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MAKING OF BIODEGRADABLE PLASTIC BASED ON CORN STARCH (Amylum Maydis) WITH ADDITION OF ACID (CH_3COOH) AND GLISEROL PLASTICIZER

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ABSTRACT

Almost all countries face the problem of plastic waste due to the large production of conventional plastics and the long degradation process. Therefore, to protect nature from the accumulation of plastic waste, research on biodegradable plastics needs to be done. Biodegradable plastics are made from starch, cellulose, chitosan, and proteins extracted from renewable biomass. Starch for making biodegradable plastics can be obtained from plants, one of which is corn. This study aims to determine the effect of the composition of acetic acid, glycerol and corn starch on the quality of biodegradable plastics which include tensile strength, elongation and biodegradation. The independent variables were variations of acetic acid and glycerol. Control variables are plastic mold size, corn starch mass of 5 grams, other compounds outside the independent variables. The dependent variable is tensile strength, elongation and biodegradation. To test the tensile strength and elongation of biodegradable plastic, Ultimate Testing Machine Mini was used. The results showed that the addition of acetic acid and glycerol to the corn starch and glycerol blending material had an effect on increasing the tensile strength value and reducing the elongation and biodegradation values of biodegradable plastics. The highest tensile strength value is 50.04 Mpa, obtained from the addition of 1.44% acetic acid and 35.71% glycerol from a volume of distilled water of 70 ml. The highest length gain or elongation of 90% was obtained from the addition of 0.48% acetic acid and glycerol as much as 21.43% of the 70 ml volume of distilled water. Percent weight loss of the largest plastic obtained from the addition of acetic acid as much as 0.48% and glycerol as much as 21.43% of the volume of distilled water as much as 70 ml, which amounted to 93.33%.

Keywords : *biodegradable plastic; corn starch; acetic acid; glycerol.*

I. INTRODUCTION

In this day and age, plastics are an essential part of everyday life. In Greek word "plastikos" is used to describe different types of polymers with higher molecular weight. Basically, the term "plastic" is used to refer to items made with synthetic or semi-synthetic techniques that are used regularly in daily life.

Plastics cause environmental problems including changes in the CO_2 cycle. Almost all countries face the problem of plastic waste due to the large production of conventional plastics and the long degradation process. Therefore, to protect nature from the accumulation of plastic waste, research on biodegradable or bioplastic technology is important.

According to ASTM subcommittee D20-96, bioplastics are defined as degradable plastics where the degradation is caused by microorganisms such as bacteria, fungi, and algae. Bioplastic composites are mainly made from organic materials such as cellulose and biopolymers. Not all household or industrial plastic waste can be recycled. Bioplastics or degradable plastics can be used as an alternative to reduce waste.

Based on the raw materials used for plastic biodegradation there are two groups. The first consists of petrochemical feedstocks, which are non-renewable resources supplemented with biodegradable additives. The second consists of renewable raw materials, which are plants such as cellulose and starch, and animal raw materials such as shells and microorganisms [1].

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Renewable biodegradable plastics are made from starch, cellulose, chitosan, and proteins extracted from renewable biomass. Such biomass is projected to reduce the amount of fossil fuels used as well as reduce carbon dioxide emissions. Biodegradable plastics can be used like ordinary plastics, but after use and disposal into the environment, they will be decomposed by microorganisms into H_2O and CO_2 [2].

In the research to be conducted, the manufacture of biodegradable plastics uses renewable raw materials, namely starch. Glucose homopolymers with α-glycosidic bonds are known as starch. The length of the carbon chain and the straight or branched shape of the molecular chain determine the properties of starch. The two starch fractions that can be separated by hot water are called amylopectin and amylose. The solubility and source of starch determine the molecular weight of starch [3].

Many researchers have examined the starch that is suitable for making biodegradable plastics including [4]. using cassava starch . using tapioca starch [5]. red bean starch [6]. using corn starch [7]. Among the many researchers, the plastic that has tensile strength that meets SNI standards is from corn starch. However, the weakness of corn starch is less elastic than plastics from other starches. Therefore, it is necessary to vary the composition of biodegradable plastics from corn starch to get the quality that meets the standards set.

