The Effect of Calcium Carbonate Addition to Mechanical Properties of Bioplastic Made from Cassava Starch with Glycerol as Plasticizer

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Abstract. Bioplastic is an environmentally friendly type of plastic that is easily degradable by air temperature, humidity, and microorganism. Cassava starch is widely used as the main ingredient in the making of bioplastics. The use of cassava starch for making bioplastics has plenty of potential because cassava is widely cultivated throughout Indonesia. This study aims to obtain the optimal value of adding calcium carbonate as a reinforcer to bioplastics made using cassava starch with glycerol plasticizer. Bioplastics were made by blending and cast printing methods. The stage of making bioplastics begins with the extraction of cassava into cassava starch as a base for making bioplastics. Then, calcium carbonate was added. Addition of calcium carbonate was done with variations (0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0%). Characteristics of mechanical properties were studied namely tensile and elongation tests. The tensile test show that the best tensile strength was obtained at 0.4% calcium carbonate (22.88 ± 1.46 MPa). While the addition of 0.5 to 1.0% decreased the tensile strength. The best elongation value was obtained by the addition of 0.8% calcium carbonate (27.57 ± 0.14 %).

Keywords: bioplastic, calcium carbonate, cassava starch, glycerol

1. Introduction
The use of plastic as packaging is very widespread in Indonesia. This causes an ever-increasing consumption of plastic. The current conventional plastics that are in use are made from petroleum or oil that are not renewable and is in decline. Conventional plastics are unable to be degraded by microorganisms in the environment [1]. This in turn, pollutes the environment with symptoms such as low quality of water and ground. Efforts are being made to change the basic material of plastic to one that is easily degradable either by temperature or microorganisms.

Bioplastic is an environmentally friendly type of plastic that is easily degradable by air temperature, humidity, and microorganism. The constituent compounds of bioplastic come from plants that contain starch, cellulose, and lignin, or from animals that contains casein, protein, and lipid [2]. Cassava starch is often used in the making of bioplastic because of the good results from past research that used cassava starch. The starch content of cassava reaches 90%, therefore, it has the potential to create a good quality bioplastic.

A filler is needed when making bioplastic to increase the stiffness, strength, and reduce solubility to water. The reason calcium carbonate is added to the bioplastic is that calcium carbonate increases the stiffness and the strength of the bioplastic and it is odourless, tasteless, biodegradable, and hygroscopic [3,4]. This research was done to find out the effects of calcium carbonate to the
mechanical and physical properties of the bioplastic that is made using cassava starch and glycerol plasticizer.

2. Materials and Method
The steps in this research start with the preparation of the ingredients to make the cassava starch, the dilution of the glycerol concentrate, the making of bioplastic, and the testing of bioplastic. The making of bioplastic consists of heating up and mixing the cassava starch with glycerol and filler, then it was poured into the cast and then dried out in the oven. After that, testing was done to the bioplastics that have been made with the variations of added calcium carbonate.

2.1. Making of Bioplastic
The making of bioplastic was using the melt intercalation method. The first step was mixing 100ml of 1% glycerol with the cassava starch and calcium carbonate in a beaker glass. Then it was stirred using a magnetic stirrer for 20 minutes at 60°C. The mixture was stirred until it turns into gel. Next, the mixture was put to rest until the bubbles disappear. The third step was pouring the mixture into a 20cm x 20cm acrylic cast. The last step was drying process where the sample was placed in an oven for (8.0±0.2) hours at 65°C until the bioplastic dried. The obtained plastic was then taken off from the mould and cut according to the sample size for testing.

2.2. Testing of Bioplastic
The testing of the bioplastic sample was mechanical testing that consisted of tensile strength test and elongation test. Tensile strength test was done to measure the mechanical characteristic of the bioplastic. The test was done to measure the tensile strength and the elongation of the bioplastic, using the ZP Recorder tool, based on ASTM D 638-02 standard. After that, another test was also done to measure the thickness of the plastic using Coating Thickness Coater tool in three spots. This test was done in micrometre scale, after each test was done, the tool was recalibrated.

3. Results and Discussion
The resulting cassava starch from the extraction of the cassava was a fine white odourless powder as seen in Figure.1. The Figure shows by using the blending method, cassava starch can be extracted from cassava [5]. Cassava starch has unique properties such as its white colour, odourless, and its smooth powdery feel after having been mashed and strained through a 200-mesh strainer.

