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Effects of Gum Arabic on the Quality of Bacterial Cellulose Sorbitol Plastic from Pineapple (Ananas sativus) Peel Waste

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Abstract **– Research on synthesis and characterization of bacterial cellulose sorbitol – gum arabic (BCS-GA) plastic has been conducted. The purpose of this research was to study effects of addition of gum arabic on the quality of BCS-GA plastic produced from pineapple (*Ananas sativus*) peel waste. The synthesis of BCS-GA was done by fermentation of extract of pineapple peel waste added with varied mass of gum arabic in the present of *Acetobacter xylinum* bacteria to produce BCS-GA gel. Purified BCS-GA gel was pressed under 300 psi to produce BCS-GA plastic. BCS-GA plastic was characterized to determine the physical and mechanical properties as well as the biodegradation ability. The results showed that the percentage of water content of BCS-GA gel was increased by addition of gum arabic. The swelling degree of BCS-GA plastic also increased by addition of gum arabic up to 5 gram, and then decreased. The tensile strength, elongation and modulus young were also increased by addition of gum arabic. The maximum tensile strength of plastic with 5 gram addition of gum arabic was 8.29 KN/m with 3.23% of elongation. The percentage of biodegradation plastic was also increased by addition of gum arabic. Biodegradation ability reached 50.93% with 7 gram addition of gum arabic up to 9th days of buried in soil. Thus, the addition of gum arabic increased quality of BCS-GA plastic compared to pure BC plastic, but it has not yet reached the standard of nonbiodegradable plastic quality.**

Keywords **– Gum Arabic; Bacterial Cellulose; Sorbitol; Pineapple Peel Extract.**

I. INTRODUCTION

Plastic is a material polymerization reaction products were mostly synthesized from petrochemical polymers (petroleum and natural gas) are unrenewable. These types are nonbiodegradable plastic, so it is very difficult to decompose and requires a very long time for the microbes to decompose it into biogas and biomass. The difficulty of plastic waste to decompose causing accumulation of plastic waste as one of the causes of environmental problems in the world today [1].

To save the environment from the dangers of plastic, now it has been developed a biodegradable plastic made from natural polymers that easily degraded by microorganisms naturally become environmentally friendly compounds. Natural polymer that we already know are: cellulose, protein, natural rubber and its kind. Production of biodegradable plastics can be done by using *Acetobacter xylinum* bacteria in producing cellulose. Cellulose produced by bacteria is known as bacterial cellulose (BC) [2].

Waste treatment pineapple peel into biodegradable plastics will produce many benefits. To be able to produce biodegradable plastics, it is necessary to add a plasticizer. Plasticizer is a non-volatile materials high boilers, when added to other materials can change the material properties. One of the natural plasticizers that can be used is sorbitol. Sorbitol is a plasticizer that is effective because it is non toxic and has the ability to reduce internal hydrogen bond on intermolecular bonding [3].

Some research on biodegradable plastic production has been done. Jannah [3] researched the production of biodegradable plastic by adding sorbitol to cassava starch water. The the results of these studies indicate good results for the mechanical properties of biodegradable plastic produced by increasing the addition of sorbitol. Marietta [4] concluded that plastic made from bacterial cellulose from pineapple peel waste with the addition of sorbitol can undergo rapid decomposition in the soil. This is indicated by the maximum biodegradation rate reached 59.53% with the addition of sorbitol, whereas without sorbitol biodegradation rate only 28.83% on the 9th day of burial. Besides plastic produced also have good tensile strength, on the addition of 10.5% sorbitol tensile strength value reached 8.41 kN/m whereas without sorbitol the tensile strength value is only 2.58 kN/m.

Based on the description above, it can be seen that the biodegradable plastic produced is still unable to reach the standard of synthetic plastic that we usually use today, which are SNI plastic tensile strength ranges between (24.7 to 302)x10^3 kN/m^2 [5]. Therefore, the authors are interested to continue the research from Marietta [4] with the addition of additives namely gum arabic. Expected with the addition of gum arabic will increase the tensile strength of the plastic produced. This study aims to determine the effect of the addition of gum arabic and the characteristics on the quality of bacterial cellulose sorbitol plastic from pineapple peel waste.