The properties of corn starch, like other starches, are that in their natural form they have a stable texture and are not resistant to stirring and heat processes. In addition, it cannot form rigid gels and cannot undergo retrogradation. The corn starch blending material used in the preparation of biodegradable plastics is added with filler in the form of acetic acid. Acetic acid is used because it is protic hydrophilic, which is an acidic compound that exchanges one proton to become acidic and hydrophilic because it is soluble in water. Acetic acid can dissolve many compounds, including inorganic compounds, glucose, polar compounds, and non-polar compounds, such as oil. Due to its polar and soluble nature, acetic acid is widely used [8].

In acetic acid, amylose is hydrolyzed and an acidic atmosphere is created by acetic acid. Amylose is then gelatinized after being hydrolyzed by acetic acid. biodegradable plastic film crystals are formed from amylose. investigated the use of acids in the dissolution of chitosan by using various types of acids, including acetic, lactic, formic, malic, and propionic acids. However, only acetic and formic acids produced films that were flexible, transparent, and suitable as packaging materials.

Another blending agent used is plasticizer. The plasticizer used in making this biodegradable plastic is glycerol. Glycerol is a neutral viscous liquid with a sweet taste and colorless, with a melting point of 20°C and a boiling point of 290°C. Glycerol is a good type of solvent because it can dissolve easily in water and alcohol, but not in oil. Glycerol is found in many animal and vegetable fats as glycerol esters of palmitic and oleic acids[9].

investigated how glycerol as a plasticizer affects starch molecules. Researcher Kruiskamp reacted glycerol and ethylene glycol with amylopectin and compared their reaction enthalpies. The results showed that both have the ability to interact with amylopectin molecules. However, since there has been no additional research, the reaction mechanism and immobilization of the plasticizer are still unknown. Plasticizers may participate in the substitution mechanism, lowering the overall mobility [9].

In a study conducted by. mechanical properties, such as tensile strength and percent elongation, can be affected by drying temperature and CMC concentration during the process of making biodegradable plastic films. Higher drying temperature will cause a decrease in tensile strength and percent elongation. This is because high temperatures can damage the chemical structure and vaporize glycerol, which increases flexibility. CMC concentration and drying temperature can affect the biodegradability properties of plastics: the more concentration of CMC added will increase the tensile strength value and decrease the percent elongation, because the hydrogen bonds of CMC become tighter and sturdier. With more CMC concentration, the plastic will degrade faster and be overgrown by mold, and with higher drying temperature, the biodegradable plastic will degrade faster [10].

Research conducted before [9] found that the addition of GO solution to corn starch-based bioplastics increased tensile strength values, but reduced elongation values, increased water absorption, and biodegradability did not experience significant changes in time [11].

Based on the results of research by Danang Jaya et al, (2010) who made bioplastics from corn starch, it is concluded that the addition of glycerol and sorbitol volume will increase solubility but will reduce the tensile strength of the resulting edible film. Preparation of edible film from corn flour with a volume of 120 ml of distilled water and the weight of corn flour l0 gr and cooling time for 15 minutes. The relative composition is good for the edible film properties produced is with a ratio of 1 ml glycerol volume and 1 ml sorbitol volume. Tensile strength of 17.2765 N and solubility of 0.0091 g/m [12].

Based on previous research and the lack of results obtained from the addition of various compounds to the corn starch mixture, the researchers are interested in conducting research to add acetic acid and glycerol plasticizers to corn starch and see its effect on the quality of biodegradable plastics [13].

II. METHOD

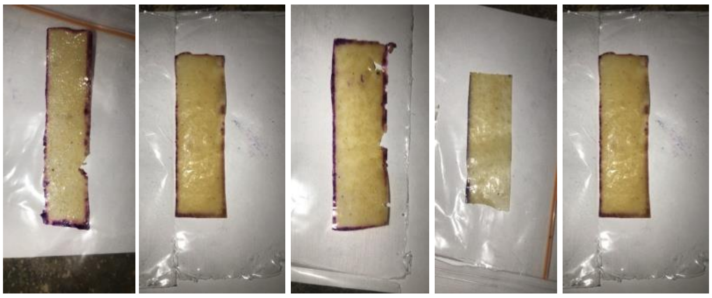
Corn starch, acetic acid, glycerol, humus soil, and distilled water were employed as the study's ingredients. Analytical scales, a blender, a hotplate, a 100 mesh sieve, an oven, a small main testing machine, a measuring cup, a beaker, a spray bottle, a mold, a mortar and pestle, and a thermometer are among the equipment utilized[14].

