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EFFECT OF SORBITOL AND STARCH MASS ADDITION ON BIOPLASTIC QUALITY

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ABSTRACT

In this modern human life, everyday life cannot be separated from the use of plastic. Starting from fulfilling primary needs such as food and beverage packaging to other tertiary needs. The use of plastic causes plastic waste to spread everywhere. Plastic waste generally comes from materials such as polyethylene (PE), polypropylene (PP) and polyvinylchloride (PVC) which cannot be broken down by microorganisms and are toxic to the body. This study aims to overcome conventional plastic waste which is increasingly polluting the environment and has an impact on health. Therefore, it is necessary to seek various methods of making plastics by utilizing polymeric materials because polymers are biodegradable and nontoxic. For this reason, researchers use natural polymer base material tapioca starch as a bioplastic and sorbitol as a plasticizer. There were 10 samples where the composition of tapioca starch consisted of 10 grams and 12 grams with a sorbitol ratio of 1 ml to 5 ml for each sample. The relationship between material variables can affect the results, this is determined by the most appropriate ingredient composition. From the results of this study, it has been proven that the water absorption test yielded 20% in sample 7, namely with a variation of ingredients between 12 kg of tapioca starch and 2 ml of sorbitol showing the best water absorption capacity compared to the other 9 samples, the degradation test yielded 26.5 %, and bioplastics grown in humus soil produced plastic films which degraded completely within 14 days. If the addition of sorbitol plasticizer is not in accordance with the composition of the starch compound needed, it will result in a bioplastic surface (morphology) that is not as desired.

INTRODUCTION

The need for plastics in the world in general and in Indonesia has increased sharply in line with the increase in people's consumption power for their needs. Almost all aspects of needs in everyday life use plastic as packaging. Plastic is ubiquitous, and it is a serious global problem for nature, human health, society, and the global economy

(Baghi et al., 2022; Cahyana et al., 2023). Plastic pollution causes harmful effects on water systems, soil conditions and air quality. Bioplastic production has increased in recent years. These negative impacts can be reduced by replacing conventional plastic base materials with materials that are easily decomposed, which are called biodegradable plastics (bioplastics). Other benefits of bioplastics are obvious, such as reducing the amount of plastic waste. Around 2.1 million tons were produced in 2019, according to Bioplastics Europe, and this number is expected to increase to 2.4 million tons around 2024. The biodegradable and non-biodegradable parts account for 58.1% and 41.9% of the total, respectively. bioplastic (Dermawan et al., 2020). Indonesia is known as an archipelagic country with a population density that is directly proportional to the output of the population in the form of waste. Most of the waste generated by residents is plastic waste. As a result, plastic pollution has become one of the most critical environmental problems.

One of the materials that can be utilized as a material for makingbiodegr adable plastics is starch because starch is a natural polymer that easily decomposes. Starch is a promising material for plastic materials because it is universally renewable, and affordable (Zulnazri et al., 2019). The properties of plastic that are not easily damaged and elastic make plastic used for various purposes, such as packaging for food, beverages, household appliances, office plastic, making it the right choice for various needs. Starch is formed by large glucose units joined by glycosidic bonds with the chemical formula (C6 H~ 10 O5~) n. It is the most common carbohydrate in the human diet. Native starch consists of two types of glucose polymers, namely amylose and amylopectin, and is produced by most green plants, including maize, wheat, potato, rice, and cassava, etc., contributing to 80% of the total starch production (Rozikhin et al., 2020; Nafiyanto, 2017; Kamsiati et al., 2017). Starches are non-toxic, abundant, biocompatible and have good film-forming potential. Indeed, its polyhydroxy structure facilitates the modulation of its structural and functional properties through chemical or enzymatic reactions (Aripin et al., 2017). This great potential and other attractive advantages of starch, such as edible, readily available, low cost and biodegradable, make it a good choice for food packaging. Despite all these properties, there are some limitations to applying native starch for food packaging, such as water susceptibility, brittle mechanical behavior, poor barrier properties and trivial resistance to extreme processing conditions such as high temperature and shear in native forms. Several methods have been proposed to overcome this limitation. Using plasticizers such as glycerol or polyglycerol (Santoso et al., 2019; Dasumiati et al., 2019; Natalia & Muryeti, 2020) and other additives, such as cellulose, gelatin, chitosan, and citric acid, can enhance the functionality of starch-based biodegradable materials (Baghi et al., 2022).