II. METHOD

2.1 Time and Place

This research was conducted at the Laboratory Kopertis Region X, Laboratory Quality Assurance, PT. Semen Padang and the Laboratory of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Indonesia

2.2 Equipment and Materials

Equipment used in production and characterization of bacterial cellulose were: glassware, plastic container size, cooker, stove, rags, newspaper, toilet paper, filter, rubber, mixers, knives, scissors, pH paper, technical balance, analytical balance , hot press, desiccator, vaporizer cup, iron, oven and tensile strength tolls (ASTM Testing Tenssion 1991 03:10 vol).

Materials used in this study were gum arabic, pineapple peel waste, *A.xylinum* inoculum (biochemistry laboratories, UNP), sugar, vinegar acid 25%, urea (PT. PUSRI), aquadest, sorbitol 70% (PT. Bratako), NaOH 2% (PT. Bratako).

2.3 Research Procedure

2.3.1 Synthesis of Pineapple Peel Extract

Pineapple peel extract obtained by smoothing and separating the filtrate from the pulp by filtration. The solvent used to extract is water at a ratio of 1: 1.

2.3.2 Synthesis of bacterial cellulose sorbitol - gum arabic (BCS-GA) medium

Synthesis of BCS-GA is done by heating the pineapple peel extract (1L) into the cooker and then add 100g sugar, 10g of urea, 20ml of 25% acetic acid, 10 ml of 10.5% sorbitol and gum arabic with variations in mass (0g, 1g, 3g , 5g, 7g). Heat all the ingredients until boiling. Pour the medium into a transparent plastic container with each height $\pm$ 1 cm, cover with newspaper that has been sterilized.

2.3.3 Synthesis of bacterial cellulose sorbitol - gum arabic (BCS-GA)

Into a transparent plastic container containing a medium that has been prepared above, was inoculated with starter *A.xylinum* with a ratio of 10: 1 (% v / v) and fermented at room temperature to form a bacterial cellulose sorbitol -gum arabic (BCS-GA) at least height 5 mm. During fermentation plastic containers may not be shaken.

2.3.4 Leaching of bacterial cellulose sorbitol-gum arabic(BCS-GA)

BCS-GA gel fermented products cleaned using running water for 24 hours, then purified by soaking the sheets of BCS-GA gel into NaOH 2% for 24 hours. Then washed again with clean water.

2.3.5 Synthesis of BCS-GA plastic sheets

BCS-GA gel that has been cleaned and purified was pressed by using a hot press tool with pressure of 300 psi for 20 minutes, and dried by using an iron with 350 watts of power for 5 minutes to get the BCS-GA plastic. This plastic sheet was then characterized its physical and mechanical properties, and its biodegradation capability.

2.3.6 Quality Analysis of BCS-GA plastic

2.3.6.1 Water content test

The water content was measured by weight ratio of BCS-GA gel (wet weight) before being pressed and after BCS-GA being a plastic sheet (dry weight). The percentage of water content calculated by the following equation.

$$\% \boldsymbol{WC} = \frac{\boldsymbol{wet\ weight} - \boldsymbol{dry\ weight}}{\boldsymbol{wet\ weight}} \boldsymbol{x100}\%$$

2.3.6.2 Swelling degree

Swelling degree was determined to find out how much the ability of plastic to the bulging back. The degree of swelling was measured by weight ratio of BCS-GA plastic after immersion (constant weight) with a dry BCS-GA plastic (initial weight). The percentage of swelling degrees calculated by the following equation:

$$\%SD = \frac{constant\ weight - initial\ weight}{initial\ weight} x100\%$$

2.3.6.3 Analysis of tensile strength

Tensile strength is the ability of a material to withstand a pull of dropping out. The tensile strength of BCS-GA plastic tested by using a tensile strength tools.

2.3.6.4 Elongation

Elongation is the percentage of the ability of a material to elongate. The percentage of elongation is obtained through a comparison of the length of the plastic material with the initial plastic length.

2.3.6.5 Biodegradation test

Biodegradation test is a test conducted to determine how much ability of biodegradable plastic to decompose by microbes in the soil, the easier the plastic breaks down the better the plastic is produced. BCS-GA plastic degraded for 9 days at a soil depth of 15 cm by controlling the condition of the soil used. Percentage of mass loss is calculated using the following equations:

$$\%B = \frac{initial\ weight\ - final\ weight}{initial\ weight}\ 100\%$$

III. Result And Discussion

3.1 BCS-GA Plastic

Bacterial Cellulose Sorbitol is the result of the conversion of glucose into cellulose with the addition of sorbitol as a plasticizer. Different treatments with the addition of additives such as gum arabic in the fermentation medium will produce different cellulose. The difference can be seen in Table 1.