The steps for making corn flour are the corn is cleaned of dust, gravel, sand or cob pieces. After cleaning, the corn is soaked in porcelain or stainless steel tanks. Set the soaking temperature between 45-50^{0}C to avoid the formation of alcohol due to the fermentation process. Set the soaking duration to about 30-40 hours. After soaking, the corn becomes soft and then the husk can be peeled off easily. The soaked corn is then dried. The dried corn kernels are ground into flour. The corn flour is then soaked to remove the protein. It is then separated from the starch grains and the starch is washed with water. The results of the extraction in the form of sediment are then taken, in the form of chunks or lumps of wet starch, and then dried to a moisture content of about 14%. Next, grind the starch 2 to 4 times. The milling tool is equipped with a sieving tool measuring 100 mesh [15].

The next step in making biodegradable plastic is weighing corn starch as much as 5 grams, glycerol as much as 15 ml, 17 ml, 20 ml, 22 ml and 25 ml with the best acetic acid concentration that has been obtained from previous tests, namely 5 drops, 7 drops, 10 drops, 12 drops and 15 drops. Putting the acetic acid solution into a beaker containing corn starch solution. Heating the acetic acid solution using a hot plate at a temperature of 75^0 C for 30 minutes. then incorporating the glycerol into the corn starch mixture in the manner prescribed by the composition. The mixture should then be heated on a hot plate for 15 minutes at 80°C. The mixture should then be added to a 20 cm by 20 cm mold. For seven hours, the mixture was heated in an oven set to 50°C. The sample of plastic was then removed from the mold [16].

III. RESULTS AND DISCUSSION

This study was conducted by adding 5 grams of corn starch and varying the concentration of acetic acid by 5 drops-15 drops and glycerol by 15ml-25 ml. The following shows the condition of the biodegradable plastic after being mixed with 5 grams of corn starch and 5 drops-15 drops of acetic acid and 15 ml-25 ml of glycerol as shown in Figure 1.



(1) (2) (3) (4) (5)

Fig 1. Plastic sheet from the addition of 5 drops-15 drops of acetic acid with glycerol.

Based on Figure 1, it is found that the biodegradable plastic produced from mixing 5 grams of corn starch with the addition of acetic acid concentration of 5 drops-15 drops and glycerol concentration of 15 ml-25 ml is yellow and transparent with a smooth and slightly oily surface structure due to the influence of acetic acid.

The tensile strength test results from the addition of acetic acid concentration of 5 drops-15 drops with corn starch and glycerol mixing materials of 15 ml-25 ml as shown in Table 1.

Table 1. Test Results of Tensile Strength Values of Biodegradable Plastics from the Addition of Acetic Acid Concentration with Corn Starch and Glycerol Blending Materials.

Starch mass (gr)	Glyserol concentration (ml)	Acetic acid (drops)	Tensile Strength (MPa)
	15 ml	5 drops	46,48 Mpa
	17 ml	7 drops	46,89 Mpa

5 gr	20 ml	10 drops	47,56 Mpa
	22 ml	12 drops	48,32 Mpa
	25 ml	15 drops	50,04 Mpa

Based on Table 1, it was found that the tensile strength value produced from mixing 5 grams of corn starch with the addition of acetic acid concentration of 5 drops-15 drops and glycerol concentration of 15 ml-25 ml was in the range of 46.48-50.04 MPa. Elongation test results from the addition of acetic acid concentration of 5 drops-15 drops with corn starch mixing material of 5 grams and glycerol concentration of 15 ml-25 ml was shown in Table 2.

