

# Review: Natural Material Polymers As A Substitute for Synthetic Polymers

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**Abstract:** The environmental problem from the manufacture of plastic waste has become an important problem because it is difficult to decompose. Therefore, it is necessary to make efforts to replace oil sources with plant materials as raw materials for polymers so as to produce plastic manufacturing technologies made from natural materials that can be degraded in a short time, namely in the form of bioplastics. Starch is one of the natural polymers that can be used for the production of bioplastic materials because it is easily degraded, but this bioplastic has disadvantages such as being hydrophilic. The method for making bioplastics from starch can use cassava starch and sweet potato starch. The process of making bioplastics is carried out with the stages of mixing, heating, stirring, printing, and drying. In addition to the basic ingredients of starch used, it is necessary to add plasticizing agents such as glycerol and other additives. In the manufacture of bioplastics from cassava starch, two variations were carried out, namely cassava starch as a basic ingredient, glycerol, water, acetic acid and a second variation with the same combination with the addition of alcohol as a comparison. Characterization of bioplastics in cassava starch includes surface observations using SEM, crystallinity using XRD, determination of functional groups using FTIR. The characterization results show that bioplastics in combination with the addition of alcohol have a high degree of degradation. According to the XRD analysis, this combination has a low crystallinity value. The results of FTIR analysis showed the presence of CH Alkanes, C =O Esters, and CH alkenes functional groups. While SEM shows a flat surface. Whereas in the manufacture of bioplastics from sweet potato starch as a base material, glycerol plasticizer, chitosan, acetic acid, and distilled water, the test analysis includes mechanical tests of tensile strength and elongation. The effect of adding the concentration of glycerol plasticizer and the effect of adding the concentration of chitosan reinforcer on the mechanical properties of bioplastics showed opposite properties between tensile strength and elongation. The result of the addition of glycerol concentration causes a decrease in the tensile strength value. While the results of the addition of chitosan concentration led to an increase in the value of tensile strength.

**Keywords:** Bioplastics, Starch, XRD, SEM, FTIR.

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## Introduction

In everyday life, most of us use plastic materials. The use of plastic has spread to almost all areas of life. Most of the items needed, such as electronic equipment, household equipment, to food and beverages, use plastic as packaging because it is light, strong, easy to shape, and affordable (Mahalik and Nambiar 2010). Polymer is a type of material that is formed by a polymerization process which is the process of combining several simple molecules called monomers through a chemical process into more complex molecules

(Kumar, 2011). Polymers are divided into two parts, namely natural polymers and synthetic polymers. Synthetic polymers are polymers made from chemicals and the materials are non-renewable. Meanwhile, natural polymer materials are polymers made from natural materials and the materials can be renewed so that they can be degraded faster than synthetic polymers (Coniwanti, 2014). Plastic material is widely used because it has superior properties such as lightness, transparency, water resistance, and the price is relatively cheap. The plastics that we usually use are synthetic polymers made by humans including

types of plastic, synthetic rubber, and synthetic fibers and are made from chemicals that cannot be degraded by microorganisms in the environment. The inability of microorganisms to decompose this material has a negative impact which can pollute the environment due to the accumulation of plastic waste (Tokiwa et al. 2009). Synthetic polymers which are The main body of plastic will be degraded in time tens or even hundreds of years. If burned, the plastic will carbon emitters that pollute the environment (Gironi and Piemonte 2011). So research is needed to produce plastic packaging materials that are environmentally friendly, namely by producing technology for making plastic from natural materials that can be degraded in a short time which is known as bioplastic or biodegradable plastic and one of the ingredients for making bioplastics that is often used is starch (Coniwanti et al. 2014; Yuniarti et al. 2014; Susanti et al. 2015).

In the manufacture of starch-based bioplastics, there are drawbacks to plastics, namely having low mechanical properties and being hydrophilic. The way to overcome this deficiency is by mixing starch with other biopolymers such as glycerol and sorbitol (Lazuardi and Cahyaningrum, 2013). Bioplastics with glycerol plasticizers have smooth fractures and small cavities (Ginting et al., 2015). From the problems above, this article aims to review plastics made from natural polymer materials so that they can be degraded faster than the plastics we usually use or are called conventional plastics.

### Materials and Methods

In this review, the journal explains quotations regarding natural polymers as substitutes for synthetic polymers. The journal reviewed is entitled Production and Characteristics of Biomass-Based Bioplastics with Glycerol Plasticizers and Studies on Making Alternative Biodegradable Plastic Materials from Sweet Potato Starch with Glycerol Plasticizers with the Melt Intercalation Method .