Table 1. The Treatment of Formation of BCS-GA

Treatment	BCS-GA1	BCS-GA2	BCS-GA3	BCS-GA4	BCS-GA5
Gum Arabic Mass	0 g	1 g	3 g	5 g	7 g
Total Medium	400 ml	400 ml	400 ml	400 ml	400 ml
The Amount of Plasticizer	10 ml	10 ml	10 ml	10 ml	10 ml
Number Starter	40 ml	40 ml	40 ml	40 ml	40 ml
Container Size	24 x 17 x 4 cm	24 x 17 x 4 cm	24 x 17 x 4 cm	24 x 17 x 4 cm	24 x 17 x 4 cm
Duration of Fermentation	9 days	10 days	10 days	12 days	12 days
Thickness	6.1 mm	5.2 mm	4.3 mm	7.5 mm	3.2 mm
Cellulose Form	Thick, white, supple and easy to elongate	A little thick, white, supple and easily to elongate	A little thick, white, supple and easily to elongate	Thick, white, supple and easy to elongate	A little thick, white, very supple and easy to elongate

In Table 1 shows that the different fermentation time needed to form a cellulose fiber reaches 3.2 to 7.5 mm. BCS-GA1 takes 9 days to transform the fermentation medium into cellulose fibers by bacteria *A.xylinum* whereas for BCS-GA4 and BCS-GA5 take approximately 12 days to form a cellulose with the same medium volume. This shows that more of gum arabic addition to the fermentation medium, take long time to form cellulose fibers by bacteria.

The differences in texture of cellulose fibers produced also can be seen in the table 1. BCS-GA1 has a thick texture, white, supple and easy to elongate. BCS-GA2 and BCS-GA3 has a texture that is not too thick, white, supple and easy to elongate. Whereas BCS-GA5 texture is not too thick, white, very supple and easy to elongate.

BCS-GA plastic formed and then pressed using a press tool, after that plastic dried using iron with 350 watts of power for 5 minutes. Heating using an iron produces a better surface of the plastic sheet, which does not shrink. The results of heating plastic use iron can be seen in Figure 1.

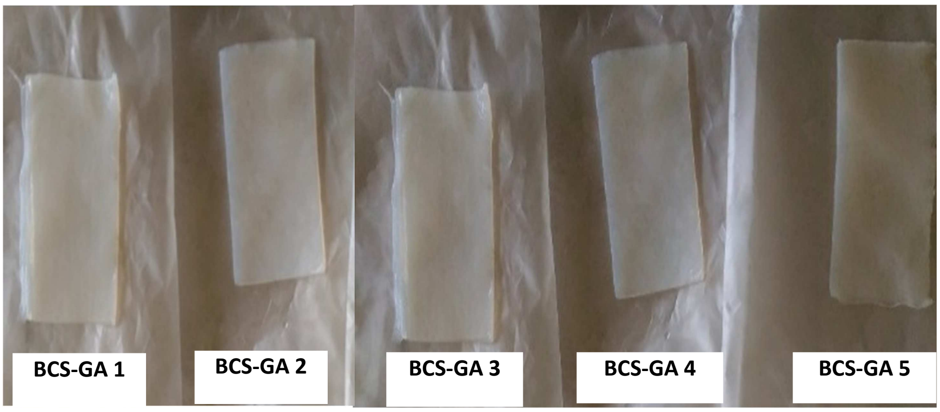

Figure 1. BCS-GA Plastic

3.2 Water content of BCS-GA

Water content on bacterial cellulose is the result of percentage division between the weight of water lost with the initial weight of bacterial cellulose [6]. Water content test is intended to determine how much water is contained in bacterial cellulose sorbitol with the addition of gum arabic during fermentation. The effect of gum arabic addition to the percentage of water content of BCS-GA plastic can be seen in Figure 2.

