OPTIMIZATION OF MANUFACTURING OF BIODEGRADABLE PLASTIC STARCH JICAMA (PACHYRHIZUS EROSUS)

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ABSTRACT

The manufacture of biodegradable plastic from jicama starch with glycerol information and temperature (60°C, 70°C, 80°C, 90°C and 95°C) was carried out in this research which was got. Optimal temperature heating at 80°C. Characterization of biodegradable plastics was carried out through tensile test, DSC, FTIR, SEM and Atomic Force Microscopy (AFM). Biodegradable plastics show elastic tensile strength properties. Temperature rises (Tg) onset + 256°C and midpoint + 272°C. The results of SEM before and after degradation on the soil indicate that biodegradable plastic is easily degraded by microorganisms in less than one week.

Keywords: Biodegradable plastic, Jicama, temperature effect

Introduction

Lately the research process on biodegradable plastics has become an attraction for world researchers. So far it has been restored by the need for the environment that was previously from fossil fuels. On the other hand, high prices for crude oil and agricultural materials that can be used to develop the economy in the biodegradable industrial sector and provide a better alternative for future development [1]. The nature of biodegradable plastics or easier to decompose from inorganic plastic. Plastic that can be used by the soil, takes a long time to break down by microorganisms. Biodegradable plastic is a renewable thing to replace non-degraded plastic [2] [3]. Biodegradable plastic base material is usually derived from biological materials such as palm sugar starch [4], cassava starch / flour [5], rice starch [6], banana [7], durian seed starch [8], potato starch [9] [10] and even from protein [11] [12]. Other biodegradable plastics are made from extracted avocado seed starch, then the function of avocado-chitosan seed starch and biodegradable plastic temperature and varied [13]. Whereas protein is also developed from eggs as plasticizers and glycerol [14] [15]. These biological sources contain polymers, can be converted into plastic and are usually called biopolymers. Starch is a biopolymer that is in nature and easy to obtain [16]. Biopolymers often have low properties compared to commodity polymers. One technique is a considerable combination in the resistance of fragile polymers [17]. Addition of plasticizers is needed for starch films, such as glycerol dates. This is as a thermoplastic material which is based on fragile properties, especially at high humidity and is therefore mostly mixed with synthetic. Biodegradable plastics can be applied at the film industry level with blown manufacturing techniques, injection molding, blow molding, and extrusion applications [18] [19] [20].

In this study reported the manufacture of biodegradable plastics from jicama starch (Pachyrhizus erosus), (reference to the effect of temperature on the heating process) Jicama is a white tuber and contains fiber. Jicama is widely found in West
Sumatra. Jicama has a different form of starch granules that are similar to corn starch (round and polygonal), granular size ranging from 3-35 μm, has a low amylopectin content and relatively higher crystallinity. Jicama is a family of Leguminosae, a subfamily of Papilionoidea [21] [22] [23]. Biodegradable plastic from jicama starch is an interesting base material to study. The biodegradable plastic that was formed was tested for its characteristics by Tensile Strength Test, DSC Test, FTIR, SEM and Atomic Force Microscopy (AFM).

**Material and Methods**

Materials and equipment used in this study are starch derived from bengkoang tubers that grow in the city of Padang (Indonesia), glycerol 85% Merck Chemicals made in Germany as pemplastis, aquadest, juicer, shaker, Hot plate, glassware, magnetic stirrer, thermometer, analytical balance (Shimadzu), oven, Tensile strength was carried out with Universal Testing Machine (Instron 3366) according to ASTM D638, thermal test using Elmer 8000 Perkin DSC, functional group was analyzed by FTIR-Bruker Tensor 27 series spectrometer, surface morphology with SEM-EDX, JSM-6510LA, JEOL Japan, and topology characteristics using AFM NanoSurf, EasyScan 2.