Therefore, there is an urgent need to use alternative packaging materials to overcome this shortage. Thanks to many recent studies, biopolymers were introduced as biodegradable packaging materials to replace petrochemical materials (Cahyana et al., 2023; Pulungan et al., 2020). There are several factors that can affect the manufacture of biodegradable plastics, including drying temperature and drying time (Maulida et al., 2020; Abe et al., 2021). If the drying temperature is too high or the drying time is too long, the bioplastic particles can undergo changes in their physicochemical structure to become denser and more homogeneous. This inhibits microorganisms from decomposing the plastic constituent particles.

However, if the drying temperature is too low or the drying time is too fast, microorganisms can only decompose some of the bioplastic particles due to the unfinished structure formation (Pulungan et al., 2020). Several studies have reported that biodegradable plastic can be made from cassava starch and cassava peel flour (Nuryati et al., 2019; Dermawan et al., 2020). Previous studies found that the best biodegradable plastic products were made from 100% cassava starch due to optimal gelatinization capacity (Anita et al., 2013). Another study showed that the optimal yield of biodegradable plastic from cassava peel starch was obtained at a drying temperature of 50°C for 6 hours, giving a biodegradability rate of 51.18% (Pulungan et al., 2020).

For this reason, researchers aim to make bioplastics by utilizing natural polymer materials from tapioca starch as the basic material for making bioplastics and sorbitol as a plasticizing agent. This is because polymer materials are easily biodegradable and non-toxic. There were 10 samples where the composition of tapioca starch consisted of 10 grams and 12 grams with a sorbitol ratio of 1 ml to 5 ml in the order of each sample. Testing of mechanical properties is carried out through water absorption tests, degradation tests and surface tests (morphology) to determine the quality of bioplastics.

RESEARCH METHOD

A product that is produced includes materials and processes. In this study, the material used for the Pemberton process of biodegradable plastic consists of the main raw material being tapioca starch processed from cassava in the form of flour purchased from the nearest store, sorbitol as a plasticizer and plastic film as well as other supporting materials namely acetic acid and H2O (water) as the solvent.

Bioplastics made from tapioca starch with plasticizers sorbitol consisted of 10 samples, wherein samples 1 to 5 used a 10-gram starch composition while samples 6 to 10 had a composition of 12-gram tapioca starch with a ratio of sorbitol each between 1ml to 5ml. These samples include the following:

Table 1. Biodegradable Plastic Samples

Samples	Tapioca paste (gr)	Sorbitol (ml)	Comparison of Tapioca Starch with Sorbitol (gr/ml)
1	10	1	10:1
2	10	2	10:2
3	10	3	10:3
4	10	4	10:4
5	10	5	10:5
6	12	1	12:1

Samples	Tapioca paste (gr)	Sorbitol (ml)	Comparison of Tapioca Starch with Sorbitol (gr/ml)
7	12	2	12:2
8	12	3	12:3
9	12	4	12:4
10	12	5	12:5

Source: Data processed

The process of making biodegradable plastic is carried out in several stages, namely the material preparation stage, namely providing the materials needed in the process of making biodegradable plastic. At this stage, the first thing to do is to weigh 10 grams of tapioca starch. Furthermore, the processing stage, namely tapioca starch from the results of the scales, is dissolved in H2O solvent 25 ml of (water) with 1N concentration of 7 ml of acetic acid and 1 ml of sorbitol. After that, stirring is carried out simultaneously on a heater (electric stove) at temperature64ºC for 30 minutes. Then the next stage is the printing stage, which is to print on the printed glass and heat treatment in the oven at a temperature of 60ºC. After heat treatment is carried outer plastic that has been attached to the printed glass is left for 48 hours, storage is done at room temperature. The last stage is the plastic being removed from the mold so that testing is carried out. This experiment was repeated on different sample variations.

The resulting biodegradable plastic products are then subjected to mechanical testing in the form of water absorption testing, namely testing manually by dipping the sample into a water container and immediately observing it, testing for degradation is carried out by the samples were planted in humus soil media, after 14 days direct optical-visual observations were carried out and surface testing (morphology) using a Scanning Electron Microscopy (SEM) tool to determine the plastic film formed.

RESULT AND DISCUSSION

Water Absorption Test

Water absorption test as shown in the following graph. The results of relatively good water absorption were found in sample 7, namely the ratio between 12 kg of tapioca starch and 2 ml of sorbitol compared to the other 9 samples. Thus, it can be explained that there is an appropriate correlation between the mass of tapioca starch and the plasticizing agent sorbitol so that bioplastics with good water absorption results are obtained.

These results are the same as previous research conducted by Z. Anita et al., where the best mechanical properties were found in 12 grams of starch with 4 ml of glycerol having a tensile strength of 0.02122 MPa and percent elongation at break of 3.5%. The plastic film was degraded in the soil for 14 days, but the difference lies in not using chitosan.

