American Journal of Sciences and Engineering Research

E-ISSN -2348 – 703X, Volume 4, Issue 6, 2021

The Addition of Gum Arabic Influence on the Quality of Plastic-Glycerol Biodegradable Bacterial Cellulose-Based of Coconut Water (*Cocos Nucifera*)

Selvi Valentina Gultom[1], Ananda Putra[2]

[1,2]*Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Jln. Prof. Dr. Hamka, Air Tawar, Padang, West Sumatra, Indonesia.*

ABSTRACT: *The maximum results from the mechanical test obtained were the addition of 3% gum arabic with a tensile strength value of 72.19 Mpa, elongation 18.54 Mpa, elasticity 1507.13 Mpa. In the analysis of functional groups with the addition of gum arabic does not have a new group or physical changes occur. The degree of crystallinity with the addition of 3% gum arabic has a high degree of crystallinity compared to pure SB. In the plastic biodegradation test with the addition of gum arabic, the most easily degraded cellulose plastic was gum arabic bacteria 1%. The degree of crystallinity with the addition of 3% gum arabic has a high degree of crystallinity compared to pure SB. In the plastic biodegradation test with the addition of gum arabic, the most easily degraded cellulose plastic was gum arabic bacteria 1%. The degree of crystallinity with the addition of 3% gum arabic has a high degree of crystallinity compared to pure SB. In the plastic biodegradation test with the addition of gum arabic, the most easily degraded cellulose plastic was gum arabic bacteria 1%.*

Keywords: *Coconut Water, Bacterial Cellulose, Biodegradable Plastic, Gum Arab*

I. INTRODUCTION

Plastic is a synthetic polymer that has a large molecular weight with a high number of aromatic rings and complex bonds. Plastics are widely used in various things such as packaging for food, beverages, school supplies, offices, and various other sectors. The large number of uses of plastic is because plastic has advantages including being economical, strong, transparent, not easily broken and flexible [10].

Given the dangers posed by plastic, an alternative is needed in the form of plastic that is environmentally friendly and safe for health. One of them is biodegradable plastic, where this biodegradable plastic can be used like conventional plastic and is a plastic that is safe for the environment because it is easily biodegradable [3].

Biodrgradable plastics can be made from natural polymers with the addition of *Acetobacter xylinum* which can be naturally degraded by microorganisms into environmentally friendly compounds. *Acetobacter xylinum* is the most efficient type of bacteria in producing cellulose with coconut water as a medium which is rich in nutrients such as sugar, protein, fat and minerals that are good for bacterial growth. Cellulose produced by the addition of *A. Xylinum* is a type of bacterial cellulose .

In the manufacture of biodegradable plastics, it is necessary to add plasticizers that are useful for improving the physical properties of the resulting biodegradable plastics and plasticizers on biodegradable plastics. One of the best plasticizers is glycerol. Glycerol is a plasticizer that has the ability to reduce hydrogen bonds between polymers the largest compared to sorbitol, propylene glycol and polyethylene glycol. Glycerol is hydrophilic so it tends to absorb a lot of watervapor [5].

 Received-02-11-2021, Accepted- 11-11-2021

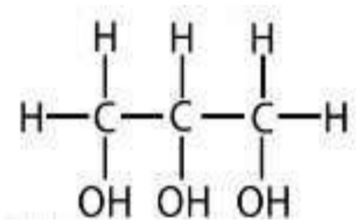


Figure 1. The structure of glycerol

Based on the research conducted by Alpira regarding biodegradable plastic with the addition of glycerol from cassava waste, it shows that the biodegradable plastic produced has a weakness, namely that the mechanical properties of biodegradable plastic do not match the JIS Z1707 standard. Therefore, the authors are interested in continuing the research by adding gum arabic as an additive so that the mechanical properties of biodegradable plastics are obtained according to the JIS Z1707 standard.

II. MATERIALS AND METHODS

2.1. Tools

The tools used in the manufacture and characterization of bacterial cellulose are: glass, plastic containers, stoves, rags, newspapers, tissue, rubber, scissors, pH paper, technical scales, analytical balances, irons, desiccators, vaporizer cups, iron, oven and toll tensile strength (ASTM Testing Tenssion 1991 03:10 vol).