### Production of Bioplastics from Cassava Starch

In the first journal, the process of making bioplastics from cassava starch was carried out with two treatments, the first treatment used 50 grams of cassava starch, 25 ml of glycerol, 25 ml of acetic acid and 50 ml of water. Whereas in the second treatment the ingredients used were the same as the first variation but added with 25 ml of alcohol. The stages of making bioplastics on cassava starch use 5 stages, namely mixing, heating, stirring, printing and drying. The first stage is mixing all the ingredients and putting them in the pan. Then it is heated using a stove with a temperature of 80°C and stirred with a stirring spoon. The heating and stirring stages are carried out until the liquid thickens to resemble glue. Then the mixture is cooled for a while then enters the printing stage, so the mixture that was cooled earlier is printed on a wooden board which has an aluminum foil backing. The next process is drying, the bioplastic mold will be dried in the sun. After drying, remove the plastic from the mold. The process was repeated for the second treatment. So the composition of the second treatment is the same as the first treatment. But the difference is added 25 ml of alcohol, its function is as a comparison (Engellita et al., 2020).

### Making Bioplastics from Sweet Potato Starch

second journal, the process for making bioplastic is the same as in the first journal, there are 5 stages, namely mixing, heating, stirring, molding, and drying. There are two concentration variations in the manufacture of sweet potato starch bioplastics, namely the process of making bioplastics with variations in glycerol concentrations and the manufacture of bioplastics with variations in chitosan concentrations . The first step is mixing , by mixing 2% chitosan with glycerol , the mass variations are 0.5%, 1% and 1.5% . The addition of glycerol serves to give a higher solubility to the plastic film compared to sorbitol. This bioplastic with glycerol plasticizer has a smooth fracture and small cavities. Then add 100 ml of water, 1% acetic acid into the mixture so that the chitosan dissolves completely. Then 5 grams of sweet potato starch is added, then proceed to the heating stage with a temperature of 80-90°C, set aside for 5 minutes to

avoid bubbles on the plastic. The next step is printing by pouring the stirred mixture into a 20×20 cm mold. The drying stage is carried out using an oven with a temperature of 40-50 °C for 5 hours . And leave it at room temperature until the mixture can be released from the mold. The process of making bioplastics with variations of chitosan was carried out by mixing 2% glycerol with chitoson with variations in mass of 1%, 2% and 3% . The steps are the same as before using the stages of mixing, heating, stirring, printing, and drying. Both of these journals have the same steps in the process of making bioplastics but differ in the tools used and also the materials, even though they use the same materials such as starch, glycerol, acetic acid, and water but there are differences , namely in chitosan and plasticizer. while the tools used in the first journal use manual methods while the second journal uses sophisticated tools (Samsul et al.,2017).

#### Characterization of the manufacture of cassava starch bioplastics

In the first journal there is a characterization of SEM, XRD and FT-IR. So the finished bioplastic is cut into small pieces with a size of 2×2 cm for testing. The first analysis was to study the surface morphology of cassava starch bioplastics using SEM (Scanning Electron Microscope) which aims to determine the surface structure, cracks, surface smoothness of the bioplastics produced. The second test is to analyze the crystal structure of starch in bioplastics which was carried out using the X-ray diffraction method in the X-Ray Diffraction (XRD) Test, X-ray diffraction of bioplastics was analyzed using an XRD type Philips X'Pert-Pro X-ray Diffractometer, this method was carried out with the aim of knowing the structure of the materials that make up bioplastic composites. And finally, the FTIR test aims to determine the functional groups of compounds contained in biodegradable plastics (Engellita et al., 2020).

#### Testing of Sweet Potato bioplastics

Analysis of the manufacture of bioplastics in sweet potatoes includes mechanical tests such as tensile strength and elongation. The tensile strength and

elongation tests consist of testing the concentration of glycerol as a plasticizer and testing the concentration of chitosan as a reinforcement. The effect of the addition of the concentration of glycerol plasticizer on the mechanical properties of bioplastics shows the contrast between tensile strength and elongation. The tensile strength value of bioplastics shows the opposite to the elongation value of bioplastics. The addition of glycerol concentration causes a decrease in the tensile strength of the bioplastic and an increase in the elongation value. While the influence of the addition of chitosan concentration increased the value of tensile strength and decreased value of elongation (Samsul et al.,2017).