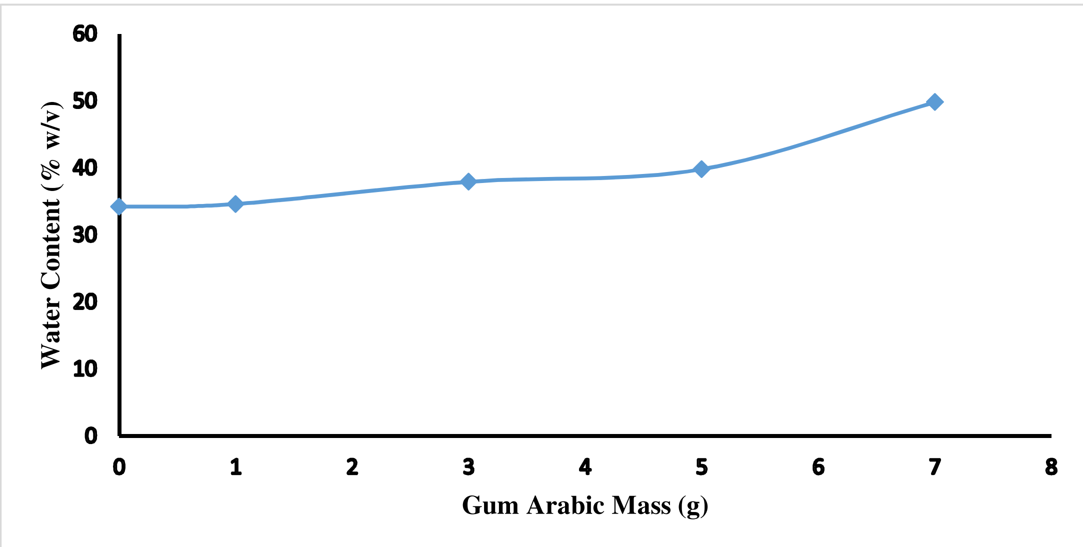

Figure 2. Effect of Addition of Gum Arabic on the Water Content of BCS-GA

Based on Figure 2 it can be seen that the water content increases with each addition of gum arabic as an additive. The water content in BCS-GA1 plastic is 34.205%, the percentage of water content was higher with the addition of gum arabic which the highest percentage of water content at BCS-GA5 was 49.815%.

According to research conducted by Iskandar [6], that the more nutrients added to the fermentation medium cause plasmolysis (dehidration) in *A.xylinum* cells, so that the formation of cellulose decreased and caused water content increased.

3.3 Swelling degrees

Water resistance test is performed to determine how much the plastic absorption of water. Plastic resistance to water is determined by the swelling test, which was the percentage of BCS-GA plastic swelling by the presence of water. Data on the effect of gum arabic addition to the percentage of swelling degree BCS-GA can be seen in Figure 3.