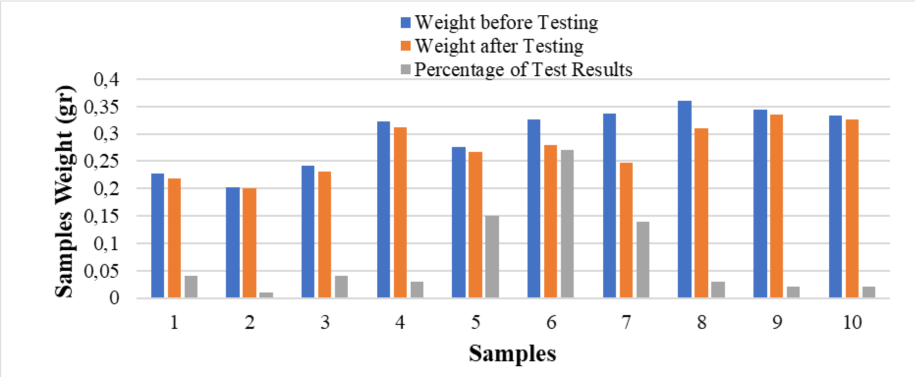

Figure 1. Graph Water Absorption Test

Degradation Test in Humus Soil Media

Tests for bioplastic degradation were carried out manually by planting samples in humus soil media. After 14 days, direct optical-visual observations were carried out on the samples. The results of the degradation test of bioplastics grown in degraded humus soil within a time span of 14 days are shown in Figure 1. Thus, the results of bioplastics made from natural polymers in the form of tapioca starch can be called environmentally friendly plastics (biodegradable plastics).

Figure 2. Degradation Test in Humus Soil Media

To determine the weight of degradation of bioplastic products, the samples were weighed first before planting in humus soil for 14 days, after which the samples were taken and weighed again to determine the percentage of degradation [23]. Plastic is cut with a size of 1 cm × 1 cm. The cut plastic is then weighed using an analytical balance. After that, the plastic was put into a 10 ml beaker filled with 5 ml of distilled water. The plastic is then weighed, and the water absorbed, and the water resistance of the plastic are calculated using the formula [24] :

$$\text{Weight of Water Absorption (W)} = \frac{W_i - W_0}{W_0} \times 100\%$$

Information:

W_i = final sample weight, W_0 = Initial sample weight

Water resistance of plastic = 100% (percent of water absorbed).

The percentage of degradation in each sample can be seen in the following table:

Table 2. Percentage of Degradation Results in Each Sample

Samples	Between Starch and Sorbitol (ml)	W_0 (gr)	W_i (gr)	Percentage (%)
1	10:1	0.2270	0.2189	4%
2	10:2	0.2013	0.1998	1%
3	10:3	0.2408	0.2309	4%
4	10:4	0.3217	0.3119	3%
5	10:5	0.2753	0.2668	15%
6	12:1	0.3264	0.2787	27%
7	12:2	0.3370	0.2478	14%
8	12:3	0.3598	0.3091	3%
9	12:4	0.3445	0.3350	2%
10	12:5	0.330	0.3255	2%

The results of the bioplastic degradation test in Figure 4.2 can be explained that there was a suitable variation of ingredients between tapioca starch and sorbitol and the perfect heating and stirring process so that a good degradation result was obtained within 14 days. From the results of this study, the plastic that was well degraded was sample 7, namely by varying the sample between 12 grams of tapioca starch and 2 ml of sorbitol.