![Figure 1. The Cassava starch.](image)

3.1. Tensile Strength Test
The result of the tensile strength test of the bioplastic using the ZP recorder tool is presented in Figure 2. It can be seen that the cassava starch bioplastic with different values of calcium carbonate addition shows different results. One sample bioplastic contained 0% calcium carbonate to be used as control. The other variables of calcium carbonate that was used are 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1%.
Results show that with the addition of more calcium carbonate, the strength of the bioplastic is decreasing. This is due to the calcium carbonate having hygroscopic properties. The more calcium carbonate added, the weaker the tensile strength of the bioplastic. The highest tensile strength is acquired with the addition of 0.4% calcium carbonate which results in a 22.88 MPa tensile strength. The lowest tensile strength is the bioplastic made with 1% calcium carbonate that gives a 13.25 MPa tensile strength. The result shows that the bioplastic made with the addition of calcium carbonate has a higher tensile strength than a bioplastic made using only cassava starch, with 3.17 MPa tensile strength [6].

Figure 2. Bioplastic Samples after Testing Tensile Strength

Figure 3. Tensile Strength of Samples of Cassava Starch Bioplastic with Calcium Carbonate Variation

Figure 3 shows the graph of the tensile strength of the various bioplastic samples with the addition of calcium carbonate ranging from 0.4% to 1%. The trend line shows a decline in tensile strength from the sample with 0.4% calcium carbonate until the sample with 1%. The regression coefficient is 0.97 which means the spread of every tensile strength is close to the trend line.

According to a research by Hasanah [7] and Eristina [8], the tensile strength of bioplastic with calcium carbonate is going to drop with the addition of more calcium carbonate. This shows that the bioplastic structure is amorphous. An amorphous molecular structure contains many branches but is not structured tightly so the distance between molecules are far and the bond between molecules are weak. The weak molecular bond in bioplastic makes the force needed to pull apart the plastic relatively low.
3.2. **Elongation**

The percentage of the lengthening of the bioplastic is measured when the tensile strength test is performed, where each sample is given a pulling force that makes the distance between molecules increases so that the sample is increasing in length. Elongation is measured as the difference between the final sample length after being tested and the initial sample length.

In Figure 4, the graph showing the additional length each sample received after being tested. Between 0.4% and 0.8% addition of calcium carbonate, there is an increase on the length of the bioplastic sample. However, it then decreased when the added amount of calcium carbonate was between 0.9% and 1%. According to research by Selphiana [9], this is due to the increase of the distance between the bioplastic molecules. With the addition of 0.7% to 1% calcium carbonate, the bioplastic has longer amount of stretching compared to those without the addition of calcium carbonate. This is because calcium carbonate is hygroscopic compound. The addition of calcium carbonate can increase the density of the bioplastic thus increase the elongation amount. The trend line shown in Figure 4 shows the effect of calcium carbonate concentration on the bioplastic length. The addition of calcium carbonate from 0.4% to 1% increases the lengthening sample but then it decreased after 1% of added calcium carbonate.

![Graph showing elongation of bioplastic samples](image)

**Figure 4.** The Elongation of Bioplastic Samples with Variations in Calcium Carbonate

According to Figure 4, the amount of lengthening in bioplastic with 0.4%, 0.5%, and 0.6% added calcium carbonate is lower than that of the bioplastic without addition of calcium carbonate. The increase of lengthening starts with the addition of 0.7% calcium carbonate until 1% calcium carbonate. The highest elongation value is shown by 0.8% added calcium carbonate, which is 27.57%. This means that the bioplastic can stretch until 0.27 times than the initial size before it eventually breaks. The addition of the correct amount of calcium carbonate can increase the strength of the bioplastic. The elongation of the bioplastic is also affected by the gelatinization process, the amount of calcium carbonate added, and glycerol. Glycerol is a plasticizer that is located between the biopolymer chains that makes the distance between the molecules further [10].

4. **Conclusion**

According to the experimental results, the addition of calcium carbonate lowers the tensile strength, and increases the elongation of the bioplastic sample. The highest tensile strength of the bioplastic sample was the sample with 0.4% calcium carbonate which is 22.88 MPa. The sample with the longest elongation was the sample with the addition of 0.8% calcium carbonate and has an elongation value of 27.57% and a tensile strength of 14.97 MPa.
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