## Results and Discussion

#### Production of Bioplastics from Cassava Starch

The results of the manufacture of bioplastics from cassava starch in two treatments namely (cassava starch, glycerol, water, acetic acid) and (cassava starch, glycerol, acetic acid, water and alcohol) . Seen in Figure 1, the result is only a slightly light brown sheet, transparent and elastic, and also light. While seen in Figure 2 is the overall bioplastic results.



Figure 1 . Plastic Film Sheets



Figure 2 . Bioplastic Results

#### Surface morphology analysis

Scanning Electron Microscope (SEM) is a type of electron microscope that produces an image of a sample by scanning a surface with a focused beam of electrons with magnification up to a certain scale. SEM testing is carried out to determine the shape and surface structure of bioplastic samples such as cracks, or the surface smoothness of the bioplastics produced (Siregar 2009). On the results

of the SEM (Scanning Electron Microscopy) test, a comparison was obtained between the two treatments, namely the treatment without using alcohol and the treatment using alcohol (cassava starch, glycerol, water, acetic acid) and (cassava starch, glycerol, water, acetic acid, alcohol). Both have differences in the results of the analysis of the surface morphology of bioplastics. The first treatment that did not use alcohol showed that the surface structure was not dense, there were cracks, and white lumps occurred which did not dissolve completely, resulting in cracks because in the first treatment the cassava starch which was not added alcohol used the manual method so that the stirring process used a spoon. stirrer so that when the stirring process is less homogeneous compared to the process of stirring cassava starch with the addition of alcohol using modern tools or sophisticated tools, using a stirrer so that when stirring it is more homogeneous than using a manual tool using a stirring spoon. Because it is less homogeneous or does not completely dissolve, it causes lumps to form. Meanwhile, the treatment using alcohol showed a homogeneous surface morphology and no cracks or smooth and no pores (Engellita et al., 2020).

### Functional Group Analysis of Bioplastics

FTIR testing is a tool used to determine the functional groups of compounds contained in biodegradable plastics. the two treatments in the manufacture of bioplastics from cassava starch, namely the treatment that does not use alcohol (cassava starch, glycerol, acetic acid, water) and the treatment that uses alcohol (cassava starch, glycerol, acetic acid, water, alcohol) both have similarities between the spectra the bioplastic (Engellita et al., 2020). The results of the FTIR test analysis showed that absorption at  $2966.52 \text{ cm}^{-1}$  occurred in the range  $2850\text{-}2970 \text{ cm}^{-1}$ , the result was a CH Alkane group (Radiyah, 2015). And in the group that is seen in the absorption of  $1050\text{-}1300 \text{ cm}^{-1}$  occurring in the range of  $1000\text{-}1300 \text{ cm}^{-1}$  to the power of  $-1$  the results show the CO Ester group so that the plastic can be degraded (Siregar, 2009).

FT-IR (Fourier Transform InfraRed) is a method performed using infrared spectroscopy. In infrared

spectroscopy, infrared radiation is passed through the sample. The sample was prepared in a plastic form with a size of  $5 \text{ cm} \times 5 \text{ cm}$ , then the sample was inserted into the Frontier FTIR spectrometer and an FTIR spectral graph was obtained for identification.

### Diffraction (XRD) Data analysis

Analysis of the starch crystal structure of bioplastics was carried out using the X-ray diffraction method. X-ray diffraction (XRD) of bioplastics was analyzed using a Philips X'Pert-Pro X-ray Diffractometer type XRD, operated at a voltage of 40 kV and a current of 30 mA. The diffraction pattern was measured between  $2\theta = 10.01^\circ$  to  $89.99^\circ$  with a scanning rate of  $20^\circ$ . The results obtained were processed using Microsoft Excel and presented in graphical form to see the pattern of each sample (Harry et al., 2016).

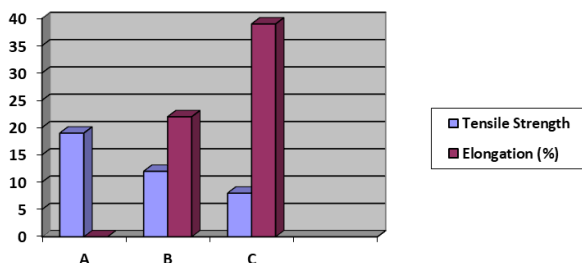
XRD analysis is a rapid analysis technique including phase formation, as well as quantitative analysis of its crystal structure, which is used to identify the phases of crystalline materials. The material being analyzed can be in the form of solid materials (especially those with a crystalline structure) in the form of powder or flour. The results of this XRD analysis show an amorphous and crystalline material. So cassava starch is a material consisting of crystal units and amorphous units (Greenwood 1997). Analysis of the XRD test is to determine which of the two treatments (cassava starch, glycerol, acetic acid, water) and (cassava starch, glycerol, acetic acid, water, alcohol) is better for decomposing in a short time. Based on the crystallization value (cassava starch, glycerol, acetic acid, water, alcohol) it has a lower value than the treatment that does not use alcohol at an angle of  $20.35^\circ$ . This shows that in the manufacture of bioplastics from cassava starch using the addition of alcohol will be better than not using alcohol so that the decomposition time or the decomposition process will be faster because it has a low crystallization value (Engellita et al., 2020).

