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THE EFFECT OF ADDITION SORBITOL AND CARBOXYMETHYL CELLULOSE (CMC) ON THE QUALITY OF BIODEGRADABLE PLASTICS FROM AVOCADO SEED STARCH

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ABSTRACT

So far the plastics used are made of synthetic polymer materials that are difficult to decompose in nature and their availability is very limited. The use of synthetic plastics increases every year so that it has an impact in the form of environmental pollution. Therefore, the effort can be made to tackle plastic waste, namely by replacing the use of synthetic plastics with biodegradable plastics. Biodegradable plastics used are made from natural materials, for example, starch. The starch used in this study was avocado seeds. Determination of the quality of biodegradable plastics is based on the results of tensile tests, elongation tests, and biodegradation tests of biodegradable plastics. The steps involved in determining the optimum conditions for CMC with a variation of CMC used as much as 15%, 20%, 25% (w/w starch), the second stage is determining the optimum conditions for sorbitol with a variation of 20%, 30%, 40% (w/w starch), the third stage is mixing avocado seeds starch with sorbitol and CMC of 20% by weight of avocado starch. The optimum condition for CMC was obtained from the addition of 3 grams of avocado seed starch and 20% CMC of starch (w/w starch) with the resulting tensile strength value of 9,07 MPa and 21,39% elongation, while the optimum condition for sorbitol was obtained from the addition of 3 grams of avocado seed starch and sorbitol of 40% by weight of avocado starch with a tensile strength value of 7,79 MPa and 24,38% elongation while the highest tensile strength value from mixing sorbitol and CMC was obtained from the addition of sorbitol concentrations of 40% by weight of avocado starch and CMC 20% by weight of avocado seed starch, namely 3,79 MPa and elongation of 32,61%. Percent of lost plastic weight has increased day by day. The largest percentage loss of biodegradable plastic weight was obtained from the addition of sorbitol concentrations as much as 20% w/w starch and CMC 20% w/w starch, which was 91,67%. The biodegradable plastic made from avocado seed starch is almost completely biodegradable by the eighth day.

Keywords : Biodegradable Plastic, Avocado Seeds, Sorbitol, CMC (Carboxymethyl Cellulose).

I. INTRODUCTION

In recent years, cases of pollution caused by plastic waste have continued to increase. The main cause is due to the increasing use of plastic and is exacerbated by the habit of people who often litter. It is estimated that there are 189 tons of waste produced by the population of Indonesia every day, 15% or around 28.4 tons of which are plastic waste [1]. Most of the waste that is disposed of comes from materials that are difficult to degrade in nature. The use of synthetic plastics is harmful to the environment and human health because they contain dangerous compounds.

Several attempts were made to reduce the amount of plastic waste, such as burying and burning plastic waste. However, the removal of plastic waste in the ground has a negative impact because the plastic is made of a material that is difficult to decompose in nature. Burning plastic waste also has a negative impact because the smoke produced from burning plastic waste produces dioxin compounds that are harmful to human health [2]. So efforts are made to reduce cases of pollution by plastic waste, namely replacing the use of synthetic plastics with

natural plastics that are safe and easily biodegradable. This plastic is known as biodegradable plastic. Biodegradable plastics can come from natural materials. One of them is obtained from plants, for example, is starch. Starch is easily biodegradable and its availability is quite abundant. Starch can be found in plant parts such as seeds and tubers. Several studies related to the manufacture of starch-based biodegradable plastics have been done before, such as the manufacture of bioplastics from sago starch with a mixing agent in the form of carboxymethyl cellulose (CMC). The results of this study indicate that the elongation value of bioplastics is greater when the sorbitol concentration is added by 20% -35% w / w starch and the tensile strength value of bioplastics increases when the CMC concentration is added by 35% -45% w / w starch [3]. Furthermore, research on the manufacture of bioplastics made from sweet potato starch with a mixture of glycerol and CMC shows that the optimum conditions for CMC are obtained from the highest tensile strength value obtained from the addition of 9% CMC concentration with the resulting tensile strength value of 0.5281 N / mm^2 [4]. However, this material is not suitable as a biodegradable plastic raw material because this material is used as an alternative to staple food. Therefore avocado seeds are used to be used as material for the formation of biodegradable plastics. Avocado seeds have a starch content of 80.1% [5]. In this study, the avocado seeds will be processed to extract starch.

