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# Local Resources, Global Impact: Crafting Bioplastics from Salak and Cassava in Indonesia

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**ABSTRACT**

**Purpose of the study:** The purpose of this study was to determine the effect of adding sorbitol and glycerol on the quality of bioplastics, as well as to determine the right formulation for making bioplastic starch from snake fruit and cassava seeds.

**Methodology:** The method used was a Completely Randomized Design (CRD) with two factors, namely the addition of the first factor of sorbitol (1, 2, and 3 mL) and the second factor of glycerol addition (1, 2, and 3 mL), each experiment was repeated three times. The data obtained were analyzed using the analysis of variance test at a significant level of 0.05.

**Main Findings:** The variation in sorbitol and glycerol addition significantly affects the characteristics of bioplastics, as confirmed by a One-Way ANOVA test (sig. $< 0.05$), indicating distinct differences based on the type and amount of plasticizer used. Optimal formulations for bioplastics made from salak seeds and cassava starch include: highest water resistance (96.19%) with 2 mL sorbitol, optimal thickness (0.33 mm) with 1 mL sorbitol, greatest tensile strength (68.93 $kg/cm^2$) with 2 mL glycerol, and highest elongation (5.88%) with 3 mL glycerol.

**Novelty/Originality of this study:** This study contributes to the advancement of bioplastic development by utilizing salak seed and cassava starch as novel base materials. The resulting bioplastics offer the potential to serve as environmentally friendly alternatives to conventional plastics, with the key advantage of being biodegradable. This innovation supports efforts to reduce synthetic plastic waste, which is notoriously difficult to decompose.



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## 1. INTRODUCTION

Plastic has become a very popular material among Indonesian people because of its practical, lightweight, unbreakable, and affordable nature [1]-[3]. Almost all basic necessities, from electronics to food and beverages, use plastic packaging [4]-[6]. Sellers in traditional markets, households, and retail massively rely on this plastic packaging for their various needs [7], [8]. The convenience it offers makes plastic the main choice in people's daily lives [9], [10]. This shows how dominant plastic is in consumption and production patterns in Indonesia.

However, the popularity of plastic has a significant negative impact on the environment. Data from the Indonesian Olefin Aromatic and Plastic Industry Association (INAPLAS) in 2015 showed that plastic use in

Indonesia reached 17 kg per capita per year [11], [12]. If calculated with the population of Indonesia which reached 261 million people in the first semester of 2017, the total weight of plastic used reached 4.44 million tons each year. This fantastic figure reflects the volume of plastic waste that continues to increase. Therefore, finding a solution to reduce the burden of plastic waste is a must [13]-[15].

The very large amount of plastic and its non-biodegradable nature are serious problems for the environment [16]-[18]. The Ministry of Environment and Forestry even stated that plastic waste in Indonesia has become an international issue [19]-[21]. Indonesia itself is one of the countries that contributes the most plastic waste to the sea, worsening the condition of the aquatic ecosystem [22]-[24]. The indiscriminate disposal of plastic waste also causes blockages in water channels, accumulation at gates and river mouths, which can ultimately trigger flooding. This condition indicates an environmental emergency that requires immediate attention.

The negative impacts of plastic do not stop at water and soil pollution [25], [26]. Plastic waste buried in the ground takes tens or even hundreds of years to be recycled, because its synthetic polymers are very stable. In addition, burning plastic waste produces carbon emissions that can cause air pollution [27]-[29]. This damage is also in line with religious views, as stated in the Qur'an, Surah Al-A'raf verse 56, which prohibits destructive acts on earth. The Hadith of the Prophet Muhammad SAW also provides a strong warning against destructive behavior, emphasizing the importance of preserving the environment. All of this emphasizes the urgency of finding safer and more sustainable alternatives.

Realizing the serious impact of conventional plastics, research continues to be carried out to develop environmentally friendly alternatives [30], [31]. One of the innovative solutions that has emerged is bioplastic, a material made from natural and easily biodegradable materials [32], [33]. Bioplastics can be produced from natural polymers such as starch, cellulose, and fat [33]-[35]. Starch, in particular, is a very promising raw material because of its abundant availability in Indonesia [36]. Various tubers and cereals, including sago, corn, and cassava, are potential sources of starch for bioplastic production. The development of this bioplastic offers new hope for reducing dependence on synthetic plastics.