Table 2. Elongation Test Results of Biodegradable Plastics from the Addition of Acetic Acid Aoncentration with Corn Starch Blending Material and Glycerol Concentration

Starch mass (gr)	Glyserol concentration (ml)	Acetic acid (drops)	Elongation(MPa)
	15 ml	5 drops	90 %
	17 ml	7 drops	88 %
5 gr	20 ml	10 drops	82 %
	22 ml	12 drops	74 %
	25 ml	15 drops	68 %

Based on Table 2, it can be seen that the elongation value obtained from the addition of acetic acid concentration of 5 drops-15 drops, glycerol concentration of 15 ml-25 ml and avocado seed starch as much as 3 grams is in the range of 68%-90%.

Biodegradation testing is carried out with the aim of knowing the ability of biodegradable plastics to decompose. The results of biodegradation testing were obtained from weighing the mass of plastic samples before and after burial as shown in Table 3.

Table 3. Biodegradation Test Results of Biodegradable Plastics from the Addition of Acetic Acid Concentration of 5 Drops-15 Drops with Corn Starch Blending Material and Glycerol Concentration.

mass (gr)	Glyserol concentration (ml)	Acetic acid (drops)	Weight loss (%) Days-				
			1	2	3	4	5
	15 ml	5 drops	20	40	53,33	73,33	93,33
	17 ml	7 drops	17,65	35,29	52,94	70,58	92,35
	20 ml	10 drops	15,79	31,58	42,11	68,42	92,11
5 gr	22 ml	12 drops	15	30	40	65	91,5
	25 ml	15 drops	13,63	27,27	36,36	63,63	90,9

Table 3 shows that the weight loss rate of biodegradable plastics increased day by day. The highest weight loss rate of biodegradable plastic was achieved on the 8th day with the addition of 5 drops of acetic acid and 15 ml of glycerol which was 93.33%. This is because the activity of microorganisms such as fungi, bacteria and algae in the soil affects the rate of weight loss of biodegradable plastics.

Table 1 shows the tensile strength test results on biodegradable plastics by mixing 5 g of corn starch, 5 to 15 drops of acetic acid, and 15 to 25 ml of glycerin. Below is a graph of the effect of acetic acid concentration and glycerin concentration added to corn starch on the tensile strength value of biodegradable plastics shown in Figure 2.

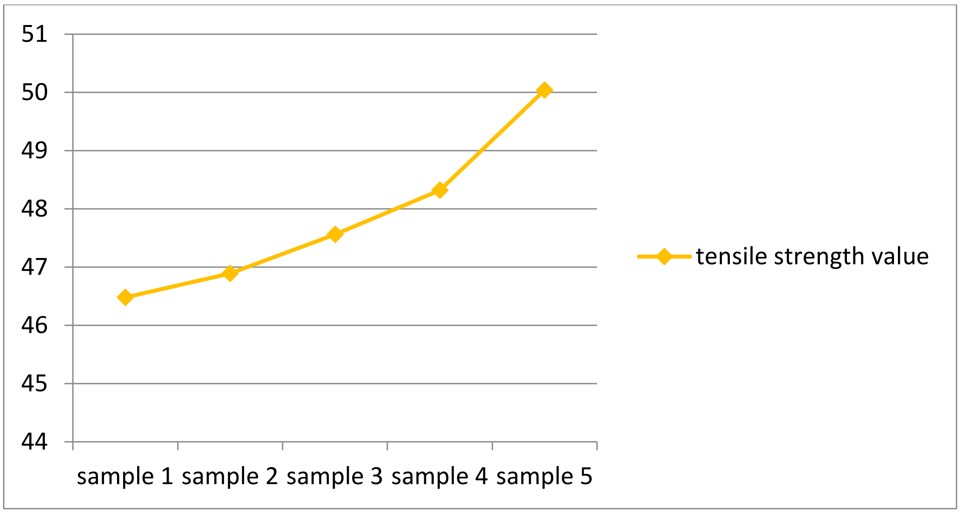


Fig 2. The effect of the addition of acetic acid concentration with corn starch and glycerol on the tensile strength value of biodegradable plastic.

Based on Figure 2, the mixture of 5 grams of corn starch, 15 drops of acetic acid and 25 ml of glycerin gave the highest tensile strength value of 50.04 MPa. The tensile strength value of the biodegradable plastic obtained increased from 5 drops to 15 drops with increasing acetic acid concentration.