2.2. Material

This study used ingredients including aged coconut water from coconut milk sales waste, gum arabic, *A. Xylinum* inoculum (biochemistry laboratory, UNP), granulated sugar, 25% acetic acid, urea, aquadest, 2% glycerol NaOH.

2.3. Pro Manufacture Of Glycerol-Gum Arabic Bacterial Cellulose Plastics (SBG-GA)

The process of making PEG bacterial cellulose using the method carried out by Agustin (2019). Put old coconut water in a saucepan and heat it until it almost boils, then add 600 g of sugar, 6 g of urea, 10 mL of PEG 400 14%, and 12 mL of acetic acid, then heat until it boils. After boiling, put the sample in a plastic container and let it sit until it reaches room temperature. After reaching room temperature, it was inoculated with *A. Xylinum* starter, then fermented for 2 weeks until it reached a thickness of at least 0.5 cm.

2.4. Bacterial Cellulose Purification

Bacterial cellulose that has been fermented for approximately 2 weeks and has formed bacterial cellulose which has reached its thickness is then purified using 2% NaOH by soaking bacterial cellulose in 2% NaOH for 24 hours.

2.5. Synthesis of Biodegradable Plastics

SBG-GA which has been washed and then cut to size according to the size of the test then coated with non-woven cloth and pressed using an iron for ± 15 minutes at maximum temperature, so that the water content is lost, this plastic sheet will be characterized by testing its physical and mechanical properties

2.6. Water Content Test

Measurements were made by weighing the initial weight of the cellulose and the final weight by means of an oven at 105^{o}C until a constant weight was obtained.

$$\% \text{ KA } = \frac{\text{Bb} - \text{Bk}}{\text{Bb}} \text{x } 100\%$$

2.7. Swelling

The results of the dry sample on the water content test were continued by immersing the plastic in 20 mL of water for 3 days, then weighing it until it weighed constant (W2).

$$\% \text{ Swelling } = \frac{\text{W2} - \text{W1}}{\text{W1}} \text{x } 100\%$$

2.8. Tensile Strength Test

The tensile test is the maximum stress that the plastic can withstand when it is pulled before the plastic breaks [8]. The plastic sample is clamped at both ends using a tensile strength tool, then the tool is operated until the sample breaks.

$$\text{Tensile Strength (MPa)} = \frac{\text{F}}{\text{Ao}}$$

2.9. Elongation

The tensile strength or elongation test is carried out with the same steps as the tensile strength test.

$$\%\ \text{Elongation} = \frac{\text{strain at break (mm)}}{\text{initial length (mm)}} \times 100\%$$

2.10. Elasticity Test

Elasticity test on biodegradable plastic is carried out in the same way as tensile strength and elongation tests.

$$\text{E} = \frac{\sigma}{\varepsilon}$$

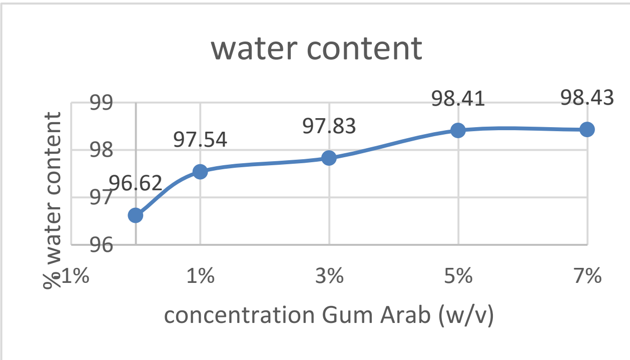
2.11. Biodegration Test

It is carried out using the method used by Gunawan (2015). The Biodegradation analysis of SBG & SBG-GA plastic sheets was carried out by burying biodegradable plastic sheets in the soil. With a size of 5x5 cm with a depth of 15 cm. Then buried in the ground for 9 days.

$$\%\ \text{Weight (W)} = \frac{\text{W1} - \text{W2}}{\text{W1}} \times 100\%$$

2.12. FTIR (Fourier Transform Infra Red Spectrophotometry)

Samples were cut in size 1x1 cm, before carrying out the test, the sample holder was cleaned first using CH_2OH. After cleaning the sample, the sample is placed on the sample holder and operate the tool. The Fource Gauge contained in the swing arm is set with a wave number of 90-100 cm^{-1} (for solid samples).