However, the use of biodegradable plastics made from starch has drawbacks because plastics produced from starch are stiff and brittle, and not resistant to water. Therefore, additional materials are needed in the form of fillers which play a role in improving the weaknesses of biodegradable plastics based on starch. The addition of filler plays a role in increasing the mechanical strength of biodegradable plastics. The filler material used in this study is CMC (Carboxymethyl Cellulose). CMC was chosen as a filler because it is cheap. The use of inexpensive fillers aims to reduce production costs.

Based on previous research, it was stated that the addition of starch and CMC had a role in increasing the mechanical strength of biodegradable plastics. However, the plastic produced by mixing the two materials is less elastic. Therefore, the addition of a plasticizer is important because plasticizers play a role in producing elastic and flexible plastic [6]. The plasticizer used in this research is sorbitol. Sorbitol plays a role in reducing the stiffness of plastic materials so that the resulting plastic is more elastic and flexible. In this research, the mechanical properties of biodegradable plastics will be tested, including tensile tests, elongation tests, and biodegradation tests. Biodegradation testing is carried out to determine the ability of plastics to decompose in nature.

II. METHOD

The research starts in July-October 2020 at the Biochemistry Laboratory of UNP. Tensile strength testing of plastic was carried out using a mini ultimate testing machine found in the Metallurgy Laboratory of the Faculty of Mechanical Engineering, UNAND.

A. Research Tools and Materials

This research material is in the form of starch made from avocado seeds, sorbitol as a plasticizer, CMC as a filler, distilled water, humus soil is used as a medium for biodegradable plastic biodegradation tests, cooking oil is used to make it easy for plastic. The tools used are hotplate, magnetic stirrer, scissors, spray bottle, ruler, thermometer, oven, filter, mortar and mortar, knife, blender, measuring cup measuring 100 ml and beaker measuring 250 ml, stirring rod, analytical scale, aluminum mold. size 20 cm x 20 cm, desiccator.

Fig. 1. (a) Sorbitol and (b) CMC.

B. Experiment Design

This research is divided into 3 stages, the first stage is to determine the optimum concentration of CMC which is carried out by varying the CMC concentration of 15% w / w starch, 20% w / w starch, and 25% w / w starch, the second step is to determine the optimum concentration of sorbitol. by varying the concentration of sorbitol by 20% w / w starch, 30% w / w starch, and 40% w / w starch, the third stage is mixing avocado seed starch with the optimum concentration obtained from CMC as much as 20% w / w starch and variations The sorbitol used was 20% w / w starch, 30% w / w starch and 40% w / w starch.

C. Research Stages

1) Making Avocado Seed Starch
   a. Prepared 1 kg of avocado seeds, separated from the husk, and washed with water until clean
   b. Washed avocado seeds are cut into small pieces and sorted, this aims to separate good avocado seeds from rotten avocado seeds
   c. Mashed avocado seeds in a blender. Done by adding water with a ratio of 1: 1 (1 kg of avocado seeds: 1 liter of distilled water
   d. The extract and liquid of avocado seed starch are separated using a filter e. Avocado seed starch liquid is collected in a container and is deposited for 12 hours until a precipitate is formed
   e. The liquid above the sediment is removed and the resulting sediment of avocado seed starch is in an oven for 6 hours at a temperature of 50C until the starch is completely dry.

Fig. 2. Starch derived from avocado seeds.