The effect of adding 5 to 15 drops of acetic acid concentration into 5 g corn starch and 15 to 25 ml glycerin on the elongation value of biodegradable plastics shown in Figure 3.

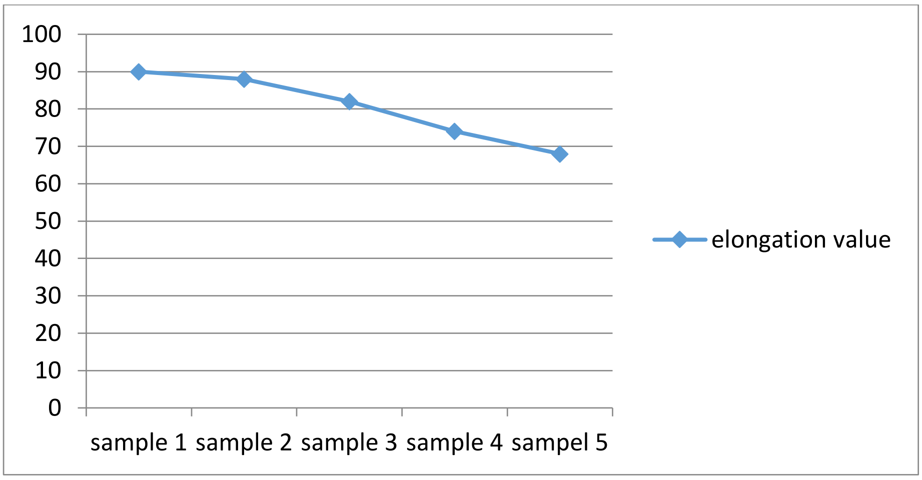


Fig 3. Graph of the effect of adding acetic acid concentration with corn starch and glycerol on the elongation value of biodegradable plastic.

From Figure 3, it can be seen that the addition of 5 to 15 drops of acetic acid and 15 to 25 ml of glycerin to 5 g of corn starch reduces the elongation value of the biodegradable plastic. The elongation values obtained were between 68 to 90%. The highest elongation value was obtained by adding 5 drops of concentrated acetic acid, 5 grams of corn starch and 15 ml of concentrated glycerin, which is equivalent to 90%.

The graph below shows the effect of adding 5 to 15 drops of acetic acid concentration to 5 grams of corn starch and 15 to 25 ml of glycerin concentration on the percent weight loss of biodegradable plastics shown in Figure 4.