Salak and cassava seed starch are the focus of this research because of their great potential. Salak seeds, which are often not utilized, contain starch that can be extracted [37], [38]. Likewise, cassava, with its high carbohydrate and amylopectin content, is very suitable as a base material for bioplastics [39], [40]. Cassava starch has been widely used in the bioplastic industry in several countries, such as Thailand [41], [42]. This starch, when combined with a plasticizer, can form a stable film and has good mechanical strength. The utilization of agricultural waste such as salak and cassava seeds is in line with the principles of a circular economy.

Considering the research of Saputri et al. [43] which focuses on the characteristics of bioplastics from cassava starch reinforced with banana bunch cellulose, as well as the research of Blancia [44] which explores the potential of mango starch and snake fruit fiber as bioplastics, the research gap that emerges is the exploration of local Indonesian resources that have not been optimally explored. The research of Saputri et al. [43] uses cassava starch, which is also one of the raw materials in the current study, but the reinforcement used is different. Meanwhile, Blancia uses mango starch and snake fruit fiber which are not considered in the other two studies. Therefore, the current study fills the gap by combining cassava starch with the potential of snake fruit starch as the main raw material, and identifying synergies between the two to produce innovative bioplastics that are relevant to the Indonesian context. This allows for the development of more diverse bioplastics and has the potential to increase the added value of abundant local natural resources in Indonesia.

This research has significant novelty because it highlights the potential of local materials, namely salak and cassava, as alternative primary sources for making environmentally friendly bioplastics. Amid the increasing issue of plastic pollution globally, this research offers an innovative solution that not only focuses on reducing plastic waste but also supports strengthening the local economy through the utilization of abundant natural resources in Indonesia. The urgency of this research lies in the urgent need to present sustainable plastic alternatives, in line with global efforts to achieve the sustainable development goals (SDGs), especially in terms of industrial innovation, environmental management, and waste reduction. In addition, this approach also provides added value to the agricultural sector, thus encouraging the development of a circular economy based on local wisdom.

This study will specifically explore the use of snake fruit and cassava seed starch as raw materials for environmentally friendly bioplastics with the addition of sorbitol and glycerol plasticizers. The addition of plasticizers is very important to improve the mechanical properties of bioplastics, such as their hardness and flexibility. Sorbitol and glycerol were chosen because both are food additives that are permitted for use. By comparing the quality of bioplastic products produced from the use of sorbitol and glycerol, this study is expected to make a significant contribution to the development of more sustainable materials. The goal is to create bioplastics that are not only environmentally friendly but also have optimal performance for various applications.

## 2. RESEARCH METHOD

### 2.1. Research Design

The study used a Completely Randomized Design (CRD) with two factors [45], [46], namely: the first factor was the addition of sorbitol (1, 2, and 3 ml) and the second factor was the addition of glycerol (1, 2, and 3 ml), so that 18 treatment combinations were obtained, each treatment was repeated three times. The data obtained were analyzed using the analysis of variance test at a significant level of 0.05.

### 2.2. Research Tools and Materials

This research requires a series of special tools for each stage, from raw material preparation to final product testing. For the manufacture of snake fruit starch, we use a blender to smooth, a mortar to pound, and a sieve to separate the starch. The process of making bioplastic solutions and formulations involves instruments such as magnetic stirrers, ovens, analytical scales, bunsen lamps, and various volume measuring instruments such as measuring cups, flasks, and pipettes. For testing the characteristics of bioplastics, we will use a tensile strength machine type AND MCT-2150 to measure mechanical properties, a screw micrometer for thickness, and a flexi glass mold to form test samples. The main materials used in this study are cassava starch and snake fruit starch, which function as the main raw materials for bioplastics. To improve the mechanical properties of bioplastics, we will add sorbitol and glycerol as plasticizers [47], [48]. In addition, distilled water will be used as a solvent, and acetic acid will be included for pH adjustment purposes or as a catalyst in the synthesis process.