2.13. XRD (X-Ray Diffraction)

XRD testing in the form of nata Plastic is cut in size of 0.5 x 0.5 cm. The sample pieces are placed above the sample holder and then inserted into the XRD tool to see the degree of crystallinity of the plastic.

$$\%\ \text{Kristalinitas} = \frac{\text{Ic} - \text{Ia}}{\text{Ic}} \times 100$$

III. RESULT AND DISCUSSION

3.1. Water Content

The water content test aims to determine how much water is contained in bacterial glycerol cellulose with the addition of gum arabic during fermentation. The effect of the addition of gum arabic on the percentage of water content of the sample image can be seen in Figure 2:

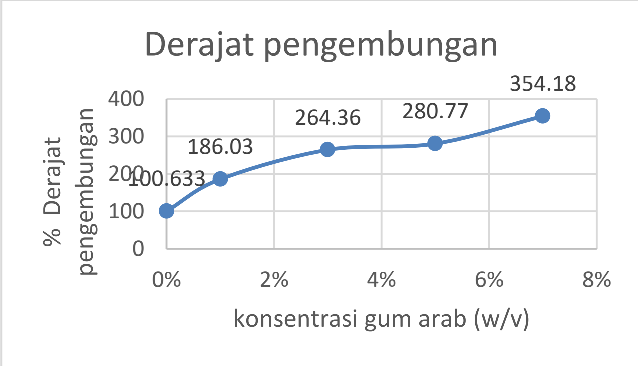


Figure 2. The Effect of Arabic Gum Addition on the Water Content of SBG-GA

Based on Figure 2, it can be seen that there was an increase in the percentage value of the water content with the addition of gum arabic as an additive. The water content of SBG-GA1 is ± 96.62%, the percentage of water content is higher with the addition of gum arabic where the percentage of water content has an increase in SBG-GA5 which is ± 98.41 to SBG-GA7 which is ± 98.43%. Because gum arabic has good properties to bind water. This ability is influenced by the hydrophilic nature of many hydroxyl groups (-OH). The water bound to the gum arabic will then form a gel so that the water is difficult to evaporate [9].

3.2. Degree Of Swelling

The degree of swelling is one of the parameters of the physical properties of biodegradable plastic which states how much the sample can swell when interacting with the solvent (water) over a certain period of time. The effect of the addition of gum arabic on the percentage of the degree of swelling of the sample can be seen in Figure 3

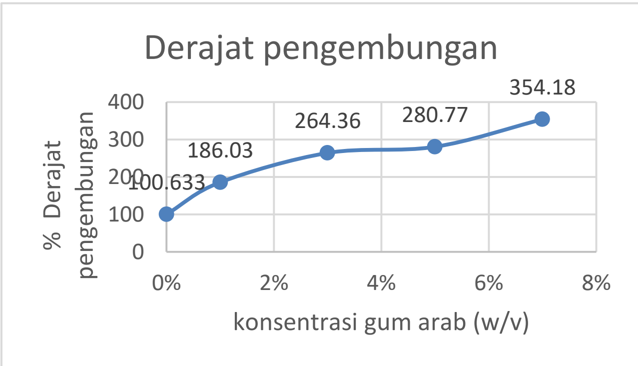


Figure 3. The Effect of Addition of Chitosan on the Water Content of Biodegradable Plastics

The water content will decrease with increasing concentration of chitosan used for soaking. The highest water content was found in bacterial cellulose without chitosan immersion which was 99.26% and the lowest water content was in bacterial cellulose with 10% chitosan immersion which was 92.38%. This can happen because the water content in bacterial cellulose without chitosan soaking is replaced by chitosan, because the concentration of chitosan is higher than the concentration of water contained in bacterial cellulose without chitosan immersion. This situation is in accordance with the theory of diffusion, namely the movement that occurs in the solvent from a higher concentration to a lower concentration [17].

3.3. Tensile Strength

The higher the tensile strength, the better the quality of the biodegradable plastic, bacterial cellulose, gum arabic glycerol, produced. The effect of the addition of gum arabic on the tensile strength of SBG-GA plastic can be seen in Figure 4.

