



Effect of Chitosan, Clay, and CMC on Physicochemical Properties of Bioplastic from Banana Corm with Glycerol

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Abstract

Bioplastic from banana corm and glycerol has been studied in this research. In addition, the physical chemical properties of this bioplastic has been improved by adding chitosan, clay and CMC as filler and glycerol as plasticizer. Plastic that produced form organic material such as starch usually has poor properties in physical and mechanical. Composition variation of chitosan, clay and CMC as filler then combined by variation of glycerol as plasticizer have produced significant improve of the bioplastic physical properties. Properties of the bioplastic that studied in this research was focused to biodegradation, elongation, and tensile strength. The addition of fillers and plasticizers is carried out to produce a better bioplastics. This study used 3 variations of the filler composition : 4, 5, and 6 grams and 2 variations of the plasticizer composition: 1 ml and 2 ml. The bioplastics that produced were tested for tensile strength, elongation at break, and biodegradation of the soil for 7 days. The best tensile strength results is 8.43 MPa for bioplastic that using CMC fillers. On the other side, the best elongation percentage is 9.87% for bioplastic which using CMC fillers. The bioplastic that added Clay as filler can be degraded up to 100% in 7 days.

INTRODUCTION

Consumption of plastic to modern society tend to improve day by day. Plastic that used by people usually produced form synthetic material. Synthetic plastics are made from petroleum or petrochemical polymers. This plastic is used because it has several advantages, such as flexible (it can follow the shape of the product), transparent, not easily broken, can be combined with other packaging, and not easily corrosive. However, this synthetic plastic cannot be broken down by microorganisms (Zuhra et.al., 2017).

One of the solution to solve this problem is replacing synthetic plastics by biodegradable plastic. It is more environmentally friendly which is commonly called bioplastics. Bioplastics are plastics made from materials that can be renewed

and easily broken down by microbes that have now been widely developed. Bioplastics are made from organic materials such as cellulose, collagen, starch, casein, protein, or lipids (Layudha et.al., 2017).

Banana corm is a part of a banana plant under a banana stem. Until now, banana corm only has a negative impact on the environment because it only becomes waste that is discharged directly into the environment. Banana corm is an agricultural waste with high starch content. The starch content in each variety of banana corm is different, such as in lady finger banana corm is 67.80% and in saba banana corm is 64.20% (Asngad, et.al., 2018). While the general composition of banana corm starch is 76% starch content, 20% water, and 4% other ingredients (Unsa & Paramastri, 2018).

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Chitosan is a protein modification of chitin that found in the skins of shrimp, crabs, lobsters and insects. Chitosan has good properties to be formed into plastic and has antimicrobial properties. Chitosan is also easily degraded and combined with other materials (Hartatik et.al., 2014).

CMC is a cellulose derivative that has excellent water solubility. CMC consists of hydrophobic groups of polysaccharides and carboxyl hydrophilic which produce their amphiphilic properties. CMC can be used in making edible films to improve mechanical and anti-moisture properties. The price of CMC is also relatively low, so this material can be considered in the formation of bioplastic films for food packaging (Han et.al., 2015).

Clay is called loam. Clay is made from a variety of materials, but the mixture has the properties that can be formed. Clay is one of the materials that attracts attention because it is strong, rigid, abundant in nature, cheap and high in its ability to interpret particles into its structure. Clay has a very flexible structure, so it is very easy to shape. Only by drying, the already formed clay will harden (Melani et.al., 2017).

MATERIALS AND METHODS

Materials

The ingredients used in this study were banana corm starch, fillers, and plasticizers. The fillers used were chitosan, clay, CMC with composition variations are 3.4 and 5 grams. And plasticizer used was glycerol with variations in composition are 1 and 2 ml. in this study using the blending method by mixing all the ingredients.

Production of Banana Corm Starch

Banana corm was separated from the stem and then chopped and soaked in a solution of citric acid for 10 minutes to remove the browning enzyme. Then the banana corm was blended until it became pulp. Banana corm pulp then filtered with a filter cloth to separate the pulp and starch and then squeezed until the pulp was dry. The starch slurry was precipitated for 60 minutes. The starch that has been obtained from the precipitate was then dried.

