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Preparation Of Bioploymer From Musa Acuminata (Banana) Peels

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Abstract— The banana fruit's peel was selected as it is a waste material rich of starch. In particular, starch is one of the most attractive feedstock for the development of biodegradable polymers because it is relatively inexpensive, abundant and renewable. Thus, starch-based can be a replacement for conventional plastics which is becoming decrease. The starch consists of two different types of polymer chains, which called amylose and amylopectin, made up of adjoined glucose molecules. Chemicals such as sodium hydroxide (NaOH), hydrochloric acid (HCl), Glycerol and sodium bisulfite (NaHSO3) were prepared since they are the most helpful agent for the formation of bioplastic film. The hydrochloric acid was used to remove the part of the starch which is amylopectin that will inhibit the formation of a film. The sodium hydroxide (NaOH) was used in the experiment for the starch neutralization and glycerol acts as a plasticizer which make the plastic less brittle. In order to improve the shelf-life, sodium bisulphite ($NaHSO_3$) was added as an antimicrobial. Analysis such as water absorption was observed to determine the physicochemical properties of the biopolymer prepared. From experimental results showed that sample 1 seemed to have the strong cross-linked structure which it absorbed the lowest percentage of water of about 56.95%. This result may due to phase separation and crystallization of glycerol by making the film more soluble which high in absorption capacity and also affected by the concentration of NaOH and HCl in the biopolymer.

Keywords—banana peel; biopolymer; biodegradability; starch-based.

I. INTRODUCTION

Plastic is derived from the Greek (plastikos) means fit for moulding, and (plastos) means moulded that is commonly known and used in daily life. Plastics are typically polymers of high molecular weight, which has molecules containing long carbon chains as their backbones with repeating units. The structure of these repeating units and types of atoms play an important role in determining the characteristics of the plastic. These long carbon chains are well packed together by Van der Waals forces between large molecules, and form a strong, usually ductile solid material [1]. Also, additives are usually added for the manufacturing of commercial plastics, in order to improve the strength, durability or give the plastic specific characteristics. However, commercial plastics can pose a serious environmental problem and human health impacts due to its toxicity and characteristics. Many kind of plastics are from polyethylene, polypropylene, polystyrene, polyamide, polysulfone, polyester, polyurethane, polycarbonate, polyvinylchloride, and polyacrylonitrile [2]. The source for most commercial plastics is petroleum which is considered as a non-renewable resource. Even though less than 5% of the petroleum is used in plastics manufacturing, the renewability of the source is often a concern as it takes millions of years for fossil fuels to be replace [3]. Separation of different types of petroleum based recyclable plastics from other solid wastes is a difficult process, hence only a very small percentage of plastics are recycled. In addition, most of the commodity plastics such as bottles, cups and many others made out of petroleum are non-compostable and non-biodegradable.

Plastic has advantages such as cheaper, can be produced in a large amount, light, transparent, flexible, and good water resistant. However, plastic also has weaknesses which low heat resistant and poor ductility, easily torn, and can be polluted because it produces toxic fumes when it is burnt, since it is non-biodegradable materials [2]. In addition, plastics that usually use is one of an important thing to consider about because it affects our food in a packaging which presence of certain substances such as Bisphenol A (BPA). Using BPA helps to increase the shelf life of many food products, however, exposure to BPA has caused increased cases of thyroid and it is also potentially carcinogenic which can cause prostate and breast cancer due to high exposure of BPA [4]. Nowadays, people rely more and more heavily on plastic, for instance, the plastic bags because they are easy to use, more practical and widely available. However, in Malaysia, the usage of plastics has been reduced by the government since its enforcement in 2011 which is Malaysia introduced the No Plastic Bag Day (NPBD) program to discourage the use of plastic bags for carrying items purchased from shopping store. In the programme, participating stores do not give out free plastic bags but instead it is charge a levy of MYR0.20 (USD0.06) for each new plastic bag requested by customers during the program. Furthermore, Malaysians on average produce an estimate of 19,000 tons of solid waste annually and plastic waste represents 24% of total solid waste as stated by Shahariah Asmuni [5].

In recent years, there has been a great interest to use renewable biomass in the manufacture of high quality, cost-competitive and biodegradable consumer goods. Bio-plastic have been considered as the most promising materials for this purpose which it is also known as edible film because it has characteristic of biodegradable and harmless [6]. Bio-plastics are non-toxic and produced naturally from natural polymers. They do not contain additives such as phthalates or Bisphenol A (BPA), that are harmful to health and do not change the flavour or scent of the food contained. They are an organic compound that can break down much faster and recycling them take less energy. Bio-plastics are mostly made of starch such as soy bean, potato, corn and other plant starch, where the required raw materials are from renewable resources. Bio-plastics have a potential to be truly sustainable replacement for petroleum-derived plastics and the plastics industry could finally free itself from its dependence on fossil fuels. With global climate change challenges and its various effects on ecosystems, the issue of bio-waste has captured the attention of governments, environmental and social organizations, businesses and academics, becoming the first priority [7]. In term of biodegradability, bio-plastics will degrade naturally by microorganisms, such as bacteria and fungi, over period of time. Manufacturing bio-plastics are significantly give less greenhouse affect which can reduce carbon footprint. Hence, they can absorb into the earth as they give no harm to plants and animals underground, instead of providing nutrients.