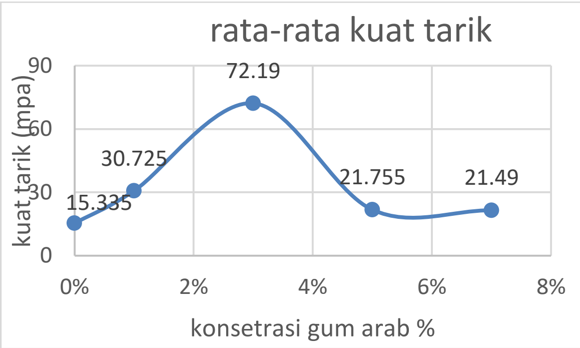


Figure 4. The Effect of Gum Arabic Addition on the degree of swelling of SBG-GA

B The value of tensile strength in the addition of gum arabic has increased by the addition of gum arabic as an additive, where the presence of gum arabic is able to bind particles in the empty space contained in the plastic pores [4]. And getting the optimum value for the tensile strength of SBG-GA3% plastic is 72.19 Mpa. SBG-GA5% and SBG-GA7% plastics decreased, this was due to the matrix in SBG-GA plastic having passed the saturation point, so that with the addition of gum arabic which was varied the food no longer affected the tensile strength value [2]. Overall, the tensile strength value of SBG-GA plastic has met the minimum standard of tensile strength set by SNI JIS Z1707.

3.4. Elongation

Elongation is a mechanical property that shows the maximum plastic length change when obtaining a tensile force until the plastic breaks. The effect of the addition of gum arabic on the plastic elongation of SBG-GA can be seen in Figure 5.

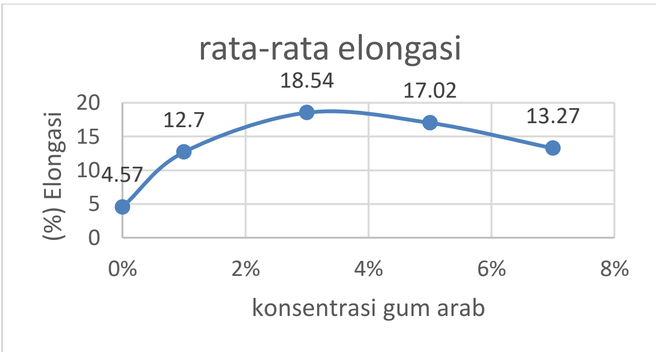


Figure 5. Effect of Addition of Gum Arabic on Plastic Elongation of SBG-GA

The elongation test with the addition of gum arabic can be seen in Figure 6, it increases this shows the nature of gum arabic is directly proportional to the elongation [4], and decreased in SBG-GA 5% and SBG-GA7% decreased because it had reached its optimum point. The value of the elongation of cellulose glycerol bacterial gum arabic plastic has met the standard elongation value set by SNI JIS Z1707, which is >10%.

3.5. Elasticity

Elasticity is the ratio of the value of stress (stress) to strain (strain). The effect of the addition of gum arabic on the elasticity of SBG-GA can be seen in Figure 6.

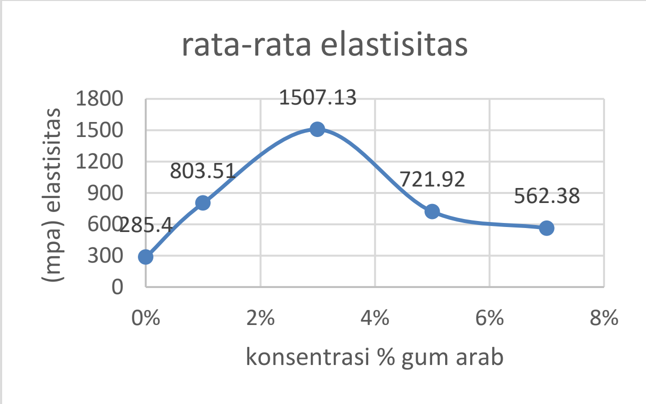


Figure 6. Effect of Addition of Chitosan on Elongation of Plastics

The elasticity test with the addition of gum arabic in Figure 6 increases. This shows that gum arabic can form molecular interactions of polymer chains to increase the speed of viscoelasticity and mobility of polymer chains [6] and experienced a decrease in SBG-GA5 and SBG-GA7 because the tensile strength and elongation tests are directly proportional. The elasticity value of SBG-GA has met the standards set by the JIS Z1707 standard, which is greater than 0.35 MPa.