Making biodegradable plastic environmentally friendly by dissolving 5 grams of starch with 100 mL of distilled water then stirring and heating on a hot plate with a speed of 500 rpm and variations in temperature of 60°C, 70°C, 80°C, 90°C and 95°C after that add glycerol. After cool, the solution is poured in a mold and dried in an oven. The experiment of making biodegradable plastic with heating temperature variations was carried out to determine the optimum temperature needed to produce biodegradable plastic from bengkoang starch with good mechanical properties. From the results of this experiment, tensile strength test, thermal properties analysis, functional group analysis, morphology and topology were performed to determine the characteristics of biodegradable plastic produced.

**Result and discussion**

Illustration of making biodegradable plastic by varying the heating temperature can be seen in Figure. Biodegradable plastic formation process In sample A with a temperature of 60°C with a weight of 5 grams of starch after being heated to more than 5 hours the solution showed no signs of thickening solution. Sample B with a weight of 5 grams was heated at 70°C. After being heated and reaching 4 hours the solution also does not coagulate perfectly where clots form in the solution. Whereas in the samples C, D and E with heating temperatures of 80°C, 90°C, and 95°C formed a thick solution. The time needed for the solution to start thickening in samples B, C and D after heating for 30, 20 and 15 minutes, respectively.
Biodegradable Plastic is not formed where biodegradable plastic is formed which has no air bubbles in it. Heating observations of heating temperature variations in the manufacture of biodegradable plastic is formed and there are not air bubbles. Heating observations of heating temperature variations in the manufacture of biodegradable plastic is formed and there are not air bubbles.

For more details, the conditions of heating temperature variations in making biodegradable plastic from bengkoang starch can be seen in Table 1.

Table 1: Observations of heating temperature variations in the manufacture of biodegradable plastics from jicama starch.

<table>
<thead>
<tr>
<th>Temperature variations (°C)</th>
<th>Heating time</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>&gt; 5 h</td>
<td>Biodegradable Plastic is not formed</td>
</tr>
<tr>
<td>70</td>
<td>4 h</td>
<td>Biodegradable Plastic is not formed</td>
</tr>
<tr>
<td>80</td>
<td>30’</td>
<td>Biodegradable plastic is formed and there are not air bubbles.</td>
</tr>
<tr>
<td>90</td>
<td>20’</td>
<td>Biodegradable plastic is formed and there few air bubbles.</td>
</tr>
<tr>
<td>95</td>
<td>15’</td>
<td>Biodegradable plastic is formed and there many air bubbles.</td>
</tr>
</tbody>
</table>

From the observations carried out in the study obtained good or optimum results in the manufacture of biodegradable plastic seen in sample C with a heating temperature of 80°C where biodegradable plastic is formed which has no air bubbles in it. Heating temperatures of 60°C and 70°C are used for a long time and do not produce biodegradable plastic. At a temperature of 90°C and 95°C can produce biodegradable plastic, it's just that there are air bubbles in the plastic. The possibility of this is caused by a high enough temperature during the manufacturing process so that the bubble of water molecules that are boiling does not evaporate completely.

**Mechanical Properties Test**

The analysis of the mechanical properties of the materials carried out in this study was the tensile strength test using tensile strength. Tensile strength testing will produce a stress-strain curve. The results of the tensile strength test analysis are presented in Figure 3.

Fig. 1: Warm-up photos with a temperature variant a) 60°C for > 5 hours, b) 70°C for 4 hours, c) 80°C for 30 minutes, d) 90°C for 20 minutes and e) 95°C for 15 minutes.
The graphic results of biodegradable plastic from jicama starch (Fig. 3) show the yield point at strain + 1.8% with stress or stress of +0.75 MPa. Whereas the break point on biodegradable plastic from jicama starch occurs at + 31.5% and +3.65 MPa. Based on this, it should be noted that biodegradable plastics from jicama starch are flexible, elastic and have high tensile strength (3.65 MPa). This value is lower than biodegradable plastic tensile strain obtained at an optimum temperature of 90 °C with a ratio of 7: 3 starch-chitosan to tensile strength of 5.096 MPa [13].

**Thermal Properties Test**

The thermal properties of biodegradable plastics can be done using DSC (Different Scanning Calorimeter) tools.

