Study on biodegradable plastic from sago with addition of glycerol and sorbitol

C Amni*, Ismet¹, S Aprilia², Mariana²

¹Department of Industrial Engineering, Serambi Mekkah University, Banda Aceh, Indonesia
²Department of Chemical Engineering, Syiah Kuala University, Banda Aceh, Indonesia

*Corresponding E-mail: chairul.amni@serambimekkah.ac.id

Abstract. The synthesis of biodegradable plastic film was carried out by using sago starch as main raw material, water as solvent, glycerol and sorbitol as plasticizer. Sago was selected as raw material for plastics not only because it's cheap and easy to obtain, but also the utilization of sago is still very minimal. The research aimed to make the environmental friendly plastic, and to be better than the conventional ones. Parameters plasticizer of the research were glycerol and sorbitol by 7%, 8% and 9% weight of total mass, and the weight ratio of sago starch and water were 1:5, 1:7 and 1:9. The characteristics of plastic film that tested were the test mechanical of characteristic (tensile and elongation) by electronic system Universal Testing Machines, the water adsorption test in accordance with put the film in water for 24 hours, and biodegradability test by buring in the ground. The results showed that the highest tensile strength was 0.363 kgf/cm² from concentration of sorbitol 7% and ratio of sago starch and water 1:5. The other way, the highest elongation percent result obtained was 125% from concentration of glycerol 9% with ratio of sago starch and water 1:9. The lowest water adsorption test obtained was 11.11% from concentration 7% glycerol with ratio of sago starch and water 1:7 and the degradable process was performed in 9-12 days.

1. Introduction
The glorious issue of global warming and the environment has become a problem in this century. One important problem concerning the environment in the world or in Indonesia in particular is about plastic waste. Practical and consumptive lifestyle demands encourage the use of plastics to grow each year. The increasing amount of plastic waste has become a thing that can threaten the stability of the environmental ecosystem, considering that the plastic used today is conventional plastic. Plastic waste also has a limited cycle to a certain quality that can still be converted into other products, after that it will still become waste.

Plastic has become the main needs of society today. These problems are not immediately resolved through banning or reducing the use of plastic. This provides an opportunity for the development of biodegradable plastic packaging. So far, a number of agricultural products that have the potential to produce biodegradable plastics are known, namely potatoes, corn, sago, and cassava. Generally the main compounds used are carbohydrates (cellulose and starch) and protein. The choice of main raw materials is very dependent on the use of plastics because each raw material provides different plastic product characteristics [1].

One of the interesting things to be developed now is sago starch. So far, sago as a source of carbohydrates is less in demand by the community as a food product, because of its sticky texture and so far its use is only for traditional ingredients or a mixture of wheat flour in making cakes. Because of the lack of various processed from sago, it is necessary to diversify the use of sago starch as a raw material for making biodegradable plastics which is expected to replace the use of...
conventional plastics so that it becomes an alternative solution to the current problems of waste, environment and global warming. Some previous studies have been carried out to produce bioplastics. But plastic Berbah’s raw starch has several kelemahan. This bioplastic is less resistant to water (hydrophilic) and its mechanical properties are still low.

2. Material and Methods
This research was conducted at the Laboratory, Department of Environmental Engineering, Faculty of Engineering, University of the Veranda of Mecca, Banda Aceh, and the analysis of tensile strength and elongation was carried out at the FMIPA Laboratory of Syiah Kuala University. This research was carried out in March - July 2019, the main tool used in this research is hot plate, 1000 ml baker glass, alcohol thermometer, aluminum foil, impeller, and stir bar. The materials used in this study are sago starch as the main raw material taken from Aceh Besar, Sorbitol and glycerol which function as plasticizers and aquadest which function as solvents.

