Biodegradable Plastic Characteristics of Cassava Starch Modified in Variations Temperature and Drying Time

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Abstract
This study aims to (1) know the effect of temperature and drying time on the characteristics of biodegradable plastic from cassava starch modified, (2) determine the temperature and drying time is right to produce biodegradable plastics from cassava starch modified with the best characteristics. This study uses a randomized block design with factorial experiment. The first factor is the temperature of the drying which consists of 5 levels that were 50 ° C, 55 ° C, 60 ° C, 65 ° C and 70 ° C. The second factor is the drying time consists of 3 levels, namely 5, 6 and 7 hours. Each combination of treatments grouped into two based on process making of biodegradable plastic, so there are 30 experimental units. Data were analyzed of variance and followed by Duncan test. The observed variables include mechanical and physical test consists of tensile strength, elongation at break, Young's modulus (elasticity), swelling of volume and degradation time. The results of the research showed that the temperature and drying time by using automatic cabinet dryer with an air flow 5 $\pm$ 0.1 m^3 / min, very significant effect on tensile strength, elongation at break, Young's modulus, percent swelling of volume and time of degradation biodegradable plastic of cassava starch modified. Temperature of 50 ° C with 5 hours drying by using automatic dryer cabinet with an air flow of 5 $\pm$ 0.1 m3 / min, had characteristics of biodegradable plastics : tensile strength of 1057.40 M Pa, elongation at break of 15.95%, Young's modulus of 6629,47 M Pa, swelling of volume of 9.91% and degradation time of 7 days.
Keywords: biodegradable plastic, cassava starch modified, temperature and drying time

1. Introduction

Plastic packaging continues to increase its use from year to year. Increased usage plastic reaches 5% per year (Damayanti, 2012); while according to Inaplas (2013) usage in Indonesia reached about 10 kg / capita / year. Increased need this plastic packaging, was also followed by an increase in environmental problems caused by waste plastic is generally derived from mineral material (Aider, 2010). The plastic waste is not easily decomposed by microorganisms (Hasan, 2006).

In order to solve the environmental problems then developed biodegradable plastic packaging materials are easily parsed microorganisms (Darni and Utami, 2010). The development of biodegradable plastic has become the trend of the world in order to prevent environmental damage (Siracusa, 2008). There are many renewable natural materials that can be used as biodegradable plastic materials such as cassava starch (Harsojuwono and Arnata, 2014), cellulose, lignin, casein, chitin, chitosan (Averous, 2004). According to Firdaus and Anwar (2004), the most potential raw material is cassava starch. According Kumoro and Purbasari (2014), cassava starch already mass produced on an industrial scale to guarantee availability.

Characteristics of starch-based plastics is influenced by several factors, including the type and concentration of starch (Harsojuwono and Arnata, 2014), the type and concentration of plasticizer (Dewi, et al, 2015), temperature and mixing in gel formation, temperature and drying time and other factors. Harsojuwono and Arnata (2016) have obtained biodegradable plastics from cassava starch using a concentration of 6% with the addition of a mixture of plasticizers glycerol and sorbitol in a ratio of 100: 0 as much as 1%. Biodegradable plastic is dried at 60 ° C for 4 hours and produce characteristics of the water content of 3.98%, elongation at break of 18.75%, tensile strength of 930 M Pa and a Young's modulus of 50 M Pa.

These results were compared to international standards for plastics plastic Poly Lactic Acid (PLA) from Japan which has the characteristics of tensile strength 2050 M Pa and elongation of 9%, then the strength of its appeal still needs to be improved. In order to improve these characteristics need to use alternative raw materials of cassava starch with modification starch. This is in accordance with the opinion of Ban (2004), which explains that to improve the film characteristics, can modify natural raw materials. In addition, it can also give treatments of temperature and drying time when printing biodegradable plastic sheet to obtain the optimal conditions.

The purpose of this study was to determine the effect of temperature and drying time on the characteristics of biodegradable plastics that use modified starch of cassava and determine the optimal conditions of temperature and drying time to produce biodegradable plastics from cassava starch modified with the best characteristics.

2. Research Method

2.1 Materials and Research Equipment

The materials used in this study were cassava starch acetylated, glycerol, and acetic acid 25% and distilled water. Tools used include glass beaker, spatula, water bath, Teflon, cabinet dryer with automatic type and equipment test of mechanical (autograph-sidmazu by ASTM D63).

2.2 Experimental design

The Research using a Randomized blocks design with factorial experiment. The first factor is the temperature of the drying which consists of 5 levels that were 50, 55, 60, 65 and 70 ° C. The second factor is the drying time consists of 3 levels, namely 5, 6 and 7 hours. Each combination of treatments grouped into two based on process making of biodegradable plastic, so there are 30 experimental units. Data were analyzed of variant and followed by test Duncan.