### Results of Tensile Strength and Elongation of Sweet Potato Starch Bioplastics

On journal second there is test strong pull and elongation to influence glycerol concentration as

well as test strong pull and elongation to influence chitosan concentration. The tensile strength value is the maximum pull that can be achieved until the plastic can survive before the plastic is broken or torn (Syaichrurrozi et al., 2012). The function of the tensile strength value is to find out how well this plastic is resistant when pulling occurs (Bourtoom, 2007). The role of glycerol as a plasticizer is to make the film surface smoother, increase flexibility, and increase the ability of edible films or bioplastics. Edible film is a thin layer used to coat food (coating).

Elongation is the percentage change in length of the plastic when the plastic is stretched until it breaks. Elongation is carried out to determine the elongation ability of bioplastics, the higher the elongation value, the more bioplastic packaging more flexible and plastic (Nuansa et al., 2017). When the glycerol concentration is added, the tensile strength value will decrease and the elongation value will increase, while on the contrary, when the chitosan concentration is added, the tensile strength value will increase and the elongation value will decrease (Samsul et al., 2017).



**Figure 3.** Graph of the Effect of Glycerol Concentration as a Plasticizer on the Tensile Strength and Elongation of Bioplastics

Seen in figure 3, The picture above is a graph of the effect of glycerol concentration on the tensile strength and elongation of bioplastics. The glycerol concentrations obtained were 0.5%, 1% and 1.5%. The best tensile strength value was obtained at a glycerol concentration of 0.5%, namely 19.23. The best elongation value was obtained at a concentration of 1.5%, namely 39.16%, because the higher the elongation value, the more flexible the plastic packaging is.

**Table 1.** Effect of Glycerol Concentration as a Plasticizer on the Tensile Strength and Elongation of Bioplastics

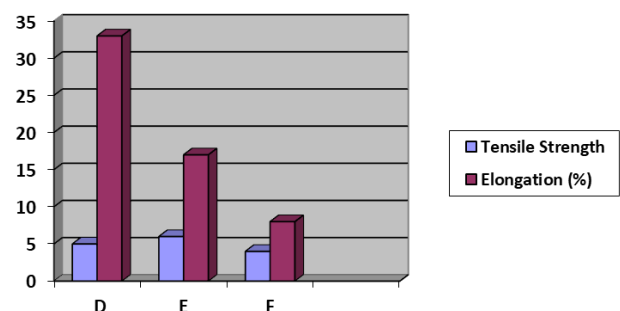
Glycerol Concentration	Tensile Strength Value	Elongation Value
0.5 %	19,23	-
1 %	11,58	21,66 %
1.5 %	8,83	39,16 %

## Discussion

Seen in table 1, there is a table of the effect of glycerol concentration as a plasticizer on the tensile strength and elongation of bioplastics. Glycerol plasticizer serves to increase elasticity by reducing the degree of hydrogen bonding and increasing the distance between the molecules of the polymer. Glycerol provides a high solubility compared to sorbital in starch-based bioplastics resulting in a smoother plastic surface and flexibility. (Bourtoom, 2007).

Shows the opposite property between tensile strength and elongation to influence addition concentration plasticizer glycerol to characteristic mechanic produced bioplastics. Thing this is shown with the addition of glycerol concentration causes an increase in the elongation value, namely at a concentration of 0.5% glycerol does not has an elongation value, 1% glycerol with an elongation value of 21.66% and glycerol 1.5% with score elongation 39.16%.

The addition of glycerol concentration causes a decrease in the tensile strength value. On score strong pull bioplastic show Thing opposite with score bioplastic elongation. So it decreases with increasing concentration glycerol. glycerol with concentration 0.5% have strong value pull of 19.23 MPa. The 1% concentration has a tensile strength value of 11.58 MPa, and the addition of 1.5% concentration has a tensile strength value of 8.83 MPa.