2) Manufacturing of *Biodegradable* Plastics
   a. This is done by weighing 3 grams of starch made from avocado seed starch.
   b. The weighed avocado seed is dissolved in a beaker containing 100 ml of distilled water.
   c. CMC as much as 15%, 20%, 25% of the weight of avocado seed starch is added to the beaker containing 100 ml distilled water.
   d. CMC solution is heated with a hotplate, stirred using a magnetic stirrer with a heating time of 15 minutes and a temperature of 75^{o}C until the solution is homogeneous. During the stirring process, the temperature is controlled with a thermometer.
   e. Then the starch solution is mixed into the CMC solution.
   f. The starch solution is heated at a temperature of 80^{o}C, for 15 minutes. This experiment was carried out in 3 stages, the first was mixing the starch with CMC, the second stage was mixing the starch with sorbitol, the third stage was mixing the avocado seed starch with the optimum concentration of sorbitol and CMC.
   g. The addition of plasticizer in the form of sorbitol is carried out by weighing sorbitol as much as 20%, 30%, 40% of the weight of avocado seed starch (3 grams) in starch solution and CMC. The mixture was heated to 80^{o}C, with a long heating time of 15 minutes.
   h. Then cool the mixture for 5 minutes, aiming to remove air bubbles on the plastic.
   i. Before the solution is poured into the mold, the aluminum mold is smeared with cooking oil. This aims to make it easier to take plastic.
   j. The mixture is filtered and poured into a mold then the solution is leveled with a spatula.
   k. The mixture is dried in the oven for 7 hours at a temperature of 50^{o}C until the plastic is dry and easy to remove from the mold.

Fig. 3. Avocado seed starch biodegradable plastic.

D. Testing the Mechanical Properties of Biodegradable Plastics

1) Strength

This is done by cutting a plastic sample measuring 1.5 x 10 cm. The two ends of the sample to be tested are clamped. Then, the samples were drawn using the ultimate mini-testing machine connected to the C-TAP software. The tests carried out are based on ASTM d256.

$$\sigma = \frac{F}{A} x 100\% \quad (1)$$

Where :

σ = Strength (MPa)

F = Added load (kgm/s^2)

A = Surface area (m^2)

2) Elongation

Elongation testing is carried out using the ultimate mini ultimate testing machine. Elongation testing is carried out to determine the increase in the length of the plastic sample before and after being drawn.

$$\varepsilon = \frac{l - lo}{lo} x 100\% \quad (2)$$

Where :

l = The initial length of the plastic sample (mm)

lo = The final length of the plastic sample (mm)

3) Biodegradation Test

This is done by cutting a plastic sample measuring 2 x 6 cm. Then put the plastic in the desiccator for 24 hours. Furthermore, the plastic sample is weighed initially before burying it in the ground. Plastic samples were buried in a plastic container filled with humus soil according to the specified time, 4 days, 6 days, 8 days at a depth of 5 cm. After reaching the specified time, the plastic sample is removed from the container and cleaned with distilled water. Furthermore, the plastic sample was dried in a desiccator for 24 hours. Then the plastic sample is weighed finally.

$$\text{Losing weight (\%)} = \frac{W_1 - W_2}{W_1} x 100\% \quad (3)$$

W_1 shows the weight of biodegradable plastic before planting in the soil, while W2 shows the weight of biodegradable plastic after planting in the soil.

III. RESULTS AND DISCUSSION

A. Strength Test

The strength test of biodegradable plastic is carried out to know the ability of biodegradable plastics to withstand loads, which occurs when the plastic is stretched. The addition of CMC concentration will have an effect on the strong value of biodegradable plastic from avocado seed starch as shown in Figure 4.

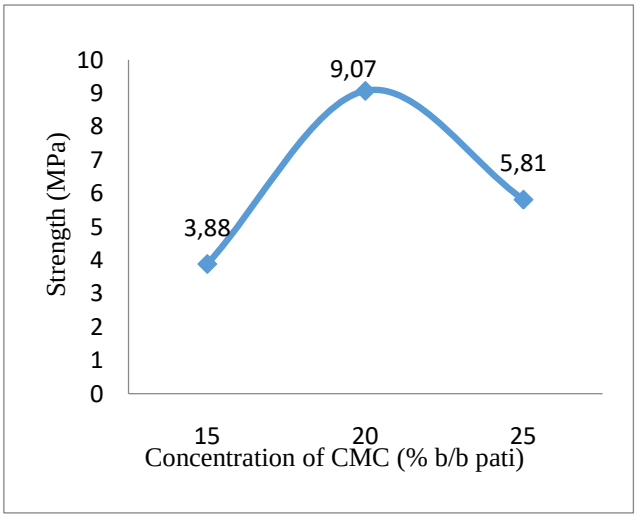

Fig. 4. Strength test results for biodegradable plastics from the addition of CMC concentrations.