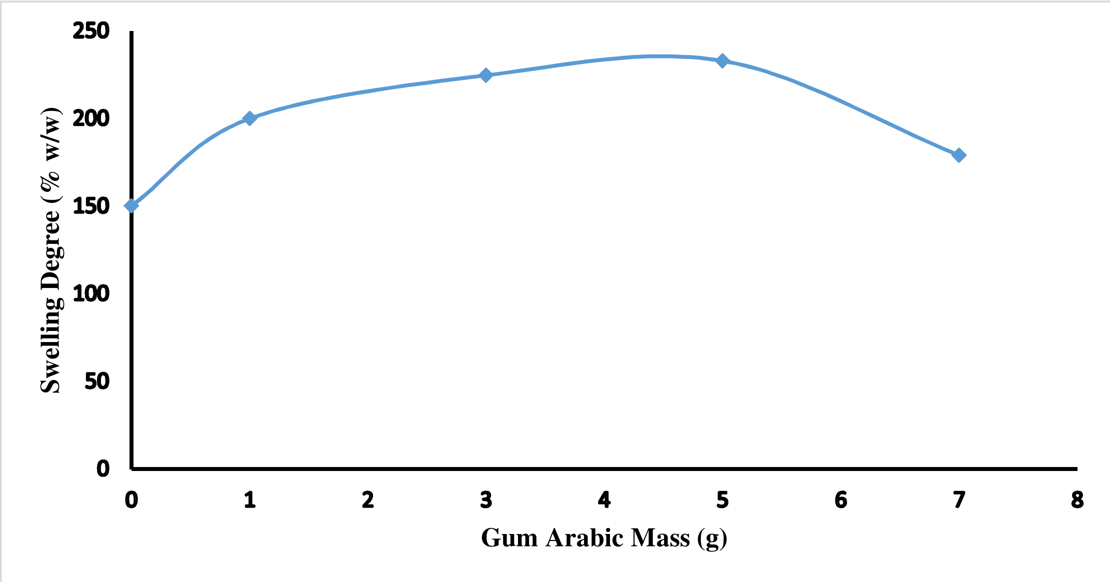

Figure 3. Effect of Addition of Gum Arabic on the Swelling Degree of BCS-GA

Based on figure 3, the percentage of swelling degree increased with the addition of gum arabic. Sweelling degree of BCS-GA1 was 150.22% and experienced a slight increase in BCS-GA2 is 199.97%, whereas in BCS-GA4 there was a very sharp increase until 232.88%. But the percentage of swelling degree in BCS-GA5 decreased to 179.05%. This indicated that the percentage of the maximum of swelling degree occurs on the addition of 5 g gum arabic (BCS-GA4). Gum arabic addition will increase to the amount of water absorbed.

According to research conducted by Bestova [7] that the amount of water absorbed by plastic increases with the increasing number of gum arabic added. This shows that the plastic is hydrophilic. Sorbitol has hydroxyl groups that can form hydrogen bonds in water and gum arabic also has hydrophilic properties, thus increasing the hydrophilic proerties of the plastic. The existence of hydrogen bonds in the sorbitol molecules tend to form intramolecular hydrogen bonds with water molecules included.

3.4 Tensile Strength of BCS-GA

Tensile strength test is done to determine the maximum force that can be held by a plastic. Tensile strength is one of the important analysis in the production of plastics, because the tensile strength can determine the quality of the plastic itself. The effect of addition gum arabic to the tensile strength of BCS-GA can be seen in Figure 4.

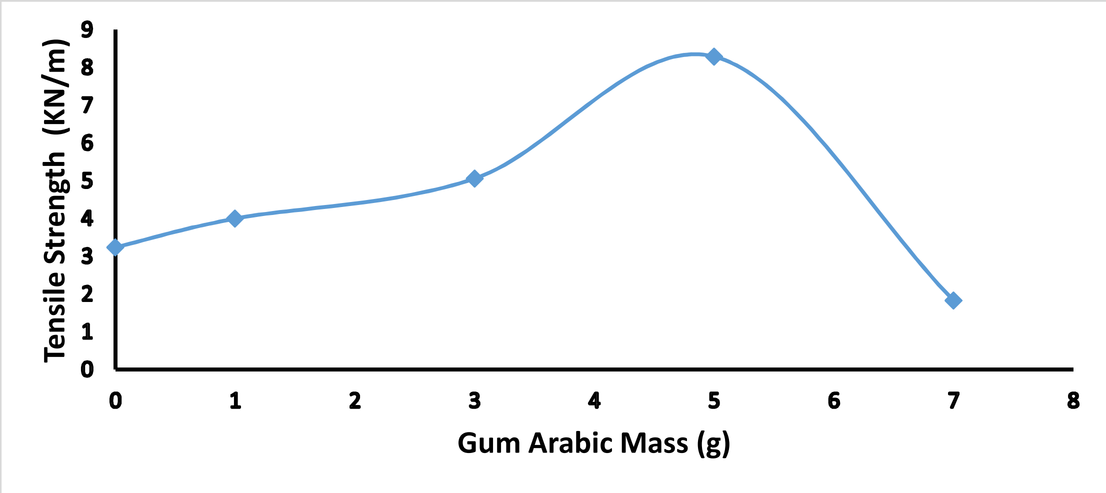

Figure 4. Effect of Addition of Gum Arabic on the Tensile Strength of BCS-GA

Based on the figure 4. tensile strength of plastic increase with the addition of gum arabic. The value of tensile strength BCS-GA1 is 3.24 KN/m and reaches a maximum at BCS-GA4 plastic that is 8.29 KN/m. While on the BCS-GA5 decreased to 1.83 KN/m. This was in accordance with the research conducted by Defira [8] which results in an increase in tensile strength value with the addition of gum arabic as an additive. The presence of gum arabic was able to bind the particles in empty space contained in the pores of the plastic. Hence, in the tensile strength test, the plastic gives a great style.