This paper study on starch is a valuable component while being one of the most abundant on earth. Starch is a suitable raw material for the production of new environmentally-friendly bio-plastics. Starch is readily transformable using existing technologies and low-cost commodity that can be easily refined. Starch-based plastics can be transformed into edible and compostable products [8]. Banana fruit was selected as it is one of the famous fruits in Malaysia and easy to get with the greatest production and consumption. Hence, fruits rich with starch are preferred in the making of bioplastic and the banana peel is rich with starch. The composition of a banana peel in (g/100g dry matter) is approximately contains Protein: 8.6±0.1, Fat: 13.1±0.2, Starch: 12.78±0.9, Ash: 15.25±0.1 and total dietary fibre: 50.25±0.2 [9]. The starch is obtained from the banana peels as starch content declines from 20-30% to 1-2%, but starch amount could be as high as 11% depending on variety [10]. Starch consists of two major components, amylose and amylopectin, which different in their degree of branching and molecular size. The starch will provide the repeating units of glucose molecules that form the polymer chains. The different composition of these starches will affect the mechanical properties of the resulting plastics form. Various combinations of additives such as sugar, glycerol, and glue will also be investigated to explore their contributions to the properties such as flexibility, brittleness, and clarity [11]. The use of waste in production of bio-plastic, can significantly improve the economics of the biomaterials by leading sources of raw materials from starch which are renewable, biodegradable and non-toxic, thus can be extracted with high purity by simple industrial process. These factors are determining the agro-industrial potential immense of the starch [12].

II. Experimental Procedure

2.1. Materials

Sodium hydroxide (NaOH), Hydrochloric acid (HCl), Sodium Bisulphite ($NaHSO_3$) and Glycerol were obtained from QRëC (Asia) Sdn.Bhd, distilled water, banana peels.

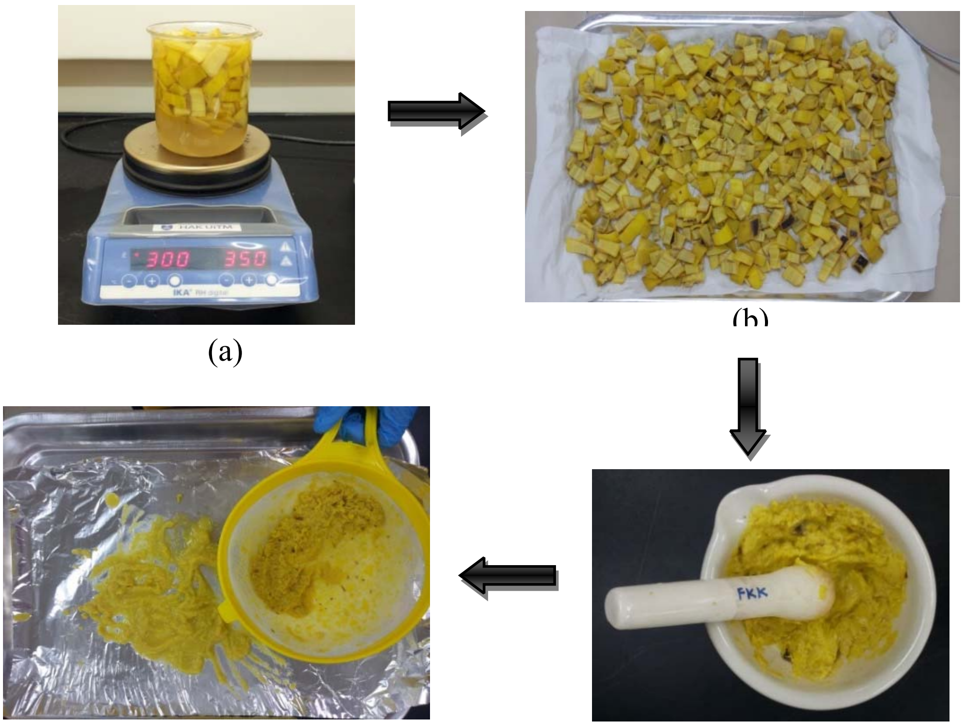
2.2. Extraction of Starch

Figure 1 shows the process of starch extraction. Firstly, banana peels were washed properly and were cut into small pieces.

