BIOPOLYMER FROM STARCH AND CHITOSAN AS BIOPLASTIC MATERIAL FOR FOOD PACKAGING

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Abstract

This research aims to improve economic value of cassava peel waste as raw material of bioplastic making, whose existence is still very abundant and has not been benefitted optimally. Bioplastic making is conducted by mixing starch and chitosan with gliserol as plasticizer. Bioplastic making is carried out at gelatinization temperature of 80ºC. Chitosan addition is carried out at variatios of 0; 10; 20; 30; and 40 (% w). Research result indicates that mechanical property i.e. optimum value of tensile strength is obtained at value of 38.25 MPa with chitosan addition as much of 30%. The highest elongation percentage is obtained as much of 41.25% with addition of 10% chitosan. Physical property of resulted bioplastic is obtained from the best swelling test at addition of 40% chitosan i.e. 0.38%, and bioplastic density obtained is ranged from 2 – 3.33 g/ml. Analysis of functional group by using FTIR exhibits the existence of ester and carbonyl groups that indicates that resulted bioplastic could be degraded. Whereas biodegradability test on environment exhibits that bioplastic could be completely degraded in soil for 24 days.

Key words: bioplastic, mechanical property, physical property, degradation

Introduction

Cassava peel (manihot utilissima) is waste that can be obtained from production of tapioca flour and various food that contains starch benefitted and obtained easily and cheaply. Generally, cassava peel is more often thrown or utilized as livestock woof. Its utilization as raw material of biodegradable plastic making is expected to reduce pollution in environment and improve cassava peel potential that is so far assessed less economical.

Bioplastic or biodegradable plastic is plastic that could be obtained by benefitting starch from cassava peel that could be utilized as food packaging material. With technology improvement, particularly in food techonology field, various alternatives are found to be utilized to lengthen storage period of ready-served food before consumed. One of them is packaging by using active packaging. Active packaging of plastic is packaging that could inhibit disturbance from external environment toward packaged food (Fabech et al., 2000). Handling of conventional plastic waste such as incineration or recycle of plastic waste has not optimal enough to overcome plastic waste problem up to in the early of 1990s. It was when plastic material that has good capacity of microbe degradation was found that is currenly known as biodegradable plastic (Muller, 2005).

Materials and Methods
Procedure

Making of bioplastic was carried out by mixing starch with chitosan, and gliserol as plastisizer, at gelatinization temperature of 80ºC. Formulation of starch-chitosan composition was set at basis of 100. Addition of chitosan was carried out at variation of 0; 10; 20; 30; and 40 (% w). Whereas gliserol as plasticizer was added at concentration of 50% of starch weight. Mixing was carried out on hot plate at constant temperature of 80ºC and magnetic stirrer velocity of 75 rpm for 25 minutes. Dope solution was casted on glass plate, with width of 2.5 mm, then it was heated in oven at temperature of 60ºC for 5 hours. After drying in oven, bioplastic was parted from the casting and kept in desicator. The next step was analysis of bioplastic properties such as mechanical property, physical property, and biodegradability property toward environment.

Results and Discussion
Tensile Strength of Bioplastic

Mechanical property of bioplastic could be known from response of tensile strength and elongation tests. Tensile strength is maximum force that could be resisted by a bioplastic until breakage. Figure 1 depicts correlation between chitosan addition and tensile strength of resulted bioplastic.

