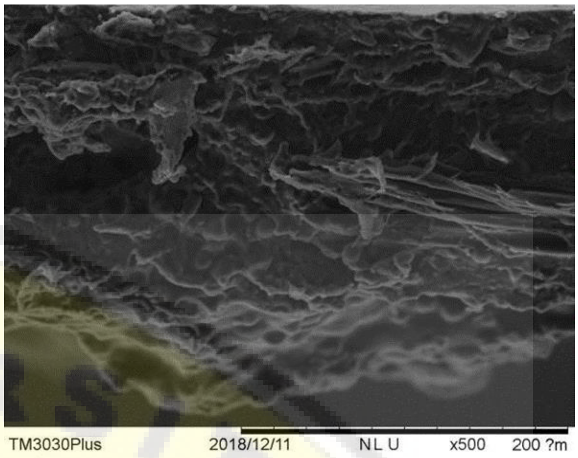

Figure 7. The SEM test of tobacco stem powder 30% glycerol 25%.

4. Conclusions

The addition of tobacco stem powder and glycerol has a significant effect on mechanical properties. The addition of tobacco stem powder and glycerol could increase the thickness value of biodegradable plastic between 0.173-0.283 mm. The percent elongation value between 6.49-2.81 % was inversely proportional to the tensile strength value between 2.07-2.91 MPa of the biodegradable plastic film produced, while the modulus young value was between 0.08-0.81 MPa.

5. References

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