Figure 4 shows that the strength value of biodegradable plastics has increased when the CMC concentration was added 15-20% w / w of starch with the strength values obtained ranged from 3.88-9.07 MPa. The optimum condition for CMC was obtained from mixing 3 grams of avocado seed starch and 20% w / w CMC of starch with the resulting strength value of 9.07 MPa. When the optimum conditions CMC can react with all the organic compounds present in the polymer chain. The increase in the tensile strength of biodegradable plastic occurs because of an increase in the attractive force between starch molecules containing hydroxyl groups (OH) and CMC molecules containing carboxyl groups (COOH).

The addition of CMC causes the structure between the starch and CMC to get tighter and the strength produced by the plastic increases. However, when the addition of the CMC concentration of 25% w / w starch, the strength of biodegradable plastics decreased. The resulting strength value is 5.81 MPa. The decrease in strength value is due to the addition of CMC concentration which causes the resulting molecular structure to become amorphous with branched chains. So that the distance between the starch molecules and CMC is far apart. The attractive forces that occur between the CMC polymer chains and the avocado seed starch are decreasing. So that the strength value of biodegradable plastic from avocado seeds also decreases.

The decrease in the strength of biodegradable plastics was caused because the CMC concentration had exceeded its saturation point. When the CMC concentration has reached its saturation point, CMC is no longer able to bind all organic compounds on the polymer chain. So that the excess CMC molecules will be outside the polymer phase. The attractive forces that occur between starch molecules and CMC will decrease. As a result, there is a movement between the starch polymer chain and CMC so that the resulting biodegradable plastic becomes hard and brittle easily.

he addition of an excess concentration of CMC will reduce the strength of biodegradable plastics [7]. Based on the results of testing the strength of biodegradable plastics made from avocado seed starch, it shows that the strength obtained from mixing 3 grams of avocado seed starch and 15% -25% CMC (w / w starch) ranges from 3.88-9, 07 MPa. The resulting strength values have met the Indonesian national standards where the strength of biodegradable plastics ranges from 1-10 MPa. In this study, the addition of sorbitol concentration will affect the elongation value produced by biodegradable plastics from avocado seed starch as shown in Figure 5.

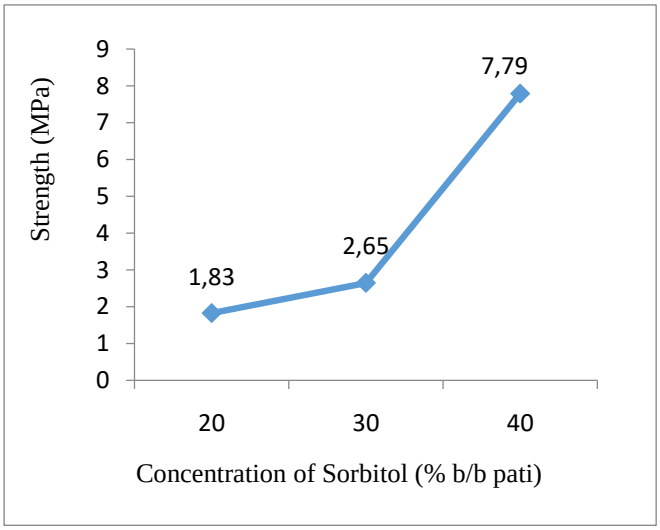

Fig. 5. Strength test results from the addition of sorbitol concentration

Figure 5 shows that the strength produced by biodegradable plastics has increased when the sorbitol concentration was added by 20% w / w starch to 40% w / w starch, ranging from 1.83-7.79 MPa. The increase in the strength of biodegradable plastics is due to the addition of sorbitol concentration which causes the plastic molecular weight to increase and the resulting structure of the biodegradable plastic is getting tighter so that breaking the polymer chain bonds requires a large enough force. The optimum value of sorbitol was obtained from the addition of the sorbitol concentration of 40% (w / w starch) with the resulting tensile strength value of 7.79 MPa. The tensile strength of biodegradable plastics has increased along with the increase in molecular weight of biodegradable plastics [8].

The strength of biodegradable plastics decreases with increasing sorbitol concentration [9]. The resulting strength value has met the Indonesian national standard where the strength value of biodegradable plastic ranges from 1-10 MPa. The addition of the concentration of sorbitol and CMC 20% w / w starch will affect increasing the strength of biodegradable plastics as shown in Figure 6.