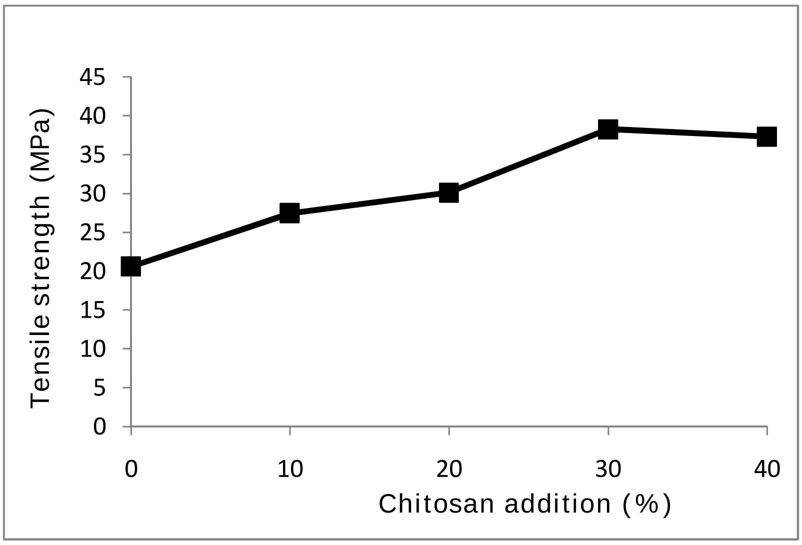

Figure 1. Correlation of chitosan addition versus tensile strength of bioplastic

Based on Figure 1, it appears that the larger chitosan concentration added, the higher tensile strength value resulted. It is because the larger chitosan concentration, the more hydrogen bonds in bioplastic, so that they will be stronger and hard to break, because large energy is needed to break them (Indriyanto et al., 2014). The optimum value of tensile strength achieves 38.25 MPa that is obtained from chitosan addition as much of 30%.

According to Ban (2005), significant factor that influence mechanical property of bioplastic material is affinity among its constituent components. Affinity is a phenomenon where particular atom or molecule has tendency to unite and be bonded. The higher affinity, the more binding occurs among molecules. Strength of material is influenced by chemical binding of its constituent. Strong chemical binding depends on the number of molecule binding and its binding type. Strong chemical binding is hard to break, so that in order to break the strong binding, it needs large energy.

Percent Elongation

Elongation is quantity of maximum length change achieved by film from the time of obtaining tensile force until the film breaks. Reseach result indicates that generally chitosan concentration addition is more improving, so that it will reduce bioplastic percent elongation.

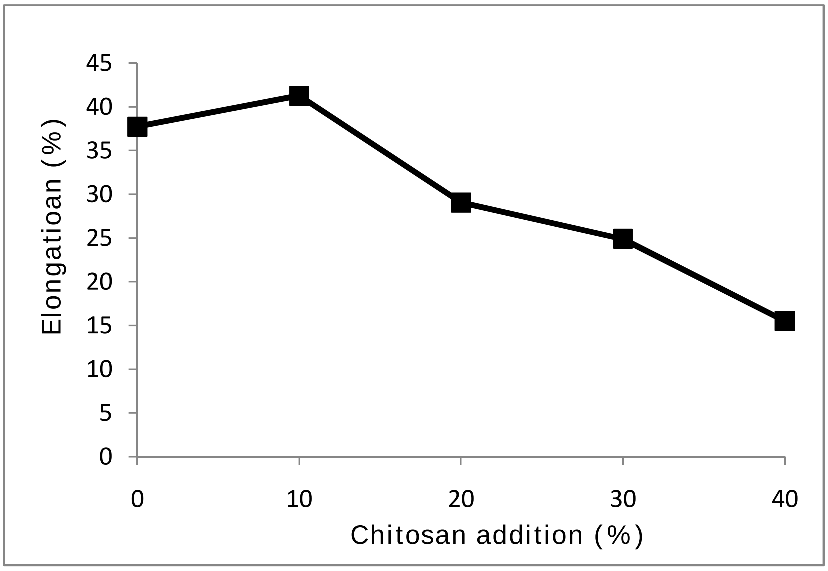

Figure 2. Correlation of chitosan addition toward bioplastic percent elongation.

Figure 2 depicts tendency that increasing chitosan concentration in starch-chitosan mixture will reduce elongation value. It is because the larger chitosan concentration,the lower intermolecule binding distance in bioplastic (Sanjaya and Puspita, 2011). The highest elongation value is obtained at chitosan addition of 10% with value of the highest elongation percent obtained is 41.25%.

Swelling

The effect of chitosan addition toward water resistant property of bioplastic could be observed in Figure 3.