3.6. FTIR

Functional group analysis aims to determine the differences in the functional groups of biodegradable plastics with the addition of gum arabic. FTIR testing was carried out at wave numbers 4000-600 cm^{-1}. The results of the FTIR test for biodegradable plastics can be seen in Figure 7. The FTIR test was carried out on samples of SB, bacterial glycerol (SBG) and bacterial glycerol-gum arabic cellulose (SBG-GA 3%).

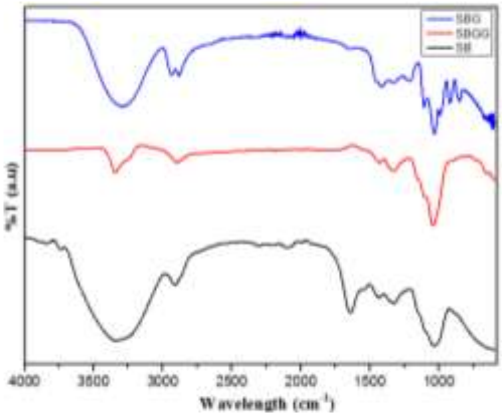


Figure 7. FTIR Spectra of SBG-GA

The first spectrum (SB), second spectrum (SBG) and third spectrum (SBG-GA3%) showed the presence of OH bonds at wave numbers 3500-3200 cm^{-1} , CH bonds at wave numbers around 3000-2840 cm^{-1} and C=C bonds. C in numbers 1620-1610 cm^{-1} and CO numbers in wave numbers 1075-1020 cm^{-1}. Based on the functional group analysis test using FTIR, it shows that there is no new functional group formed. This shows in the process of making bioplastics accompanied by the addition of addictive substances which is a physical blending process [7].

3.7. XRD

This XRD analysis aims to see the degree of crystallinity and produces sharp peaks, while the amorphous structure will produce widened peaks, while the difactogram graph of the three bioplastic samples is shown in Figure 8.

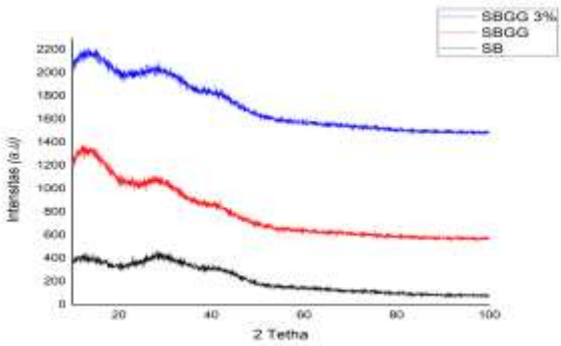


Figure 8. SBG-GA XRD Diffractogram

SB which is located at 2θ namely at 14°, 16°, 23°, and 34° The degree of crystallinity of the SB is 75.04% SBG has dominant peaks at an angle of 2Ɵ between 80, 280 , 420 and has a degree of crystallinity of 91.06% and SBG-GA3 has dominant peaks at an angle of 2Ɵ between 80-360 with a degree of crystallinity of 94.27%.

3.8. Biodegradation

Biodegradation test aims to determine the ability of plastic degradation obtained in a certain time interval. The biodegradation of SBG-GA plastic that has been buried for 9 days has caused damage to the SBG-GA buried in the ground which is marked by a perforated and damaged surface, while the biodegradation test graph can be seen in Figure 9.

.