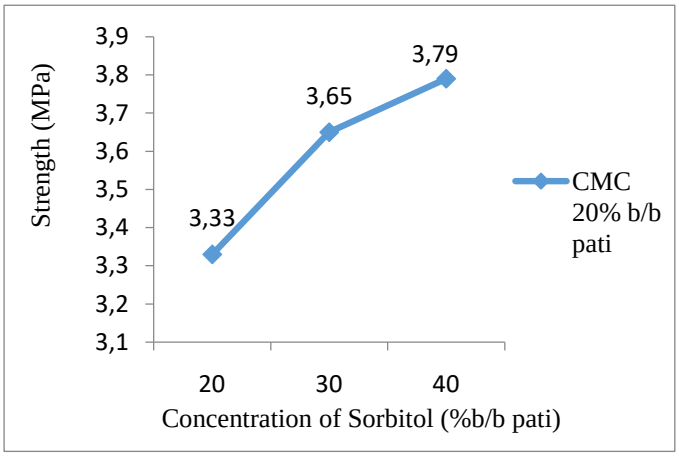

Fig. 6. Static strength test results for biodegradable plastics from the addition of sorbitol and CMC concentrations 20% w / w starch

Figure 6 shows that the tensile strength of biodegradable plastics increased when the sorbitol and CMC concentrations were added 20% w / w starch. The highest tensile strength was obtained from the increase in the CMC concentration of 20% w / w starch and sorbitol 40% w / w starch, namely 3.79 MPa. The increase in the tensile strength of bio-degradable plastics was due to the addition of the concentration of sorbitol and CMC which caused the matrix structure of the biodegradable plastic to be more tightly arranged. So that to break the starch polymer chain bonds with CMC and sorbitol, a large force is required. The tensile strength of biodegradable plastics increased when the sorbitol concentration was added [10].

B. Elongation Test

The elongation test was carried out to determine the increase in the length of biodegradable plastic before and after being withdrawn. The addition of CMC concentration has an effect on the magnitude of the elongation value of biodegradable plastic from avocado seed starch as shown in Figure 7.

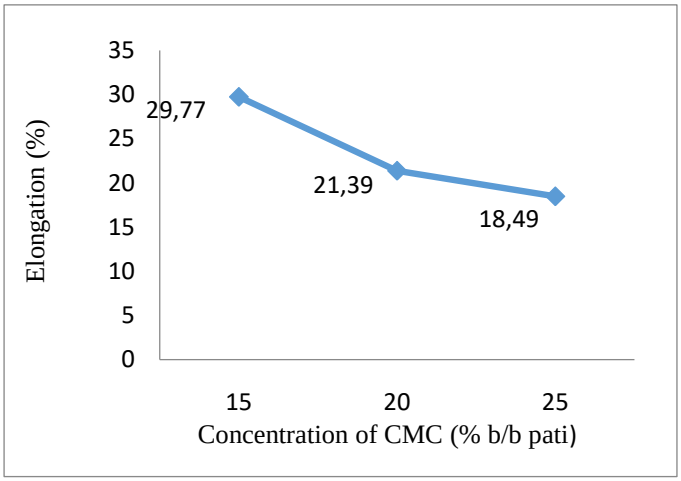

Fig. 7. Elongation test results for biodegradable plastics from the addition of CMC concentrations

Figure 7 shows that the highest elongation value for biodegradable plastic was obtained from the addition of 3 grams of avocado seed starch and 15% CMC (w / w starch) with the resulting elongation value of 29.77%. The addition of CMC concentration causes the elongation value produced by biodegradable plastic to decrease. The reduction in the elongation value of biodegradable plastics occurred when the CMC concentration was added by 20% -25% (w / w starch) with the resulting elongation values ranging from 18.49% -21.39%. The decrease in the value of biodegradable plastic elongation occurs due to the addition of an excessive concentration of CMC which causes the CMC to no longer be able to bind organic compounds in the polymer chain. As a result, sorbitol is outside the polymer phase and causes the attractive forces that occur between polymer molecules to decrease so that the resulting plastic becomes hard and easily brittle. The addition of excess CMC concentration will cause the elongation value of biodegradable plastic made from tofu liquid waste to decrease. The elongation value of bio-degradable plastics decreased when the CMC concentration was added 4% -4.5% (w / v) [11].