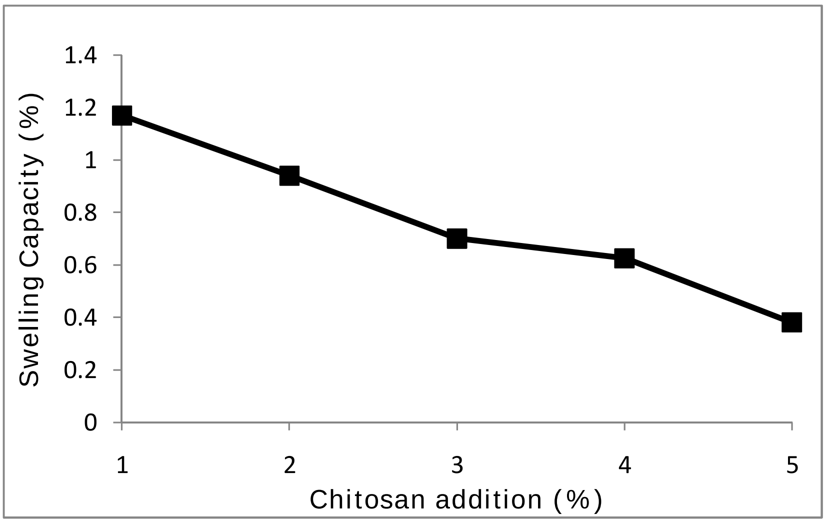

Figure 3. The effect of chitosan addition on swelling capacity of bioplastic

Generally, the higher chitosan concentration added into bioplastic, the lower resistant property of the bioplastic, which means bioplastic capacity to absorb water will be less. It is caused by polymer chain in chitosan that contains many $-NH_2$ or hydrophobic amine groups, which means large hydrophobicity property of constituent polymer of chitosan. As a consequence, the harder for water to penetrate into bioplastic. It is in accordance with research conducted by Darni and Herti (2010), who states that chitosan is a biopolymer that could give good property of water resistant on bioplastic. It is caused by hydrophobicity (dislike water) property of starch-chitosan property.

Figure 3 indicates that the more chitosan added, the less water absorbed into biodegradable plastic. It is indicated at the best value of water resistance i.e. at chitosan addition as much of 40% with the best capacity of water absorption of 0.38%.

Density of Bioplastic

Density of bioplastic is value that indcates material mass per volume unit (g/ml). The objective of the test is to identify biodegradable plastic density. Figure 4 indicates correlation of chitosan addition versus biodegradable plastic density. The figure displays that the more chitosan added, the higher value of biodegradable plastic density obtained.

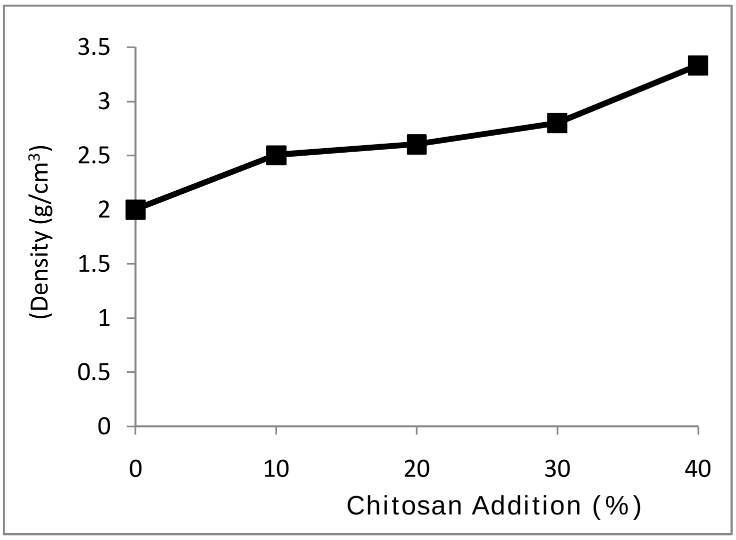

Figure 4. The effect of chitosan addition on bioplastic density

The density of resulted bioplastic is in the range of 2 – 3.33 g/ml. Research result indicates that increasing of chitosan concentration will increase bioplastic density value. It is because the more chitosan added, the larger biogradable plastic mass resulted. Density is proportional to material mass, so that the larger a material mass, the higher density value (Widyaningsih et al., 2012).

Analysis of Functional Group

Characterization result toward bioplastic material with spectroscopy technique of FTIR is indicated in Figure 5. Its spectrum exhibits the existence of low peak at wave number of 991.41 cm^{-1} that indicates C-O (ester) group, and 1627.2-1674.21 cm^{-1} that is group of C=H (carbonyl) stretch. Therefore, the existence of the functional group indicates that the bioplastic could be degraded.