### 2.3. Research procedures

The research procedure is divided into four main stages: making salak and cassava seed starch, making starch solution samples, making bioplastic samples, and testing and characterizing bioplastics. Each stage is designed to ensure accurate and replicable results, in accordance with applicable scientific standards. The process of making salak seed starch begins with washing 1 kg of salak seeds thoroughly, followed by breaking the seeds using a special tool. Then, 445 grams of salak seeds are mixed with 2 liters of water and filtered using a filter cloth to separate the pulp and starch suspension. The pulp obtained is re-extracted with the same volume of water, and the filtrate is combined with the results of the first filtration. This starch liquid is then precipitated for 60 minutes, the sediment water is discarded, and the starch obtained is dried in the sun. The same procedure in parallel will also be applied to make cassava starch.

After the starch is available, the next step is to make a starch solution sample. A total of 5 grams of starch will be weighed, then mixed with 40 ml of distilled water and 10 ml of acetic acid. This mixing process is repeated for each variation of the solution to be tested, ensuring consistency in sample preparation. The bioplastic sample making stage begins by mixing the plasticizer (sorbitol or glycerol) into the prepared starch solution. This mixture is then heated on an electric stove while continuously stirring homogeneously to prevent clumping. Heating is continued until a homogeneous clear paste is formed, then the paste is continuously stirred to reduce the water vapor content. Finally, the ready bioplastic paste is poured into a glass mold to form a sheet. This procedure is repeated for each bioplastic formulation to be made.

Bioplastic testing and characterization are crucial stages to evaluate the quality of the resulting material, including water resistance, thickness, tensile strength, elongation, and biodegradability tests. For the water resistance test, a 1.1 $cm^2$ bioplastic sample was cut and weighed as the initial mass ($W_0$). Each sample was then immersed in distilled water for 10 seconds, lifted, placed on tissue, and reweighed (W) until its mass was constant. This test was conducted three times for each plasticizer sample (sorbitol and glycerol) to ensure data reliability.

The bioplastic thickness test was conducted according to the ASTM D638-02a-2002 standard using a micrometer screw with an accuracy of 0.01 mm. Measurements were taken at five different points: the center and four corners of the bioplastic. The final thickness value was obtained from the average of the five-point measurements. This test was repeated three times for each plasticizer variation.

The tensile strength test measures the maximum tensile force that can be withstood by the bioplastic sheet before breaking, according to the ASTM D638-02a-2002 standard. A 2 x 10 cm test sample was clamped on both sides for 1.5 cm, then tested using an AND MCT-2150 type tensile strength machine. This test was conducted three times for each sample. The elongation at break test measures the maximum increase in length of the bioplastic before breaking when stretched. Adding more plasticizer will generally increase the percentage elongation value. This test was conducted three times. Weight loss or biodegradability test is very important to assess the environmental friendliness of bioplastics, namely by observing the degradation time. Bioplastic samples measuring 5 cm x 1 cm were dried to constant weight ($W_0$), then planted in the soil for ± 7 days. After that, the sample was dried again and weighed to constant weight (W).

### 2.4. Data Analysis

Analysis of the experimental design table data on bioplastic characteristics using SPSS (Statistic Package for Social Science) version 22.0 with the One-Way-ANOVA method. If p is less than 0.05 then the treatment carried out has a significant effect. If p is more than 0.05 then the treatment carried out has no significant effect.

## 3. RESULTS AND DISCUSSION

The results of bioplastic testing in this study include water resistance, thickness, tensile strength, elongation and weight loss (biodegradability).

### 3.1. Water Resistance Testing

The results of the water resistance test design are as follows:

Table 1. Results of Water Resistance Experiment (%)

| | Plasticizer Volume (ml) | | |
|---|---|---|---|
| | 1 mL | 2 mL | 3 mL |
| Plasticizer | Water Resistance (%) | Water Resistance (%) | Water Resistance (%) |
| | 94.32 | 98.45 | 84.75 |
| Sorbitol | 85.69 | 92.87 | 73.59 |
| | 82.63 | 97.26 | 76.13 |
| Average | 87.55 | 96.19 | 78.15 |
| | 62.22 | 79.14 | 50.89 |
| Gliserol | 73.08 | 79.14 | 40.62 |
| | 70.14 | 81.00 | 61.06 |
| Average | 68.48 | 79.90 | 50.86 |

The average water resistance results are depicted in the following graph:

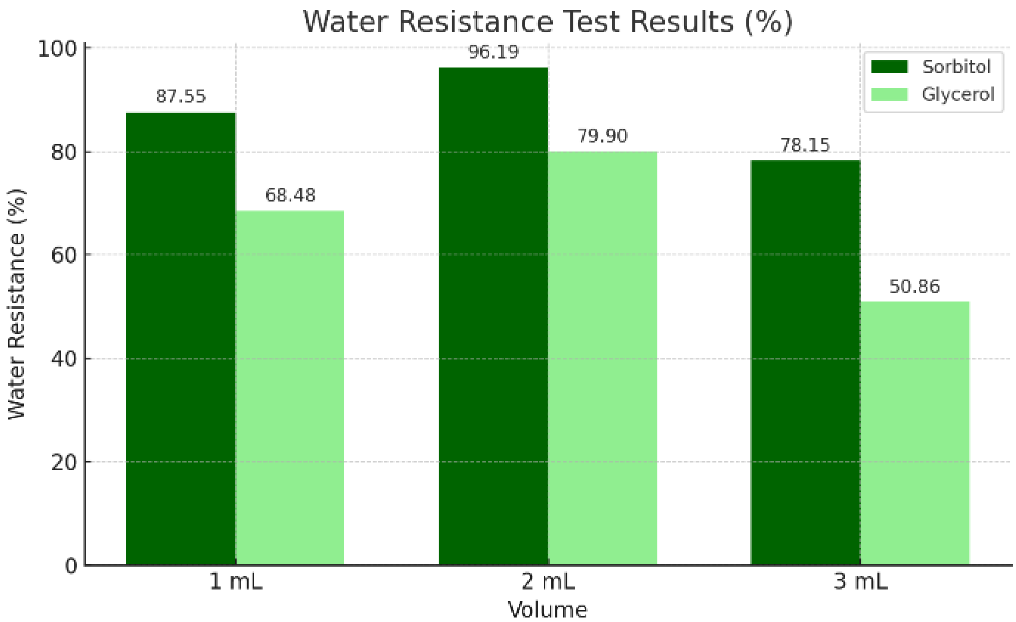


Figure 1. Water Resistance Test Results

Table 1 shows that the more plasticizer added, the more water absorption is done by bioplastic. The water resistance of a molecule is related to the basic properties of its constituent molecules. The starch material used in this study is hydrophilic and is also added with hydrophilic glycerol and sorbitol plasticizers, so the more plasticizer added, the more water is absorbed by the plastic. The water resistance of the use of sorbitol plasticizer, obtained the best water resistance at a volume of 2 mL of 96.19%. Water resistance in the use of sorbitol from a volume of 1 mL to 2 mL increased and decreased water resistance at a volume of 3 mL.

Plasticizers do make bioplastics more flexible, but the increasing free volume also increases the gaps that can be occupied by water molecules, so that at a volume of 3 mL the water resistance decreases. Bioplastics with sorbitol plasticizers have a higher water resistance value compared to glycerol plasticizers with the highest water resistance value.

### 3.2. Effect of Plasticizer Mixture on Thickness

The results of the thickness test design are as follows:

Table 2. Thickness Experiment Results (mm)

| | Plasticizer Volume (ml) | | |
|---|---|---|---|
| | 1 mL | 2 mL | 3 mL |
| Plasticizer | Thickness (mm) | Thickness (mm) | Thickness (mm) |
| | 0.30 | 0.25 | 0.15 |
| Sorbitol | 0.30 | 0.10 | 0.20 |
| | 0.40 | 0.20 | 0.20 |
| Average | 0.33 | 0.18 | 0.18 |
| | 0.30 | 0.10 | 0.10 |
| Gliserol | 0.20 | 0.20 | 0.20 |
| | 0.20 | 0.10 | 0.15 |
| Average | 0.23 | 0.13 | 0.15 |

The results of the average thickness values are depicted in the graph as follows:

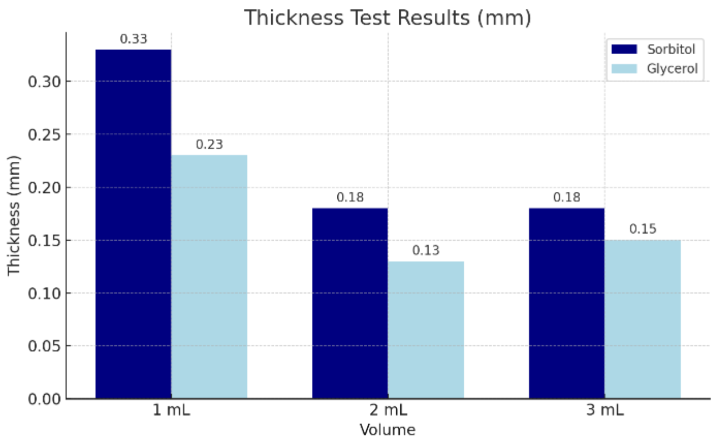


Figure 2. Thickness Test Results

Table 2 shows that with the addition of plasticizer mixture concentrations with different concentrations, the thickness varies. At a concentration of sorbitol plasticizer of 1 mL, it produces a thickness of 0.33 mm, then decreases, namely at a concentration of 2 mL to 0.18 mm, then remains at 0.18 mm at a concentration of 3 mL. At a concentration of glycerol plasticizer of 1 mL, it produces a thickness of 0.23 mm, then decreases, namely at a concentration of 2 mL to 0.13 mm, then increases to 0.15 mm at a concentration of 3 mL. It can be seen that in general, along with the addition of the concentration of the plasticizer mixture, the thickness produced also increases. Sorbitol plasticizer has an effect on producing a thicker bioplastic thickness than glycerol plasticizer. This condition is because the viscosity of sorbitol plasticizer is higher than the viscosity of glycerol plasticizer, so that bioplastics with a larger sorbitol composition produce thicker bioplastics. In addition, as the plasticizer concentration increases, the thickness of the bioplastic produced increases. The optimum condition is achieved at a variation of 2 grams of starch weight and 1.75 grams of sorbitol weight with a thickness of 0.197 cm.

### 3.3. Effect of Plasticizer Mixture on Tensile Strength

The results of the tensile strength test design are as follows:

Table 3. Results of Tensile Strength Experiment (kg/cm$^2$)

| | Volume Plasticizer (ml) | | |
|---|---|---|---|
| | 1 mL | 2 mL | 3 mL |
| Plasticizer | Tensile Strength (kg/cm$^2$) | Tensile Strength (kg/cm$^2$) | Tensile Strength (kg/cm$^2$) |
| | 31.67 | 36.59 | 56.42 |
| Sorbitol | 30.87 | 79.59 | 44.39 |
| | 25.63 | 43.37 | 43.88 |
| Average | 29.39 | 53.18 | 48.23 |
| | 34.97 | 81.00 | 78.13 |
| Gliserol | 51.00 | 50.26 | 50.51 |
| | 50.75 | 75.52 | 65.71 |
| Average | 45.75 | 68.93 | 64.57 |

The average tensile strength value results are depicted in graphic form as follows:

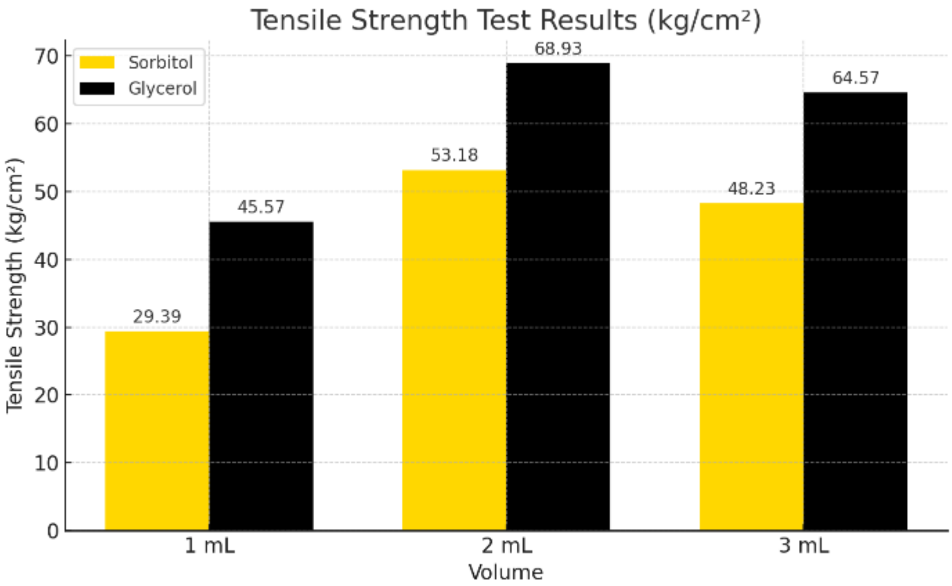


Figure 3. Tensile Strength Test Results

Table 3 shows that the addition of different concentrations of plasticizer mixtures produces varying tensile strengths. When the concentration of sorbitol plasticizer is 1 ml, it produces a tensile strength of 29.39 kg/cm$^2$, then increases at a concentration of 2 ml to 53.18 kg/cm$^2$, then decreases to 48.23 kg/cm$^2$ at a concentration of 3 mL. At a concentration of glycerol plasticizer of 1 ml, it produces a tensile strength of 45.57 kg/cm$^2$, then increases at a concentration of 2 ml to 68.93 kg/cm$^2$, then decreases to 68.93 kg/cm$^2$ at a concentration of 3 mL. It is known that in general, along with the addition of the concentration of the plasticizer mixture, the tensile strength decreases. This is because the plasticizer is able to reduce the energy required for molecules to move, as a result, its stiffness decreases and the tensile strength value also decreases. Plasticizers also have an impact on reducing molecular hydrogen bonds and the intermolecular attraction of adjacent polymer chains is weakened so that the breaking tensile strength decreases. Glycerol plasticizers have an effect on producing stronger bioplastic tensile strength compared to sorbitol plasticizers. The main components of starch are amylose and amylopectin. The molecular weight between amylose and amylopectin varies depending on the plant from which the starch is obtained. The levels of amylose and amylopectin contained in starch can affect the strength of the resulting bioplastic.

### 3.4. Effect of Plasticizer Mixture on Elongation

The results of the elongation experiment design are as follows:

Table 4. Results of Elongation Experiment (%)

| | Volume Plasticizer (ml) | | |
|---|---|---|---|
| | 1 mL | 2 mL | 3 mL |
| Plasticizer | Elongation (%) | Elongation (%) | Elongation (%) |
| | 1.75 | 1.70 | 3.25 |
| Sorbitol | 3.72 | 3.48 | 3.67 |
| | 3.22 | 3.02 | 4.67 |
| Average | 2.89 | 2.73 | 3.86 |
| | 3.55 | 3.33 | 5.00 |
| Gliserol | 4.77 | 4.75 | 6.33 |
| | 4.72 | 4.58 | 6.30 |
| Average | 4.34 | 4.22 | 5.88 |

The average elongation value results are depicted in graphic form as follows:

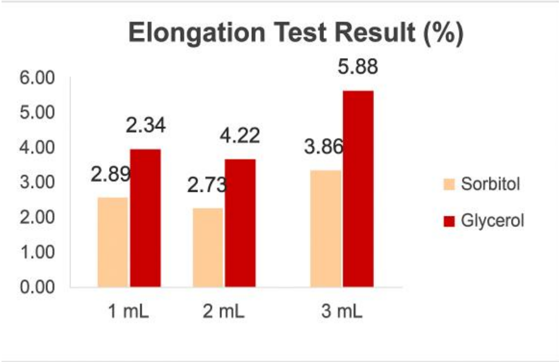


Figure 4. Elongation Test Results

Table 4 shows that the elongation results vary, the optimal results are seen in the addition of a plasticizer mixture concentration of 3 ml, which is 5.8% and the smallest at a plasticizer mixture concentration of 2 ml, which is 2.73%. The greater the concentration of plasticizer used, the greater the elongation of bioplastics. If plasticizers are combined with polymers, they will obtain flexible and soft properties. The greater the plasticizer added, the thinner the percentage of elongation, but after adding a certain concentration, the value decreases. The more plasticizer added will have an impact on the cohesive bonds between polymers which are getting smaller and the resulting film becomes soft, resulting in the edible film formed being easily broken. The results obtained are also affected by the less homogeneous mixing factor which results in the insertion of plasticizers into the film matrix not taking place properly. Glycerol plasticizers in bioplastics have an effect on producing a greater percentage of elongation compared to sorbitol plasticizers. The best time was achieved when the weight variation of cassava starch was 3.5 grams and the volume of glycerol was 1.75 ml with a tensile strength of 1035 cN, elongation of 33.9% and a thickness of 0.245 cm.