3.5 Elongation of BCS-GA

Elongation is the mechanical properties are closely related to the physical properties of the plastic. The elongation process is the maximum length change during stretching until the plastic sample is cut off. The effect of addition gum arabic to the BCS-GA plastic elongation can be seen in Figure 5.

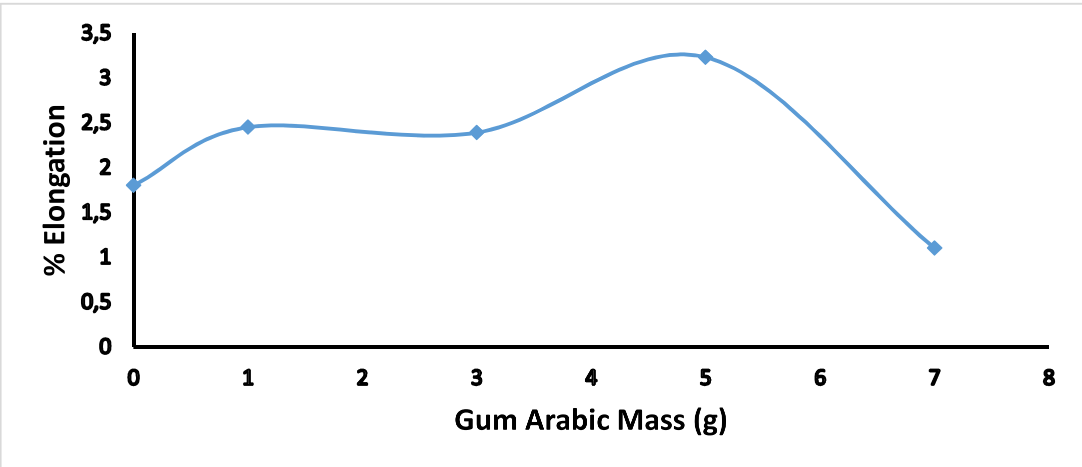

Figure 5. Effect of Addition of Gum Arabic on the Percentage of Elongation of BCS-GA

Based on Figure 5. its showed that the more gum arabic was added, it increased percentage of elongation. Elongation of BCS-GA1 was 1.8% and reached a maximum at BCS-GA4 that was 3.23%. While on the BCS-GA5 decreased to 1.1%. This was the same as that of Bestova [7], which states that the addition of gum arabic was directly proportional to the percentage of elongation.

3.6 Biodegradation of BCS-GA

Biodegradation test is a test conducted to determine the level of biodegradable plastic resistance against microbes, soil moisture, temperature, and physical chemical factors contained in the soil. The biodegradation test of BCS-GA plastic was carried out by plastic burial in the soil. The biodegradation test results of BCS-GA plastic were marked by damage to the plastic sheet after being buried for 9 day. As seen in Figure 6 where on day 0 BCS-GA plastic was not been damaged, and on the 9th days there was damage shown in the BCS-GA plastic that has been buried in the soil marked by a hollow plastic surface.