In this study, the elongation value of biodegradable plastic resulting from the addition of CMC concentration of 15% -25% (w / w starch) was in the range of 18.49% -29.77% (w / w starch). The elongation value of biodegradable plastic produced has met the Indonesian national standard where the elongation value of biodegradable plastic ranges from 10% -20%. The magnitude of the elongation value for biodegradable plastics is also influenced by the increase in the concentration of the plasticizer used. shows that the increase in the elongation value of biodegradable plastics is also influenced by the addition of sorbitol concentrations as shown in Figure 8.

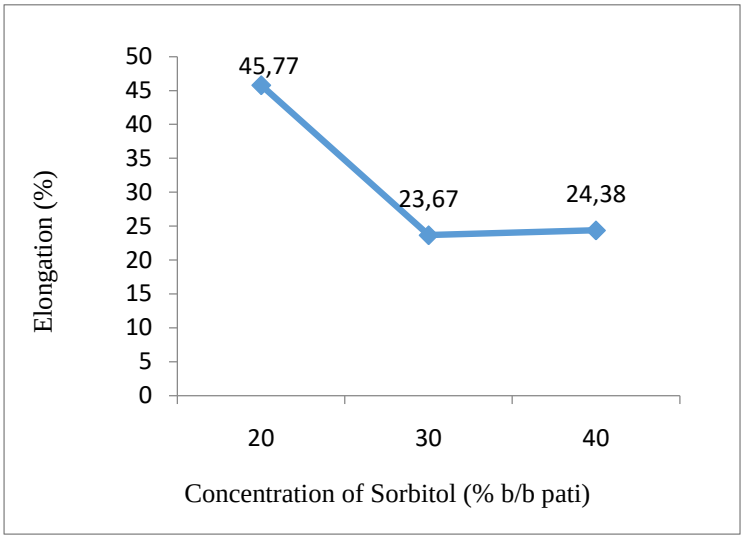

Fig. 8. The test results for the elongation of biodegradable plastics from the addition of the sorbitol concentration

Figure 8 shows that the elongation value of biodegradable plastics has decreased with increasing sorbitol concentrations. The highest elongation value was obtained from the addition of 3 grams of avocado seed starch and 20% sorbitol (w / w starch), which was 45.77%, while the lowest elongation value was obtained from the addition of 30% sorbitol (w / w starch), which was 23, 67%. The decrease in the value of biodegradable plastic elongation occurs due to the addition of excess sorbitol which makes the distance and strength between biodegradable plastic molecules less and less. So that the plastic becomes easier to tear.

The elongation value of biodegradable plastic depends on the composition of the plasticizer used. The biodegradable plastic elongation value obtained has met the bioplastic elongation standards ranging from 10% - 20%. The addition of the concentration of sorbitol and CMC 20% w / w starch also had an effect on the magnitude of the elongation value of biodegradable plastic from avocado seed starch as shown in Figure 9.

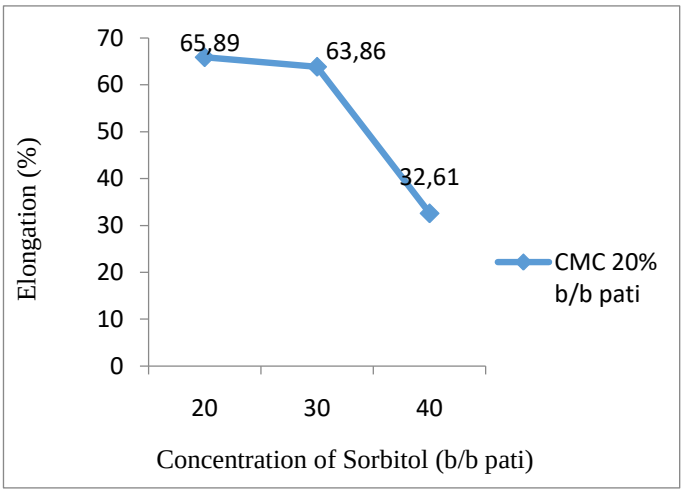

Fig. 9. The elongation test results for biodegradable plastics from the addition of sorbitol and CMC concentrations 20% w / w of starch

Figure 9 shows that the elongation value of biodegradable plastics has decreased with increasing concentrations of sorbitol and CMC 20% w / w starch. The highest elongation value was obtained from the addition of the sorbitol concentration of 20% w / w starch and CMC 20% w / w starch of 65.89%. The decrease in the value of biodegradable plastic elongation is due to the mixing of the materials that are not perfect, causing the spread of particles to accumulate at a point. This buildup occurs because the size or surface area of the filler particles is larger so that the filler cannot enter the matrix cavity. As a result, the distance between the filler and the matrix is further away and the resulting elongation value of biodegradable plastic is decreasing [12].