### 3.5. Effect of Plasticizer Mixture on Weight Loss

The results of the weight loss experimental design are as follows:

Table 5. Results of Weight Loss Experiment (gr/day)

| | Volume Plasticizer (ml) | | |
|---|---|---|---|
| | 1 mL | 2 mL | 3 mL |
| Plasticizer | Weight Loss (gr/day) | Weight Loss (gr/day) | Weight Loss (gr/day) |
| | 0.0000 | 0.0179 | 0.0046 |
| Sorbitol | 0.0000 | 0.0129 | 0.0026 |
| | 0.0000 | 0.0164 | 0.0000 |
| Average | 0.0000 | 0.0157 | 0.0024 |
| | 0.0176 | 0.0199 | 0.0102 |
| Gliserol | 0.0145 | 0.0190 | 0.0075 |
| | 0.0131 | 0.0178 | 0.0060 |
| Average | 0.0151 | 0.0189 | 0.0079 |

The average weight loss results are depicted in the following graph:

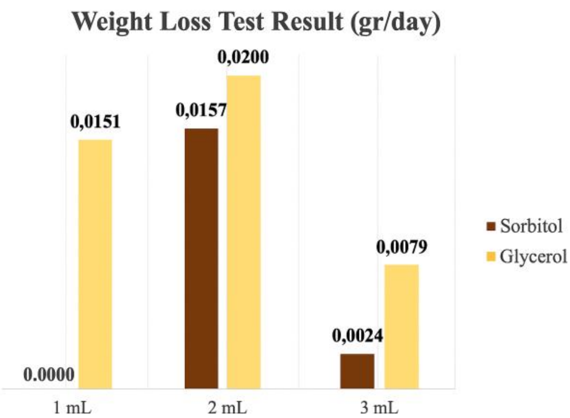


Figure 5. Weight Loss Test Results

Table 6 shows that the weight loss of the use of glycerol plasticizer, obtained the largest weight loss at a volume of 2 mL of 0.0189 grams/day. Weight loss in the use of glycerol from a volume of 1 mL to 2 mL increased and decreased weight loss at a volume of 3 mL. Weight loss in the use of sorbitol plasticizer, obtained the largest weight loss at a volume of 2 mL of 0.0157 grams/day. Weight loss in the use of sorbitol from a volume of 1 mL to 2 mL increased and decreased weight loss at a volume of 3 mL.

The process of bioplastic weight loss occurs because plasticizers and starch have OH groups that can initiate hydrolysis reactions after absorbing water from the soil. So that the starch polymer will decompose into small pieces until it disappears in the soil. The polymer will degrade due to the process of damage or degradation due to the breaking of the chain bonds in the polymer. This shows that the optimum weight loss for bioplastics from salak and cassava seed starch with glycerol plasticizer at a volume of 2 mL.

The results of the study showed that the high water absorption value. Edible film can be degraded naturally so that it contributes significantly to overcoming environmental problems that have been caused by the use of synthetic plastic waste. Generally, after the waste (plastic) is thrown into the ground it will undergo a natural destruction process, either through photodegradation (sunlight), chemical degradation (water, oxygen), or biodegradation (bacteria, fungi, enzymes). Edible film has hydrophilic properties that are easily degraded without causing the risk of environmental damage which is different from the use of synthetic plastics that are difficult to degrade.

Based on the results of the research that has been done, it shows that the variation of the addition of sorbitol and glycerol greatly affects the characteristics of bioplastics. This is shown by the results of the One-Way-ANOVA test with a sig value <0.05, which means there is a difference between the volume of plasticizers. The results of the water resistance anova test (%) are as follows:

a. Homogeneity of Variance Test

   It can be seen that the Levene Test count is 1.505 with a probability value of 0.260. Because the probability/Sig > 0.05 then Ho is accepted or the six sample variances are identical. So that further analysis can be done.

b. Anova test

   It can be seen that the calculated F is 20.702 with a probability value of 0.260. Therefore, the probability/Sig is 0.000, then Ho is rejected or there is a difference between the volume of Sorbitol plasticizer 1 mL, Sorbitol 2 mL, Sorbitol 3 mL, Glycerol 1 mL, Glycerol 2 mL, Glycerol 3 mL.