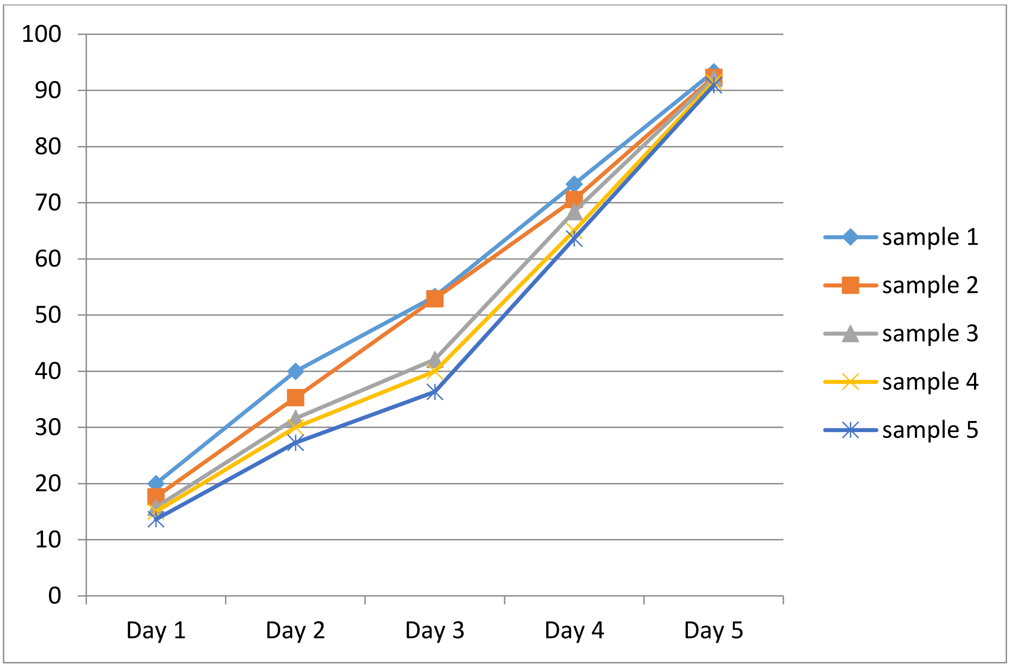


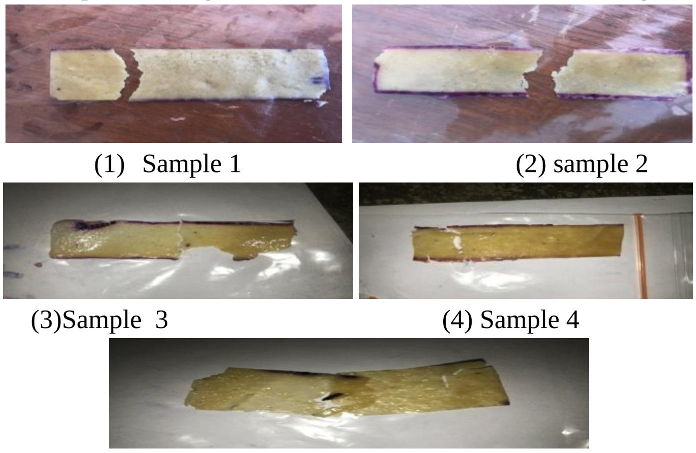
Fig 4. Graph of biodegradation test results of biodegradable plastics from the addition of acetic acid concentration with corn starch blending material and glycerol concentration.

Figure 4 shows that the weight loss rate of biodegradable plastics made from corn starch increased day by day. On the 5th day, the biodegradable plastic was almost completely degraded. This can be seen from the maximum weight loss of biodegradable plastic (93.33%) obtained by adding 5 drops of concentrated acetic acid to 5 grams of corn starch and 15 ml of concentrated glycerin. The increase in the weight loss rate of biodegradable plastics is due to the activity of microorganisms such as fungi and bacteria in the soil which causes the mass of corn starch-based biodegradable plastics to decrease over time.

The tensile strength of biodegradable plastics increased with increasing concentrations of 5-15 drops of acetic acid and 15-25 mL of glycerol. The highest tensile value was obtained with the addition of 15 drops of acetic acid concentration and 25 mL glycerol concentration, which was 50.04 MPa. The increase in the tensile strength of biodegradable plastics is due to the addition of acetic acid concentration which causes an increase in the amount of substrate constituent polymers produced and an increase in the attraction that occurs between starch and acetic acid molecules. Therefore, the durability of the resulting biodegradable plastic will be greater.

Thickness is also one of the factors that affect the tensile strength of biodegradable plastics. Based on the results of previous studies, the relationship between thickness and tensile strength is directly proportional. H. The thicker the plastic, the higher the tensile strength.

The addition of acetic acid concentration with corn starch blending agent and glycerol concentration will increase the tensile strength value produced, as shown in Figure 2. The tensile strength value of biodegradable plastics increases as the acetic acid concentration and glycerol concentration increase. Increasing the concentration of acetic acid with the mixture of corn starch and glycerol concentration, the total solids in the solution will increase, so the resulting tensile strength value will be higher. The thickness of the plastic is closely related to the tensile strength of the plastic. The thicker the plastic, the greater the tensile strength of the resulting plastic. The highest tensile strength value was obtained in the addition of 15 drops of acetic acid concentration, 5 grams of corn starch and 25 ml of glycerol concentration, equivalent to 50.04MPa. The results obtained from this study are the same as those obtained [17]. which states that the tensile strength of biodegradable plastics increases with increasing glycerol concentration. The tensile values obtained according to the Indonesian National Standard (SNI) for bioplastics range from 24.7 to 302 MPa, as shown in Figure 5.