C. Biodegradation Test

The addition of 20% sorbitol and CMC concentrations (w / w starch) had an effect on the amount of weight loss percent of biodegradable plastics as shown in Figure 10.

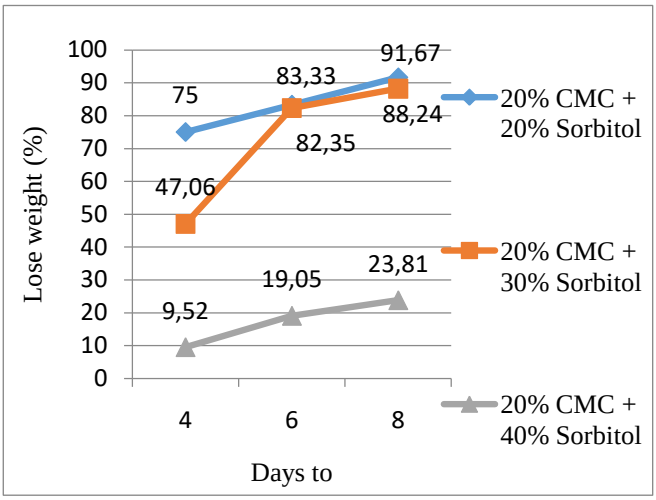

Fig. 10. The biodegradation test results of biodegradable plastics from the addition of sorbitol and CMC concentrations of 20% w / w starch

Based on Figure 10, it can be seen that the percentage of weight loss experienced by biodegradable plastics has increased from day today. The increase in plastic weight loss occurred due to the activity of microorganisms such as fungi and bacteria. Sorbitol and starch contain hydroxyl groups and CMC contains carboxyl groups. So that sorbitol and CMC can bind water molecules in the soil. This results in reduced polymer molecular weight and biodegradable plastics that will easily decompose or disintegrate in the soil [13].

The largest percentage of biodegradable plastic weight loss was obtained from the addition of the sorbitol concentration of 20% w / w starch and CMC 20% w / w starch, namely 91.67%. Biodegradable plastics can almost completely decompose on day 8. The process of decomposing biodegradable plastics takes place slower when the addition of sorbitol concentrations of 40% w / w starch and CMC 20% w / w starch with percent loss of biodegradable plastic weight of 23.81%. This is due to the addition of large concentrations of sorbitol and CMC so that the breaking of the polymer chain bonds by microbes will last longer.

The decomposition of the bioplastic depends on the sorbitol and CMC concentrations used. The smaller the concentration of sorbitol and CMC, the breaking of the chain bonds by microbes will take place faster. Biodegradation that occurs in biodegradable plastics also depends on the structure possessed by biodegradable plastics, the shorter the chains that the polymer has, the easier is for biodegradable plastics to be cracked.

IV. CONCLUSION

The strength value of biodegradable plastics increases with increasing concentration of sorbitol and CMC. The optimum concentration of CMC was obtained from the addition of 3 grams of avocado seed starch and 20% CMC (w / w starch) with a strength of 9.07 MPaa. The elongation value of biodegradable plastics has decreased with increasing concentrations of sorbitol and CMC. The optimum concentration of sorbitol was obtained from the highest tensile strength by adding 3 grams of avocado seed starch and 40% sorbitol (w / w starch), namely 7.79 MPa and 24.38% elongation, while the highest strength value from mixing sorbitol and CMC was obtained from the addition of sorbitol concentration was 40% w / w starch and CMC 20% w / w starch was 3.79 MPa and elongation was 32.61%. Biodegradable plastics made from avocado seed starch can almost completely decompose on day 8 with the largest percentage value of plastic weight loss obtained from the addition of sorbitol concentration 20% w / w starch and CMC 20% w / w starch which is 91.67%.

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