Production of Bioplastic

Chitosan Filler

Chitosan was varied by 4, 5 and 6 grams. It was dissolved into beaker glass and then 100 ml of

distilled water and 1 ml of acetic acid, were added and then stirred until homogeneous. Starch was dissolved in 100 ml of distilled water that has been added 1 ml of acetic acid and stirred until homogeneous. Then chitosan and starch solution were mixed and added with glycerol according to variations and heated using a hotplate with a solution temperature of 80°C for 40 minutes by stirring using a magnetic stirrer

CMC Filler

CMC according to the design variation was dissolved in 100 ml of distilled water until evenly mixed to obtain a thick solution. Starch was dissolved in 100 ml of distilled water which has been added 2 ml of acetic acid and stirred until homogeneous. Then the CMC solution and the starch solution were mixed and added glycerol according to obtained variations then heated to 80°C using a hotplate for 40 minutes and stirred using a magnetic stirrer.

Clay Filler

A 3 grams of banana corm starch was dissolved in 100 ml distilled water and then 2 ml of acetic acid was added and then stirred until homogeneous. The solution was added by glycerol and clay filler into the beaker glass. The solution was heated to 80°C and stirred by a magnetic stirrer until the solution thickens.

Molding Process

The solution was cooled and molded using a spatula on ceramic that taped on each side. Then the bioplastic solution was dried for 2-3 days. After dried completely, the plastic was released from the mold slowly.

Testing Methods

Tensile Strength Test

To do a tensile strength test, bioplastic film samples were cut according to the standard that was 3 x 9 cm. Then both ends of the sample were clamped. Then initial length before adding the load was noted. Calculation of tensile strength follow Eq. (1).

$$\text{Tensile Strength} = \frac{\text{Force of tensile strength (F)}}{\text{surface area (A)}} \quad (1)$$

Elongation Test

Elongation is the change in maximum length during stretching until the plastic sample is

cut off. Elongation is noted as a percentage. Changes in length can be seen when the plastic is torn. Eq. (2) was used to calculate the elongation of the material.

$$\text{Elongation} = \frac{\Delta L}{L_0} \times 100\% \quad (2)$$

Where, ΔL is the length increment - initial length (cm) and L_0 is the Initial length (cm).

Biodegradation Test

Samples were planted in the soil with a certain depth and allowed to completely degraded. Before planting, the sample was weighed and measured. Eq. (3) was used to calculate percent weight loss.

$$\% \text{ weight loss} = \frac{W_1 - W_2}{W_1} \times 100\% \quad (2)$$

Where, W_1 is the plastic weight before biodegradation testing and W_2 is Plastic weight after biodegradation testing.

RESULTS AND DISCUSSION

The mechanical properties test aims to determine the mechanical characteristics of the bioplastic starch of banana corm with the addition of glycerol and fillers. Table 1 shows the comparison of the current research data with Bioplastic Quality Standards. Physical form of produced bioplastic is presented in Figure 1.

Table 1. Comparison of test results with bioplastic quality standards.

	Bioplastic Quality Standards	Result in this study
Tensile Strength	1-10 MPa	1.67 – 8.43 MPa
Elongation	10-20 %	0.54 – 9.78 %
Bio-degradation	100 % on 60 days	60-100% on 7 days

Tensile Strength Test

According to Figure 2, it can be seen that increasing the filler tend to increase the tensile strength. This result is consistent to Zuhra (2017) which obtained tensile strength values from banana corm starch. In this study, the tensile strength

values of all variations qualify the bioplastic quality standards, about 1.67 to 8.43 MPa. The results of the highest tensile strength test is 8.43 MPa by adding of 1 mL of glycerol and 5 grams of CMC. The result proved that addition of cellulose, in this case is CMC, causes increasing interaction force of attractions between the molecules so making up thin of the film. This condition is related to the hydroxyl groups which forming inter hydrogen bonds and intramolecules that forming a thin layer consisting of reinforcing fibers. This is in accordance with Ningsih (2019).

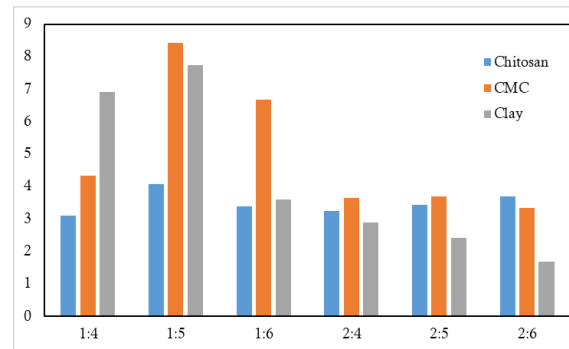


Figure 2. Tensile strength test results.