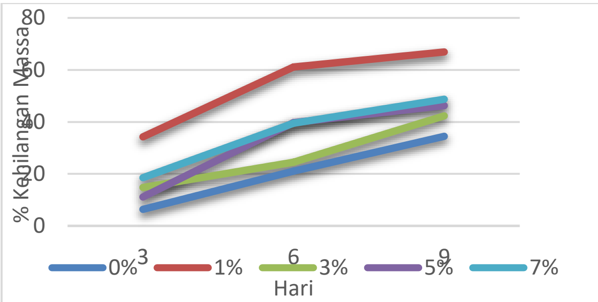


Figure 9. FTIR Spectrum of Biodegradable Plastics

It can be seen that the addition of gum arabic causes the plastic to be easily degraded. With variations in the time of the addition of gum arabic which was added for 3, 6 and 9 days, the plastic was degraded. 1% SBG-GA plastic shows the most easily degraded. This is because gum arabic is hydrophilic, so it is more easily degraded [4].

IV. CONCLUSIONS

Based on the research that has been done, it is obtained conclusion :

1. The effect of adding gum arabic additives to the manufacture of SBG-GA plastic shows that the higher the concentration added, the longer the plastic will take to form. The best quality plastic can be seen in the addition of 3% gum arabic based on tensile strength and elasticity.
2. The effect of adding gum arabic as an additive to biodegradation plastic is more easily degraded as the concentration of gum arabic increases. In this study, 1% SBG-GA variation was the fastest degraded.

V. ACKNOWLEDGMENTS

The author would like to thank the supervisors who greatly contributed to my research and study, thank you to the chemistry laboratory, Department of chemistry, Faculty of Mathematics and Natural Sciences, Padang State University for providing facilities and support.

VI. REFERENCES

[1] Anggarini, F., & Sundari, S. (2013). *Info Artikel*. *2*(2252).

[2] Darni, Y., Lismeri, L., Hanif, M., & Evaniya, D. S. (2019). *Peningkatan Kuat Tarik Bioplastik Dengan Filler Microfibrillated Cellulose Dari Batang Sorgum*. *18*(2), 37–41. Https://Doi.Org/10.5614/Jtki.2019.18.2.1

[3] Fauzi Akbar, Zulisma Anita, & Hamidah Harahap. (2013). Pengaruh Waktu Simpan Film Plastik Biodegradasi Dari Pati Kulit Singkong Terhadap Sifat Mekanikalnya. *Jurnal Teknik Kimia Usu*, *2*(2), 11–15. Https://Doi.Org/10.32734/Jtk.V2i2.1431

[4] Gunawan, A. (2019). *Effects Of Gum Arabic On The Quality Of Bacterial Cellulose Sorbitol Plastic From Pineapple (Ananas Sativus) Peel Waste*. 181–188.

[5] Hanani, Z. A. N., Roos, Y. H., & Kerry, J. P. (2014). International Journal Of Biological Macromolecules Use And Application Of Gelatin As Potential Biodegradable Packaging Materials For Food Products. *..A. Nur Hanania, Y.H. Roosb, J.P. Kerryc*, *71*, 94–102.

[6] Ibekwe, C. A., Oyatogun, G. M., Esan, T. A., & Oluwasegun, K. M. (2017). *Synthesis And Characterization Of Chitosan / Gum Arabic Nanoparticles For Bone Regeneration*. *5*(1), 28–36. Https://Doi.Org/10.12691/Ajmse-5-1-4

[7] Marbun, E. S., (2012). Sintesis Bioplastik Dari Pati Ubi Jalar Menggunakan Penguat Logam Zno Dan Penguat Alami Selulosa. Skripsi, Universitas Indonesia.

[8] Panjaitan. (2017). *Plastic Waste Is One Of Environmental Problem Especially In Indonesia . Conventional Plastic Is Made From Synthetic Polymer That Is Made By Petroleum Which Hard To Recycle Or Break Down By Microorganism . Bioplastic Is The Answer Of This Problem . Starch*. *4*(1), 1–7.

[9] Santoso, B., Pratama, F., Hamzah, B., & Pambayun, R. (2011). *Pengembangan Edible Film Dengan Menggunakan Pati Ganyong Termodifikasi Ikatan Silang [Development Of Edible Film By Using Modified Cross-Linking Ganyong Starch] Hasil Dan Pembahasan*. *Xxii*(2), 105–109.

[10] Zibethinus, D. (2015). *Jurnal Bahan Alam Terbarukan*. *4*(1), 21–26. Https://Doi.Org/10.15294/Jbat.V4i1.3770