2.3 Research Implementation

Tapioca modified as much as 6 g, 100 g of distilled water, 0.2 g of acetic acid 25% were mixed and stirred for 10 minutes with a spatula in a glass beaker, after which the plasticizer glycerol plus 1 g. The mixture was stirred again with a spatula for 10 minutes so that homogeneous mixture. Next, the mixture is heated and stirred in a water bath at 60 ° C to form a gel. The gel formed is then molded in the Teflon with a diameter of 20 cm. After it is dried in a cabinet dryer with automatic type that to use air flow of 5 $\pm$ 0.1 m3 / min at a temperature and drying time according to treatment. The plastic sheet is formed is cooled at room temperature and taken slowly from the Teflon after 24 hours and the resulting biodegradable plastic.

2.4 Variables Observed

Variables observed were mechanical characteristics consisting of tensile strength, elongation at break, and Young’s modulus by using ASTM D638, and the physical characteristics that include percent of the volume swelling and degradation time of biodegradable plastic.

3. Result and Discussion

3.1 Tensile Strength, Elongation at break and Young’s Modulus

Drying biodegradable plastic from cassava starch modified using a dryer that equipped of temperature controlled automatic and an air flow 5 $\pm$ 1 m3 / min. Drying with this machine treats the temperature and drying time, so that to be known its effect to characteristics of biodegradable plastics from starch modified of cassava.

Analysis of variance showed that the temperature and drying time showed a significant influence on the tensile strength, elongation, and Young's modulus of biodegradable plastic from modified cassava starch material. Table 1 shows the mean of tensile strength, elongation at break, and Young's modulus of the biodegradable plastic from cassava starch modified, each ranging from 674.90 to 1057 M Pa, from 15.95 to 34.09% and 1979.76 to 6629.47 M Pa.

Table 1. The mean of tensile strength, elongation at break, and Young's modulus of biodegradable plastic of starch cassava modified

Treatments	The mean of Tensile Strength (M Pa)	The mean of Elongation at Break (%)	The mean of Young’s Modulus (M Pa)
Temperature of 50°C, 5 hours	1057.40a	15.95d	6629,47a
Temperature of 50°C, 6 hours	938.40b	18.06c	5196,01b
Temperature of 50°C, 7 hours	902.70bc	19.11c	4723,70bc
Temperature of 55°C, 5 hours	950.30b	17.42c	4555,22b
Temperature of 55°C, 6 hours	895.90bc	20.63bc	4342,70bc
Temperature of 55°C, 7 hours	873.80bc	22.32bc	3914,87bc
Temperature of 60°C, 5 hours	936.70b	18.70c	5009,09b
Temperature of 60°C, 6 hours	887.40bc	21.90bc	4052,05bc
Temperature of 60°C, 7 hours	863.60bc	24.65ab	3503,45bc
Temperature of 65°C, 5 hours	785.40cd	25.80ab	3044,19cd
Temperature of 65°C, 6 hours	761.60cd	27.70ab	2749,46cd
Temperature of 65°C, 7 hours	741.20cd	28.20ab	2628,37cd
Temperature of 70°C, 5 hours	746.30cd	27.93ab	2672,04cd
Temperature of 70°C, 6 hours	678.30d	33.56a	2021,16d
Temperature of 70°C, 7 hours	674.90d	34.09a	1979,76d

Description: The same notation is behind the mean in the same column show not significantly different at the level of 5% error

Table 1 also shows that 50 ° C with 5 hours of drying time to produce the greatest tensile strength of biodegradable plastics from cassava starch is modified with a value of 1057.40 M Pa, which is significantly different from the other. This value is higher if compared to the results of research Utomo, et al (2013) which make biodegradable plastics from starch aloe vera mixed with chitosan and dried at 80 ° C for 3 hours which has a value of tensile strength 104.648 M Pa, moreover when compared to the results of research Epriyanti et al (2016) which the value of tensile strength of 1.04 M Pa at a temperature of 50 ° C with a drying time of 6 hours. However, biodegradable plastics from cassava starch modified not meet tensile strength values based on international plastics standard (ASTM5336) for PLA plastic from Japan which has a value of 2050 M Pa but meet the plastic standards of the UK for plastic PC that have a value of 190 M Pa (Averous, 2009).