The graph shown that increasing the value of tensile strength also occurs in bioplastics added by chitosan filler. The increasing concentration of chitosan will increase the value of bioplastic tensile strength. This happens because the more chitosan used, the more hydrogen bonds are formed, so that it stronger and harder to break. This is according to Oetary (2019)

In contrary, the graph shown that adding the clay filler, the tensile strength tends to decrease. It can be explained that, too much clay concentration added to bioplastic as a filler cause the pores of the bioplastic sheets excess by filler so it produce bioplastics with poor quality or properties. It is indicated by the physical form of the bioplastic film produced in the 6 gram clay filler variation tend to cracked. The same thing was said by previous researchers Melani (2017) where too much clay filler concentration produce bioplastics that are not good or break easily.

In contrast to the addition of filler which will cause bioplastic tensile strength increase, the addition of glycerol will decrease the tensile strength value. It can be seen from the graph obtained in this study that bioplastics with the addition of 1 ml of glycerol have higher tensile strength compared to the addition of 2 ml of glycerol. These results are also consistent with

Haryati (2017) where the value of tensile strength decreases by adding plasticizer. This is due to the plasticizer will reduce the strength of hydrogen bonds in the plastic so that it increases the flexibility of the plastic and decreases of the tensile strength results.

Elongation Test

Based on Figure 3, it shows that the more glycerol used the elongation also increase. This is in accordance with Septiosari (2014) where the use of glycerol as a plasticizer serves as a provider of elasticity properties on plastic films so that the more glycerol added increase the elongation value in the plastic. The addition of plasticizer causes a decrease in inter-molecular force along the polymer chain thereby increasing flexibility. In this study with the addition of 1 ml of glycerol the elongation values ranged from 0.54 to 3.26% while in the addition of 2 ml of glycerol ranged from 1.09 to 9.78. This results still does not meet the bioplastic quality standards.

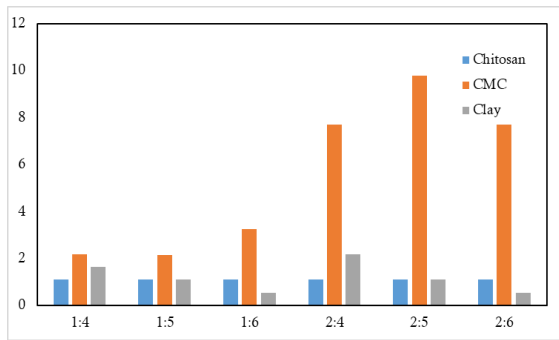


Figure 3. Elongation test results.

Biodegradation Test

Figure 4 shows that the more glycerol content, the faster the degradation process. These results are consistent with Septiosari (2014) that the percentage of weight of degraded plastic increases by adding the glycerol.

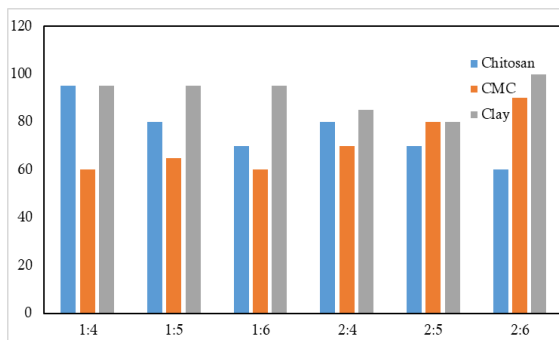


Figure 3. Biodegradation test results.

The addition of CMC fillers to bioplastics also causes a faster degradation process. This is in accordance with Septiosari (2014) which conveys that the factor that affects the biodegradability of a plastic is the cellulose content in it. The greater the cellulose content, the faster the degradation process of a plastic, because cellulose is a material that can be degraded in nature due to microbial activity in the soil.

The higher concentration of clay filler added, the ability to degrade in the soil also increases. This is because clay is a filler made from organic raw material which is very easily biodegradable or degraded by soil. The same thing was also conveyed by Melani (2017) where clay fillers which are made from clay when used in bioplastic mixtures will easily decompose

Whereas on chitosan filler, the more chitosan added, the slower the degradation process. This is in accordance with the research of Oetary (2019) because chitosan is an antimicrobial agent which slows down the work of decaying bacteria, even though chitosan is an easily decomposed material.

CONCLUSION

From this research, it can be concluded that bioplastics have the highest tensile strength and elongation values when added CMC as filler. That are 8.43 MPa in 1: 5 variation and 9.78% in 2: 5 variation, respectively. The fastest biodegradation is resulted by add Clay as filler. That is 100% in 7 days for 2:6 variation.

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