(1) Sample 1 (2) sample 2

(3)Sample 3 (4) Sample 4

(5) Sample 5

Fig 5. Plastic after tensile test

In addition, based on Figure 3, it can be seen that the addition of acetic acid concentration from 5 drops to 15 drops and glycerol concentration from 15 ml to 25 ml caused a decrease in the elongation value of the biodegradable plastic obtained. This is because the increase in acetic acid concentration causes the resulting polymer matrix to become denser. As a result, the tensile strength of the plastic becomes stronger. so that the biodegradable plastic is more difficult to stretch or expand. This results in a reduction in the percentage elongation of the biodegradable plastic. Based on the results obtained, the elongation and tensile values of biodegradable plastics are inversely proportional to each other, i.e. the more concentration of acetic acid added, the higher the tensile strength and the elongation of the plastic will decrease.

The test results of the elongation value of biodegradable plastics obtained by adding 5 drops to 15 drops of acetic acid concentration and glycerol 15 ml to 25 ml have met the Indonesian National Standard (SNI) of biological plastics ranging from 21 to 220%. The results obtained are in accordance with the conditions obtained from the research of which states that under certain conditions, the addition of plasticizers and fillers will reduce the elongation value obtained. One of the causes is the disproportionate amount of filler and plasticizer that affects the elongation value obtained.

The highest elongation value was obtained by adding 5 drops of acetic acid concentration to 5 grams of corn starch and 15 ml of glycerol. The elongation value obtained is in accordance with the Indonesian National Standard (SNI) for bioplastics ranging from 21 to 220% [18].

Based on the results of the biodegradation test when adding acetic acid concentration to the mixture of corn starch and glycerol concentration as shown in Figure 4, the mass loss rate of biodegradable plastic is increasing day by day. The biodegradable plastic decomposed almost completely on day 5, this is indicated by the largest weight loss of biodegradable plastic obtained on day 5 with the addition of 5 drops of acetic acid concentration and 15 ml glycerol concentration equivalent to 93.33% while the mass loss of biodegradable plastic was the smallest obtained when adding 15 drops of concentrated acetic acid and 25 ml glycerol concentration, which is 90.9%. Based on the previous data analysis, the degradation of plastics resulting from the addition of acetic acid concentration to the mixture of corn starch and glycerol concentration takes a longer time. This is because the addition of acetic acid concentration to cornstarch and glycerol concentration increases the time required for the bacteria to break down the biodegradable plastic [19].