The results of DSC (Different Scanning Calorimeter) aim to determine the glass transition temperature (glass transition temperature, Tg) and melting point (melting point temperature, Tm). Glass transition temperature is the temperature at which the plastic changes its state and behavior from stiff, brittle, solid like a glass, to be flexible, soft, and elastic. From the DSC spectra of biodegradable plastic sheets from the bent starch in Figure 4 shows the glass transition temperature (Tg) onset at + 256°C and the glass transition (Tg) midpoint at + 272°C. This value is higher than the palm sugar...
biodegradable starch 242.14°C, the low value is due to the low concentration of glycerol [4].

FTIR analysis

FTIR analysis is carried out to determine the functional groups contained in starch. The specific peaks found in the biodegradable plastic test from jicama starch at wave number 3345.54 cm\(^{-1}\) indicate the peak of O-H; at wave numbers 2897.33 cm\(^{-1}\) and 2936 cm\(^{-1}\) showed the peak CH\(_2\), CH\(_3\); at wave numbers 1647.66 - 1364.11 cm\(^{-1}\) shows the peak of C-O, C = O and at wave numbers 1341.32 - 1022.10 cm\(^{-1}\) shows the peak of C-C-C. The results of functional group analysis with FTIR showed the presence of alcohol functional groups derived from the structure of glucose in starch, and glycerol and the presence of a C atomic bond which is a polymeric bond. This functional group is not much different from the biodegradable plastic functional group from plantain starch [7].

Figure 5. FT-IR Biodegradable plastic from jicama starch

Biodegradation Test

Testing of the degradation of the Javanese starch biodegradable starch was done using SEM (scanning electron microscope). SEM testing was carried out to see the surface structure of biodegradable plastic from jicama starch produced after seven days in the soil. The surface structure can be a general description of the quality of mixing, the distribution of materials in plastic, and the estimated processes that occur in plastics.

Figure 6. SEM biodegradable plastic before degradation (A) and biodegradable plastic after degradation on soil (B).
SEM test aims to see the changes that occur to the morphology of biodegradable plastics before being degraded and after being degraded by microorganisms. Characteristics of biodegradable plastic based on morphology before being degraded by microorganisms, initially seen to have relatively flat surfaces with slightly homogeneous and non-porous forms (Figure 6A). After the degradation process, the plastic surface becomes kropos or porous. This analysis shows that there has been degradation of biodegradable plastics from jicama starch (Figure 6B). This analysis is in accordance with what has been described by Qureshi [26].

**Surface Topology Test**

![Surface Topology Test](image)

Figure 7. AFM test on the jicama starch biodegradable plastic at 80°C

One of the most important characteristics of images obtained by scanning AFM is the 3D geometry of objects that allows detailed analysis of morphology as long as the sample profile is drawn and performs morphometry [24] [25]. The jatropha biodegradable plastic visualized by scanning AFM is as follows: length 17.46 μm, width 11.24 μm, and height 239.2 μm. Ultrastructure of the surface represented by globular formations of the same type. Topography scans depict the shape of a surface in nanometer size that illustrates the presence of peaks that are still not flat with uniform brightness. Analysis of the developmental level of aid using the mean parameters of square roughness showed that the surface of the biodegradable plastic material based on the jicama starch was a uniform texture with a Sq value of about 0.33 μm.

**Conclusion**

Temperature greatly affects the shape and performance of biodegradable plastics. The optimum temperature of heating on the formation of the jicama starch biodegradable plastic is at 80°C. Tensile strength properties show elastic plastic with a strain ability reaching + 31.5%, yield point occurs at stress (0.75 MPa) and breaking point occurs at stress (stress) 3.65 MPa. Thermal properties showed that the plastic had glass transition temperature (Tg) onset + 256°C and midpoint + 272°C. SEM results show that biodegradation has occurred in plastics with the formation of pores on biodegradable plastics. Topography scans using AFM equipment illustrate the shape of the surface in nanometer size which illustrates the presence of peaks that are still not flat with uniform brightness.
References