**Figure 4.** Graph of the Effect of Chitosan Concentration as a Strengthenener on the Tensile Strength and Elongation of Bioplastics

Seen in figure 4, The picture above is a graph of the effect of chitosan concentration on tensile strength and elongation. The chitosan concentrations obtained were 1%, 2% and 3%. The addition of chitosan concentration as a reinforcement will increase the tensile strength value and will decrease the elongation value. The best tensile strength value is obtained at a concentration of 2% chitosan, which is 5.60 Mpa and the best elongation value is obtained at a concentration of 1%, which is 32.62%, because the higher the elongation value, the more flexible the plastic packaging is. The addition of chitosan concentration as a reinforcement will increase the tensile strength value and will decrease the elongation value.

**Table 2 .** The Effect of Chitosan Concentration as a Strengthenener on the Tensile Strength and Elongation of Bioplastics

Chitosan Concentration	Tensile Strength Value	Elongation Value
1 %	4,90	32,62 %
2 %	5,60	16,60 %
3 %	4,22	8,35 %

## Discussion

Seen in table 2, there is a table of the effect of chitosan concentration as a strengthener on the tensile strength and elongation of bioplastics. Polymer raw materials can be utilized from plants, bioplastics are natural polymer materials as an alternative to plastic substitutes from synthetic polymers. Because it is made from natural materials that are environmentally friendly so it will degrade more quickly. Bioplastics can be produced from starch which is widely available in Indonesia such as cassava starch and sweet potato starch. The manufacture of bioplastics is relatively simple and the resulting products have characteristics similar to the types of plastic packaging that are commonly used.

Cassava starch bioplastic with the addition of alcohol is the best composition in terms of decomposition. Bioplastics with the addition of alcohol have a surface structure that is smooth and non-porous, the results of the FTIR analysis show the presence of CO ester groups so that they are

categorized as plastics that easily decompose. testing of sweet potato bioplastics on the addition of chitosan concentration caused a decrease in elongation value, namely at 1% chitosan concentration with an elongation value of 32.62%, 2% chitosan with an elongation value of 16.60% and 3% chitosan with an elongation value of 8.35%. and addition of chitosan concentration causes an increase in the tensile strength value, chitosan with a concentration of 1% has a tensile strength value of 4.90 MPa. The 2% concentration has a tensile strength value of 5.60 Mpa, and at a 3% concentration the tensile strength value decreases to 4.22 MPa. the best tensile strength value at 2% chitosan concentration was 5.60, while the best elongation value at 1% chitosan concentration was 32.62%. Changes in the mechanical properties of bioplastics with chitosan reinforcement are caused by the influence of the amount of reinforcement used.

There are two treatments for making bioplastics from cassava starch, namely the treatment that uses alcohol and the treatment that does not use alcohol. Making bioplastics from cassava starch using the addition of alcohol will be better so that the decomposition time or decomposition process will be faster because it has a low crystallization value. Whereas in the manufacture of bioplastics from sweet potato starch it is more optimal to use chitosan concentrations compared to glycerol concentrations.

## Conclusions

The best mechanical properties of the tensile strength values at various concentrations of glycerol were obtained at a concentration of 0.5%, namely 19.23 MPa, while the best elongation values were obtained at a concentration of 1.5%, namely 39.16%. The mechanical properties of the best elongation value at the chitosan concentration were obtained at a concentration of 1%, namely 32.62% because the higher the elongation value, the more flexible the plastic packaging is and the best tensile strength value at the concentration of chitosan is at a concentration of 2%, namely 5.60 MPa. While the more chitosan concentration added, the tensile strength value will increase from 1% concentration

to 4.90 MPa and 2% concentration to 5.60 MPa but at 3% concentration the tensile strength value does not increase or decrease to 4.22 MPa. This is because during the stirring and heating process on the stirrer the bioplastic solution is very viscous compared to the previous concentration so that when stirring the bioplastic solution it will be difficult to stir and it becomes less homogeneous. In the printing process, bioplastic solutions are also difficult to print because the solution is very viscous and the heating and drying processes will affect the mechanical and morphological properties of bioplastics.

The process of making bioplastics in cassava starch and sweet potato starch is more optimal for making sweet potato starch bioplastics because in the manufacturing process it uses modern tools such as the stirring stage using a stirrer and the drying stage using an oven while in the manufacture of cassava starch bioplastics using manual tools, such as in the drying stage. stirring using a stirring spoon and the drying stage using the help of sunlight.

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