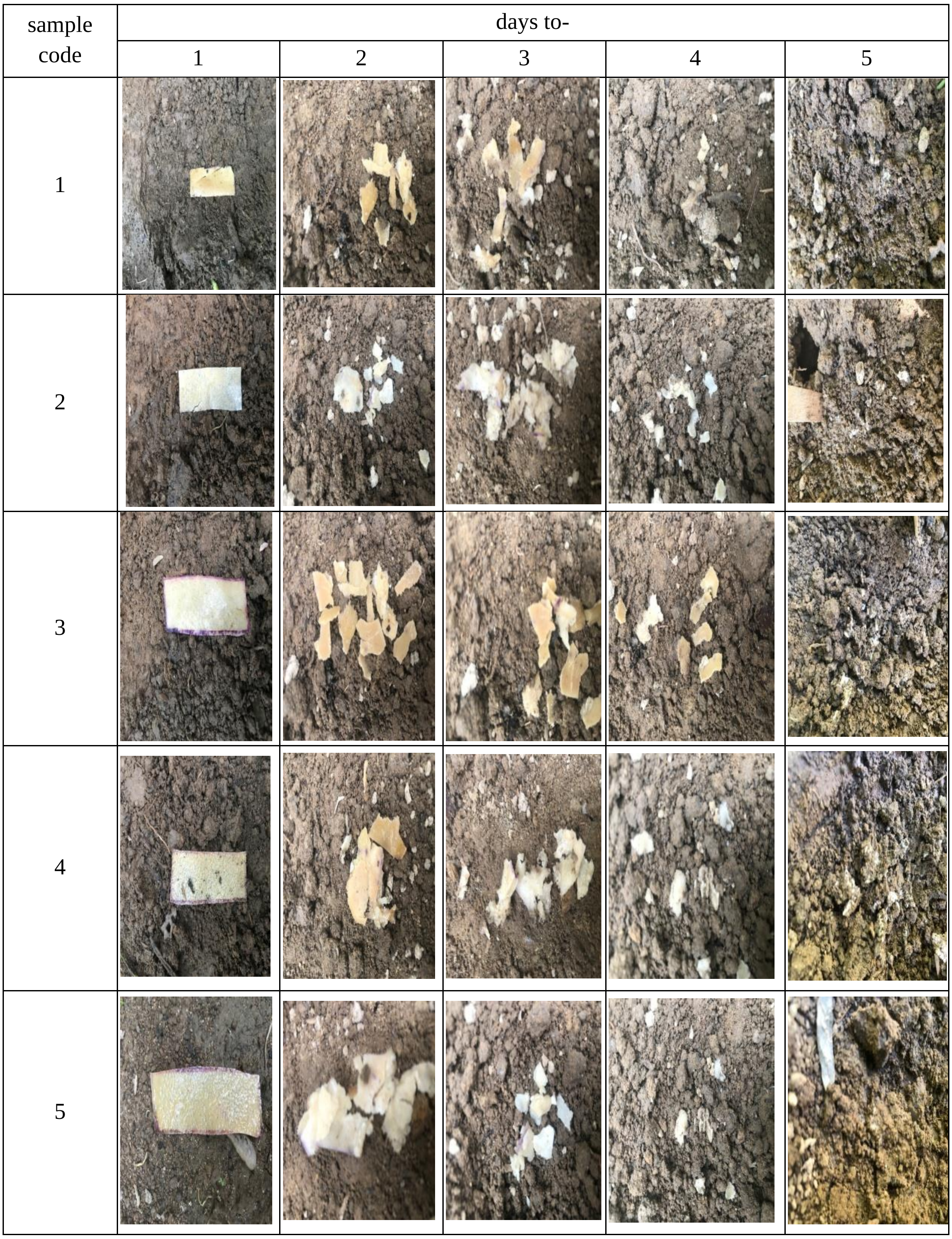


Fig 6. Physical form of biodegradable plastic biodegradation testing results biodegradable from corn starch

Based on figure 6. The increasing percentage of plastic weight loss due to the activity of microorganisms such as fungi and bacteria contributes to the decomposition of biodegradable plastics in the soil. The decomposition of biodegradable plastics starts with micro-organisms breaking or severing the plastic chain. The micro-organisms will convert the carbon in the plastic chain into carbon dioxide. This is due to the increase in acetic acid concentration with the increase in cornstarch and glycerol concentration, which increases the time it takes for the bacteria to break down the biodegradable plastic. This makes acetic acid and glycerol suitable for use as a growth medium for bacteria and microbes that play a role in the decomposition of biodegradable plastics. As a result of the biodegradation process, the molecular weight of the resulting polymer is reduced and the biodegradable plastic decomposes in the soil. The results obtained are in accordance with the conditions obtained from that the degradation of biodegradable plastics by microorganisms will take place faster if the concentration of acetic acid and glycerol used is less. Biodegradable plastic made from the addition of acetic acid concentration to the mixture of corn starch and glycerol will decompose faster than the bioplastic quality standard which states that bioplastics are fully compostable after 60 days[20].

IV. CONCLUSION

Based on the results of the previous research, it can be concluded that the addition of acetic acid with corn starch and glycerol mixing materials has an effect on increasing the tensile strength value and reducing the elongation and biodegradation values of biodegradable plastics. The addition of acetic acid with corn starch and glycerol will cause the plastic decomposition process to last longer while the percent of plastic weight loss increases from day to day. The highest tensile value was obtained by adding 15 drops of acetic acid concentration with 5 grams of cornstarch and 25 ml of glycerol concentration which is equivalent to 50.04MPa. The highest elongation or length gain was obtained by adding 5 drops of acetic acid concentration to 5 grams of cornstarch and 15 ml of glycerol concentration, which amounted to 90%. The largest decrease in resin mass was obtained by adding 5 drops of acetic acid concentration to 5 grams of cornstarch and 15 ml of glycerol concentration at 93.33%.

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