2.1 Research Procedure
Sago starch solution in accordance with the operating variable is put into a glass baker, then covered with aluminum foil and placed on a hot plate accompanied by a stirrer. The solution is stirred until it dissolves. The purpose is to stir so that no lumps or grains occur. Heating is carried out until gelatinization temperature (70 °C) occurs. Starch pastes which have been formed are removed from the hot plate and cooled for 5 minutes until it reaches a temperature of 50 °C. Then glycerol or sorbitol are added based on variations in the composition while continuing to stir to prevent clumping until it reaches room temperature (25-30 °C). The thick solution formed is then printed on a glass casting whose edge has been coated with duct tape with a thickness of 0.3 mm. Thin film (film) is left for 24 hours. After drying the layer is removed from the mold and stored in a closed container [2].

2.2 Tensile Strength and Percent Elongation Test
Tensile strength test is performed using the Electronic System Universal Testing Machines with the following working procedures: The sample to be tested is installed between two clamps or grips, then tightened the clamp by using a bolt lock. The sample size used is 10 cm x 1 cm. Screen tensile and elongation values at zero right by pressing the "Display Change".

2.3 Water Absorption Test
Water absorption test is carried out with the following work procedures: The plastic to be tested is weighed as initial weight. Soaked plastic that has been weighed initially for 24 hours, and weighed in weight. Water absorption is calculated and the results obtained on each variation of plastic.

3. Result and discussion
3.1 Characterization
After the plastic is formed, several tests / characterizations are carried out to support the purpose of making the plastic, i.e. as a plastic bag that can load certain items with a certain capacity and mass. Characterization includes plastic mechanical test (tensile and elongation strength), water absorption, and biodegradability test.

Tensile strength (tensile strength) is the maximum pull of the last before the break. This test aims to see the changes that occur in the mechanical strength of plastics. Tensile strength testing is done using the Electronic System Universal Testing Machines based on the ASTM D638 standard. Data on the tensile strength test results can be seen in appendix A. The tensile strength values obtained for the
addition of glycerol ranged from 0.016 kgf/cm² - 0.056 kgf/cm², while the tensile strength values obtained for the addition of sorbitol ranged from 0.096 kgf/cm² - 0.363 kgf/cm².

Figure 1. Effect of Plasticizer Composition on Tensile Strength by Comparison of Weight of Sago Starch and Water 1:5.

Figure 1 showed changes in the tensile strength of plastic films with the addition of plasticizers 7%, 8%, and 9% with a ratio of sago starch and water 1:5. The highest tensile strength value was produced on the addition of sorbitol with a composition of 7%, 0.363 kgf/cm². However, the addition of glycerol with a composition of 7% and sorbitol with a composition of 9% cannot be tested for its tensile strength because the mixture of starch and water in the comparison is still very viscous. At low glycerol levels, the polymers formed have a fragile structure, whereas at high sorbitol levels it also shows that amylopectin in the film has insubstantial properties causing the plastic structure to be cracked.

3.2 Elongation

Elongation is the maximum length change of the film before it is disconnected (4) high concentrations of plasticizer, then it will be the higher the value elongasinya. The higher the elongation value of a plastic, the better the quality of the plastic. This percentage of elongation is also influenced by the content of glycerol and sorbitol added to the mixture for the manufacture of these plastics. The test data percent elongasi can be found in appendix A. The elongation value in the plastic film produced by the addition of glycerol ranged from 105% - 125% while the addition of sorbitol ranged from 105% - 120%.
Figure 2. Effect of Plasticizer Composition on Percent Elongation with Weight Comparison of Sago Starch and Water 1: 5.

3.3 Water Absorption Test

One of the properties of conventional plastic is that it is impermeable to liquids. Water absorption is much of its water is absorbed by the film of plastic in percent after the test sample immersed in water at room temperature for 24 hours. The water fills the empty spaces in the plastic film. The lower the percent water absorption obtained then the better quality of the plastic. The value of water absorption results of the study ranged from 14%, 28% - 75%.

Figure 3. Effect of Plasticizer Composition on Water Absorption by Comparison of Weight of Sago Starch and Water 1: 5.