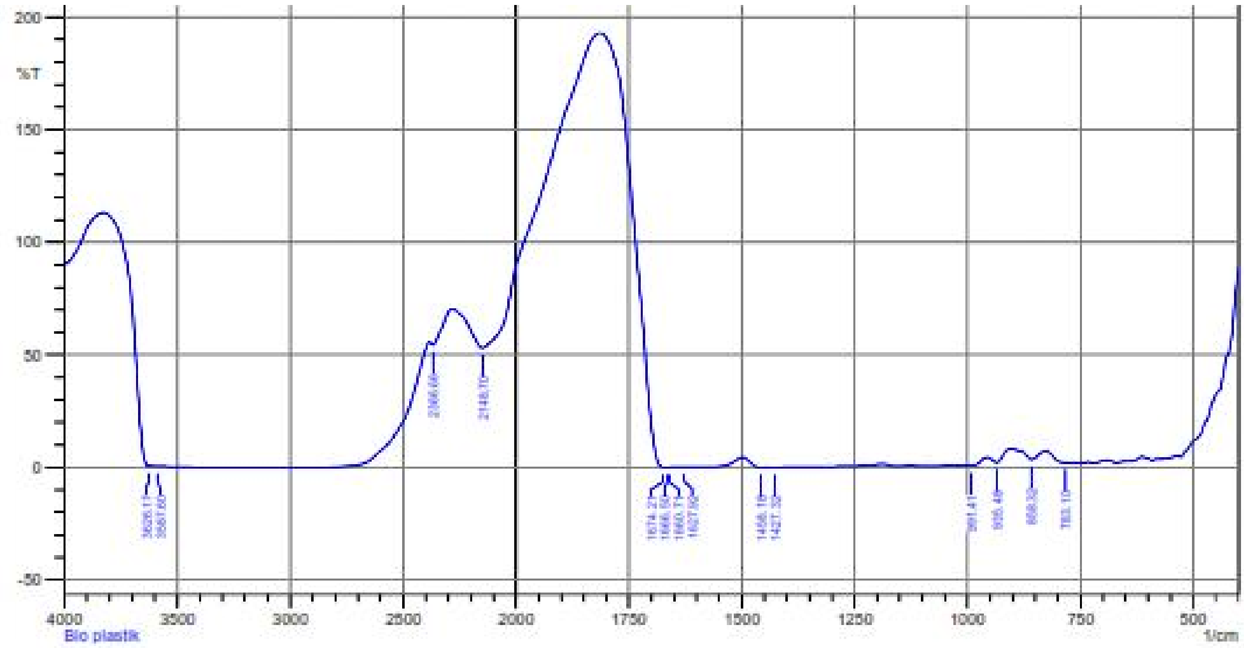

Figure 5. FTIR spectrum of bioplastic

Biodegradation Test on Environment

In this research, biodegradation test of biodegradable plastic is carried out by composting in soil media. Soil used is soil that is from landfill.Testing is carried out on all samples and weighing is carried out once every 3 days. Reduction of sample weight on every biodegradable plastic could be observed in Figure 6.

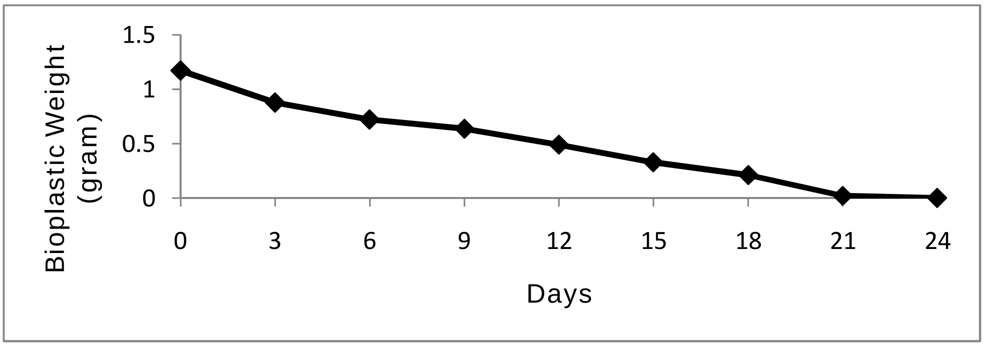

Figure 6. Reduction of bioplastic mass during bioplastic biodegradation test

Figure 6 indicates reduction of bioplastic mass during test of biodegradability property toward environment on chitosan addition of 40%. Biodegradable plastic with chitosan addition of 40% has been decomposed completely in the 24th day. It indicates that chitosan addition into bioplastic still results in degraded (decomposed) bioplastic in soil.

Conclusions

The bioplastic results in the value optimum value of tensile strength of 38.25 MPa at 30% chitosan addition, and the highest elongation obtained is 41.25% at 10% chitosan addition. The physical property of bioplastic resulted from the best swelling test with 40% chitosan addition is 0.38%, and the bioplastic density obtained is in the range of 2 – 3.33 g/ml. FTIR spectrum of bioplastic indicates the existence of ester and carbonyl groups. Test of the biodegradability in environment indicates that bioplastic from cassava peel with the addition of chitosan and gliserol could be decomposed completely in soil for 24 days.

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