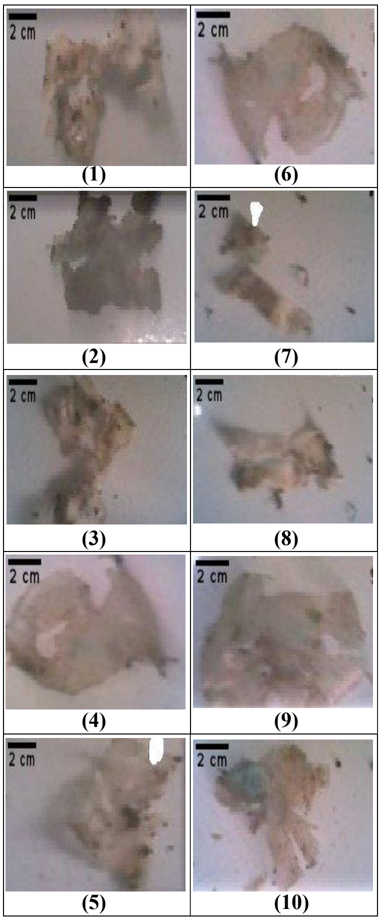

Figure 2. Bioplastic Degradation Results in Each Sample

Surface (Morphology) of Bioplastics Testing in Each Sample

Surface Testing (Morphology) of bioplastics aims to know the surface on the bioplastics formed. The results of the bioplastic surface (morphology) test with SEM consisted of two stages, namely the first stage with a sample order of 1 to 5. With a comparison of the composition of 10 grams of tapioca starch and 1 ml to 5 ml of sorbitol in each sample sequence. In the sequence of samples 1 to 5 the bioplastics are not completely gelatinized due to the presence of small air voids and quite large air cavities in the other samples which spread over all surfaces of the plastic film. This shows that the surface (morphology) of bioplastics is uneven because the product undergoes an incomplete mixing process and the formation of unbalanced materials.

The second stage is with a total sequence of 6 to 10 samples. Where the composition ratio of 12 grams of tapioca starch and sorbitol is the same as the first stage, namely 1 ml to 5 ml in each sample order. In sample 6 the plastic film still shows voids and white granules, while in sample 7 the surface (morphology) of the bioplastic looks even and smooth. Thus, it can be said that there is formation of the right composition between the ingredients accompanied by perfect mixing. In the sample of 8 plastic films, it is slightly visible that the surface shape (morphology) is almost perfect but there are still white grains. This indicates that the starch is not completely gelatinized. Meanwhile, in samples 9 and 10, the plastic films showed quite large air voids and quite a lot of white granules that formed an uneven and uneven surface (morphology) of bioplastics due to the influence of the improper composition formation as previously described.

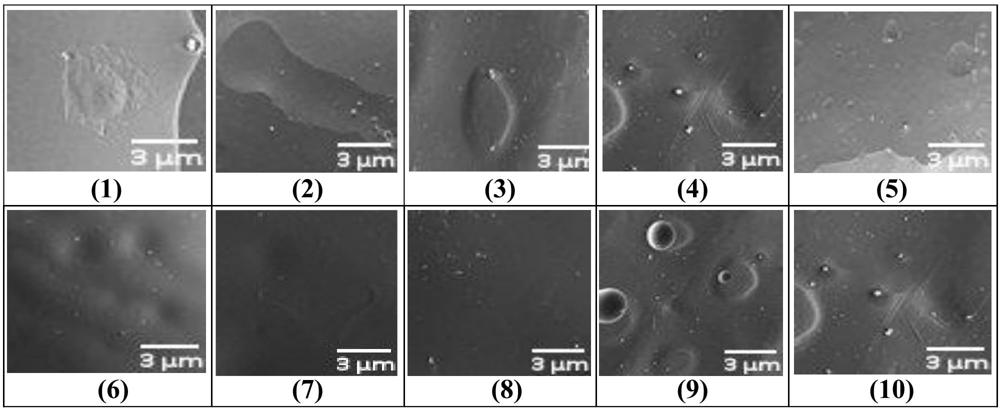

Figure 3. Surface (Morphology) of Bioplastics Testing in Each Sample

CONCLUSION

From the results of research on the manufacture of biodegradable plastics made from natural polymers in the form of tapioca starch compounds or bio cellulose and a supporting material, namely sorbitol as a plasticizer. Plasticizers work by forming polymer chain bonds so that the gelatinization process occurs. The gelatinization process occurs during a homogeneous heating and stirring process to obtain a thin, smooth bioplastic surface (morphology). The variation of sorbitol plasticizer in each sample, from sample 1 to 10 with 10 grams or 12 grams of tapioca starch as raw material, lies in the working system of the plasticizer itself. A plasticizing agent called sorbitol can work by forming polymer chain bonds (tapioca starch) to form biodegradable plastics. The addition of sorbitol as a binder or plasticizer influences the formation of a thin smooth bioplastic surface (morphology).

The results of this study were tested for the quality of bioplastics in the form of a water absorption test yielding 20%, found in sample 7, namely the material variation between 12 kg of tapioca starch and 2 ml of sorbitol showed the best water absorption compared to the other 9 samples, the degradation test yielded by 26.5%, and bioplastics grown in humus soil produced plastic films that were well degraded in a span of 14 days. This result can be proven by visual observation (direct observation) on bioplastic films and surface tests (morphology) found in sample 7, namely the material variation between 12 grams of tapioca starch and 2 ml of sorbitol. The thin smooth surface (morphology) of bioplastics is called environmentally friendly plastics (biodegradable plastics). In future research, it is necessary to combine the basic ingredients of bioplastics with a balanced plasticizing agent to improve the surface of the bioplastic film (morphology) where there are still air cavities or plastic films that are not completely formed and need to be careful when mixing.

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