Figure 3. shows the change in water absorption from plastic films with the addition of plasticizers 7%, 8%, and 9% with a ratio of sago starch and water 1: 5. The addition of the composition of glycerol 7% and sorbitol 9% cannot be read by the graph because no plastic is produced, this is because the mixing of sago starch, water, and plasticizer is still too viscous.
3.4 Decomposition Test (degradability)

Plastic biodegradable is interpreted as the film packaging which can be recycled and can be destroyed naturally. The process of biodegradation of these pesticides in the environment begins with the chemical degradation stage, namely by the process of molecular oxidation producing low molecular weight polymers. The next process is the attack of microorganisms (bacteria, fungi and algae) and enzyme activity (intracellular, extracellular). Examples of microorganisms such as bacteria phototrophic (Rhodospirillum, Rhodopseudomonas, Chromatium, Thiocystis), forming endospores (Bacillus, Clostridium), and gram-negative aerobic (Pseudomonas, Zoogloa, Azotobacter, Rhizobium), Actinomyces, Alcaligenes (5). This test is performed by way of burying the film of plastic with the destruction of the target for 2 weeks.

![Figure 4. Effect of Plasticizer Composition on the Degradation Time with a Weight Comparison of Sago Starch and Water 1:5.](image)

Figure 4. show the test process biodegradable is happening, where after do the burial for 1 minggu, observations show flood wa plastic film has decomposed naturally in soil, although still remaining slightly, resulting by many factors, including microorganisms decomposing factors, soil moisture and soil moisture content. The main reason for making plastic packaging based on bioplastic is its nature which can be easily destroyed or degraded. Generally after packaging waste dumped into the ground, will undergo a process of destruction of nature through the process of photodegradation (sunlight), degrade the chemical (water, oxygen), biodegradation (bakteri), nor degraded mechanically (wind) (6).

In the following week, after another excavation, the plastic film was clean/degraded completely. The condition of the soil used for the burial process is very moist and contains a lot of water and it is possible that there are many microbial pesticides that play a role. The character of biodegradability has been practically proven that the resulting plastic film can be easily decomposed in soils biologically or chemically and is certainly safe for the environment. So how chemical, plastic film dihasilkan fish are overtly biodegradable, it is caused by the material standard that is in use is the organ of raw materials ik and natural easily interact with water and noodles kro organism e other.
4. Conclusion

Tensile strength decreases with increasing concentrations of plasticizer, and compared between glycerol and sorbitol, N use values obtained sorbitol highest tensile strength with a ratio of weight of sago starch and water 1: 5 at a concentration of 7% that is equal to 0.363 kgf / cm$^2$. The lowest water absorption was obtained in the composition of glycerol 9% with the weight ratio of sago starch and water 1: 9 was 11.11%.

References

[1] Bourtoom, T. 2006. Effect of Some Process Parameters on The Properties of Edible Film Prepared From Starch. Department of Material Product Technology. Songkhala. London.

[2] Erizal, 2010. Synthesis and Characterization of Cross-bonded Polyacrylamide (PAAM) Superabsorbent Hydrogel - Carrageenan Gamma Irradiation Results. Indo, J.Chem. 10 (1), 12-19.

[3] Farida. SP (2009). The Role of Glycerol as Plasticizer in Corn Starch Films with Corncob Fine Powder Fillers. Thesis, University of North Sumatra, Medan.

[4] Nadarajah, K., 2005 Development and Characterization of Antimicrobial Edible Films from Crawfish Chitosan, Dessertation in the Department of Food Science, university of Paradeniya.

[5] Prasetyo, R and Rudiana Agustini, 2013. Effect of Glycerol Mass on Biodegradable Plastic Melting Points of Cassava Starch. Journal of Chemistry UNESA, Vol.2 No.1.

[6] Purwanti, Ani. 2010. Analysis of Sorbitol Plasticized Chitosan Tensile Strength and Elongation. Journal of Technology, vol 3 no 2, December 2010, 99-106.

[7] Sanjaya, I Gede and Tyas Puspita. 2011. Effect of Addition of Khitosan and Glycerol Plasticizer on the Characteristics of Biodegradable Plastics from Cassava Skin Waste starch. Thesis of Chemical Engineering Department, ITS Surabaya.