In the same way, Anova tests for water resistance, thickness, tensile strength, elongation and weight loss are as follows:

Table 6. ANOVA Test Results on Bioplastic Characteristics

| Probability/Sig. | Test Results | | | | | Information |
|---|---|---|---|---|---|---|
| | Water Resistance | Thickness | Tensile strength | Elongation | Losing Weight | |
| Homogeneity | 0.260 | 0.614 | 0.063 | 0.931 | 0.172 | Identical |
| Anova | 0.000 | 0.011 | 0.036 | 0.006 | 0.000 | There is a difference |

The results of water resistance using sorbitol plasticizer, obtained the best water resistance at a volume of 2 mL of 96.19%. This shows that the optimum water resistance for bioplastics from salak and cassava seed starch with sorbitol plasticizer at a volume of 2 mL. Sorbitol plasticizer in bioplastics produces better water resistance compared to a mixture of glycerol plasticizers [47], [49]. The addition of different concentrations of plasticizer mixtures shows varying thicknesses. In general, along with the addition of the concentration of the plasticizer mixture, the resulting thickness also increases. Sorbitol plasticizer has an effect on producing a thicker bioplastic thickness than glycerol plasticizer [50].

In general, the higher the concentration of the plasticizer mixture, the lower the tensile strength of the bioplastic. This is because the plasticizer can reduce the energy needed by the molecules to move, so that its stiffness decreases and causes a decrease in the tensile strength value. The addition of plasticizers can also reduce the internal hydrogen bonds of the molecules and cause a weakening of the intermolecular attraction of adjacent polymer chains, thereby reducing the breaking tensile strength [51], [52]. Glycerol plasticizers have an effect on producing stronger tensile strength of bioplastics compared to sorbitol plasticizer mixtures.

The higher the concentration of plasticizer used, the higher the elongation of the bioplastic. Plasticizer when mixed with a polymer will provide a soft and flexible nature. The greater the addition of plasticizer, the greater the percentage of elongation, but it affects the cohesion bonds between polymers which are getting smaller and become softer so that they are easily broken. Glycerol plasticizer in bioplastic has an effect on producing a greater percentage of elongation compared to sorbitol plasticizer.

Weight loss (biodegradability) is very important to see a bioplastic is truly environmentally friendly, namely by looking at the degradation time of the bioplastic. Weight loss using glycerol plasticizer, obtained the largest weight loss at a volume of 2 mL of 0.0189 grams / day. weight loss in the use of glycerol from a volume of 1 mL to 2 mL increased and decreased weight loss at a volume of 3 mL.

This study shows the positive impact of utilizing local resources as an environmentally friendly alternative to conventional plastics. By utilizing starch from snake fruit and cassava, this study contributes to reducing plastic waste while encouraging local economic resilience through optimizing agricultural products. However, this study has limitations in terms of production scale and durability of the resulting bioplastic, which still needs improvement to match the performance of synthetic plastics in long-term use. In addition, further testing is needed to ensure product stability under various environmental conditions.

## 4. CONCLUSION

Variations in the addition of sorbitol and glycerol greatly affect the characteristics of bioplastics. This is indicated by the results of the One Way-ANOVA test with a sig value <0.05, which means that there are differences in the results of the characteristics of bioplastics using sorbitol and glycerol plasticizers. The right formulation for testing the manufacture of salak and cassava seed starch bioplastics with the best water resistance of 96.19% using 2 ml of sorbitol plasticizer. Meanwhile, the best thickness formulation of 0.33 mm uses 1 ml of sorbitol plasticizer. The best tensile strength formulation of 68.93 kg/cm2 uses 2 ml of glycerol plasticizer and the best elongation formulation of 5.88% uses 3 ml of glycerol plasticizer. Further research is suggested to explore the formulation of additional materials that can improve the mechanical strength and water resistance of salak and cassava bioplastics. In addition, long-term biodegradability tests in real environments are also needed to ensure their overall ecological impact.

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