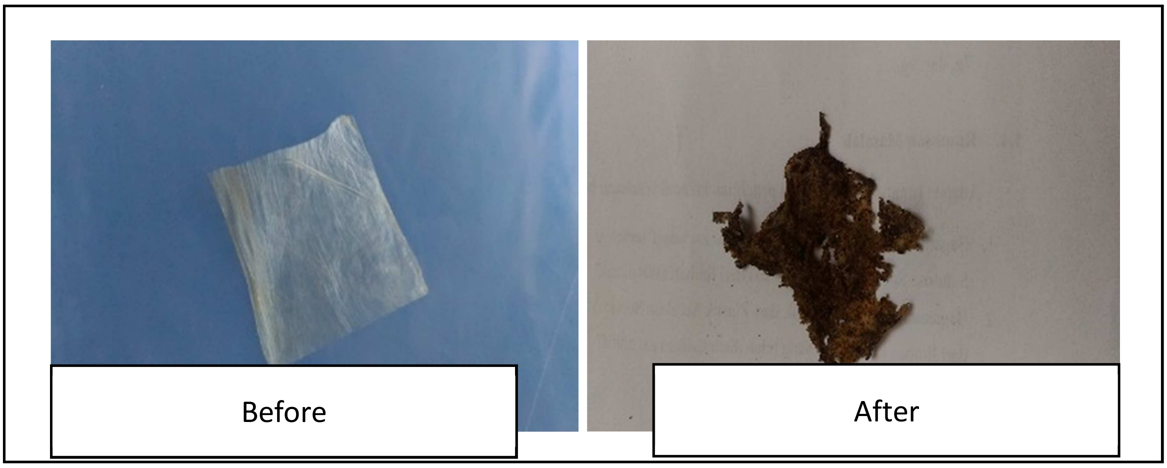

Figure 6. Differences BCS-GA Before and After Biodegradtion Process

The plastic produced was easily biodegradable because the raw materials used were materials that easily interact with water and microorganisms and sensitive to the effects of chemical physics. The effect of gum arabic to the BCS-GA plastic biodegradation can be seen in Figure 7.

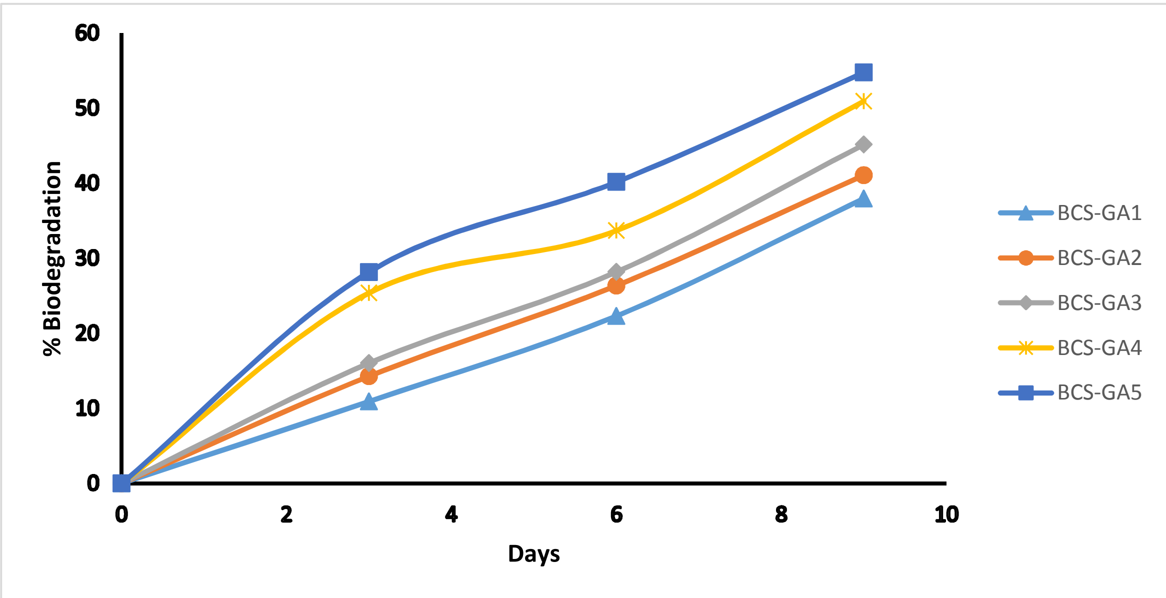

Figure 7. Effect of Addition of Gum Arabic on the Percentage of Biodegradation of BCS-GA

Based on the figure 7, it can be seen that the addition of gum arabic caused BCS-GA plastic degraded faster. The most rapidly degraded BCS-GA plastic was found at BCS-GA5 plastic that was 54.75%. This result was in accordance with Jannah [3], which states that the degradation ability of a plastic was related to the ability to absorb water. That was, the more water content of a material, the more easily degraded. Water is a medium for most bacteria and microbes, especially those in the soil. So that the water content causes the plastic to become more easily degraded. Marietta [4], states that sorbitol and starch have OH groups which can initiate hydrolysis reactions after absorbing water from the soil. So that the starch polymer decomposes into small pieces until it disappears in the soil. The polymer will be degraded due to the process of damage or deterioration due to the breaking of the chain bonds in the polymer.

IV. CONCLUSION

Based on research results can be concluded that the more arab gum was added to BCS-GA, the longer the fermentation time was needed. Gum Arabic increased the water content and swelling degree of BCS-GA. Similarly, its increased the tensile strength and elongation of BCS-GA. The more gum arabic was added, the faster the plastic degraded. Thus, the addition of gum Arabic increased quality of BCS-GA plastic compared to pure BC plastic, but it has not yet reached the standard of no biodegradable plastic quality.

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