The smallest value of the mean elongation at break was 15.95% is indicated by a biodegradable plastic from modified cassava starch were dried at 50 ° C with 5 hours of drying time, which is significantly different from the other. This elongation value is smaller than the results Epriyanti et al (2015) which had the percent elongation value of 54.99% of the biodegradable plastic composite drying of cassava skin starch and chitosan at 50 ° C for 6 hours. Both value the according to the standard international plastics (ASTM5336) which has an elongation at break <500% for plastics PCL from England but not yet eligible for PLA plastic from Japan which sets the elongation of 9%.

Drying at 50 ° C with 5 hours of drying time also causes biodegradable plastic of cassava starch modified, has the mean of Young's Modulus of 6629.47 M Pa, this greatest value is significantly different from the other. It is far greater than the results Epriyanti et al (2016) which shows the Young's modulus of 0.019 M Pa for composite of biodegradable plastic of starch of cassava skin and chitosan were dried at 50 ° C for 6 hours.

3.2 Swelling of Volume and Time of Degradation

Analysis of variance showed that the temperature and drying time affect very significant on swelling of volume and time of degradation of biodegradable plastic from modified cassava starch. Table 2 shows the mean of swelling of volume and time of degradation from biodegradable plastic of cassava starch modified. The swelling of volume about 9.91 to 11.28% and 7-9 days for time of degradation of biodegradable plastic

Table 2. The mean swelling of volume and time of degradation of biodegradable plastic from cassava starch modified

Treatments	The Mean of Swelling Volume (%)	The Mean of Time Degradation (days)
Temperature of 50°C, 5 hours	9,91b	7,00b
Temperature of 50°C, 6 hours	9,96b	7,33b
Temperature of 50°C, 7 hours	10,03ab	7,67b
Temperature of 55°C, 5 hours	9,99b	7,33b
Temperature of 55°C, 6 hours	10,12ab	7,67b
Temperature of 55°C, 7 hours	10,44ab	8,00ab
Temperature of 60°C, 5 hours	10,12ab	7,67b
Temperature of 60°C, 6 hours	10,40ab	8,00ab
Temperature of 60°C, 7 hours	10,59ab	8,33ab
Temperature of 65°C, 5 hours	10,57ab	8,00ab
Temperature of 65°C, 6 hours	10,87a	8,33ab
Temperature of 65°C, 7 hours	10,93a	8,67ab
Temperature of 70°C, 5 hours	10,67a	8,33ab
Temperature of 70°C, 6 hours	11,07a	8,67ab
Temperature of 70°C, 7 hours	11,28a	9,00a

Description: The same notation is behind the mean in the same column show not significantly different at the level of 5% error

Table 2 shows that the drying temperature of 65°C with drying time of 6 and 7 hours and a drying temperature of 70 ° C with a drying time 5, 6, 7 hours, generating swelling of volume biodegradable plastic with the respective value of 10.87; 10.93; 10.67; 11.07 and 11.28%. This value significantly different and relatively greater than percent of the development of biodegradable plastic that is dried at 50 ° C with 5 and 6 hours, that its value 9.91 and 9.96%. These results are relatively lower compared to the results of research Utomo et al (2013), which has the mean of 41.23% for biodegradable plastic from mix of starch aloevera and chitosan.

Table 2 also shows that the biodegradable plastic of cassava starch modified dried at 70 ° C for 7 hours, degraded after 9 days, which is significantly different from the plastic biodegradable dried at a temperature of 50 ° C for 5, 6, 7 hours and a temperature of 55 ° C for 5, 6 hours and a temperature of 60 ° C for 5 hours. In addition there is a tendency that the higher the temperature and the longer the drying showed the biodegradable plastic for longer degraded. This is likely due to the drying temperature is higher, causing biodegradable plastic particles undergo much physicochemical change (Henrique et al, 2007). According Utomo, et al (2013), this causes the plastics structure are increasingly homogeneous and dense, so that the microorganisms difficult to disentangle the particles making up the biodegradable plastic. According to Suderman et al (2016), the drying temperature affects the rate of degradation. Low drying temperature will cause the speed of degradation of biodegradable plastic that is higher than on the drying temperature is high.

4. Conclusion

a) The temperature and drying time and its interaction with the use of automatic dryer cabinet by air flow discharge 5 $\pm$ 0.1 m3 / min, greatly influence the tensile strength, elongation at break, Young's modulus, swelling of volume and time of degradation of biodegradable plastic from cassava starch modified.

b) Temperature 50°C with 5 hours of drying time by using air flow 5 $\pm$ 0.1 m3 / min that use automatic dryer cabinet, produce biodegradable plastic from modified cassava starch at its best with the characteristics of tensile strength 1057.40 M Pa, elongation at break of 15.95%, Young's modulus of 6629.47 M Pa, swelling of volume of 9.91% and degradation time 7 days.

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