Next, they were added to a beaker which filled with sodium bisulfite solution and boiled for 30 minutes at 300˚C (a). After the boiling process, the peels were transferred to an oven tray and decanted off the water until dry (b). This was done for removing any impurities and soften the peels for easy preparation of paste. Then they were mashed in a mortar and pestle (c) and sieved to obtain the starch (d). The starch was measured to a desired mass as shown in Table 1, Experiment 1.

Table 1: Variation of Glycerol Concentration and Acid-Base Condition of NaOH and HCl

Experiment	Sample	Starch (g)	Glycerol (mL)	NaOH (mol)	HCl (mol)
1	1	25.0	2.0	0.1	0.1
	2	25.0	2.0	0.5	0.5
	3	25.0	2.0	0.1	0.5
	4	25.0	2.0	0.5	0.1
2	5	25.0	3.0	0.1	0.1
	6	25.0	4.0	0.1	0.1
	7	25.0	5.0	0.1	0.1
	8	25.0	6.0	0.1	0.1



(a) (b) (c) (d)

Figure 1- Preparation of starch

2.3. Preparation of Bio-Polymer Film

The banana paste was placed in a beaker. For the samples in Table 1, 3 ml of HCl, 2 ml of glycerol and 3 ml of NaOH were added, alternately, and the mixture was mixed together. Then, the mixture was poured into a moulding and put in the oven at 130˚C for 30 minutes, then let it cool overnight. It is necessary to bake in a proper composition of paste and proper time for the strength of the sheet. The experiment was repeated with a different volume of glycerol as shown in Table 1, Experiment 2.

2.4. Determination of Water Solubility

Solubility in water is important to take into consideration because it is kind of property of starch based films. This may be required to enhance product integrity and water resistance before it consumes to the potential applications. It was defined as the percentage of the dry matter of film which is solubilized after the immersion in water. Four samples were carried out on circle probes which the diameter, D is about 15.5 cm and 2 mm thick. The initial dry matter of each film was obtained after drying for a night. The samples were weighed and immersed in 100 ml of distilled water for 20h at room temperature and the weight loss was evaluated to obtain the final dry weight of the film. The percentage of water solubility (WS%) was calculated according to equation (1), where the solubility relates with the initial mass, W_i, and final mass, W_f.

$$WS(\%) = \frac{[(W_i - W_f)]}{W_f} \times 100\% \tag{1}$$

III. Results And Discussion

3.1. Effect of the Palsticizer on The Biopolymer Films

Glycerol is selected due to its low cost, non-toxicity and it is liquid at room temperature. It is a material that makes the polymer chain molecules bend and slide to each other more easily, which add to the flexibility and elasticity of the plastic even at the very low temperatures. Moreover, too much of it makes the plastic curl up in a microwave oven and turn into gum. Glycerol tends to lose its effectiveness as a plasticizing agent over time which is leading to a slow increase in brittleness. Hence, the addition of glycerol to the starch showed an influence on the opacity of the films which make it looks clear and has almost same with "synthetic plastic".

3.2. Effect on Biodegradability

The degradation period for biopolymer is directly depend on the micro-bacteria that occur in the sample. By adding the sodium bisulfite ($NaHSO_3$), the degradation period should be much longer than sample that is not added with sodium bisulfite which acts as antimicrobial. Without using it, the starch films will degrade quickly which it will turn from yellow to dark brown color. Before trial in Table 1 were running, one experiment was conducted where the banana peels were not dipped in $NaHSO_3$ resulted to be brown black after drying and started to decay within a week. However, when banana peel is dipped in $NaHSO_3$ the color of starch film still remains in its origin color as shown in Figure 2.

(a) Sample 2 (b) Sample 3

Figure 2-Colour Analysis of Sample 2 and Sample 3 (Before and After)

Based on Figure 2(a), it can be seen that after 10 weeks, the colour of sample 2 was a little darker than sample 3. Both samples contain same concentration of 0.5M of HCl, but different concentration of NaOH which contain of 0.1M and 0.5M of NaOH, as shown in Table 2. Through the observation, it can be concluded that high concentration of alkaline solution can slow down the browning effect that caused by oxidation and the microorganisms growth.

Table 2: Effect of the Acid-Base Condition of NaOH and HCl on Sheet Formation of the Sample

Experiment	Sample	Starch (g)	Glycerol (mL)	NaOH (mol)	HCl (mol)	Sheet Formation
1	1	25.0	2.0	0.1	0.1	Formed
	2	25.0	2.0	0.5	0.5	Formed
	3	25.0	2.0	0.1	0.5	Formed
	4	25.0	2.0	0.5	0.1	Formed

Table 3: Effect of Variation of Glycerol Concentration on Sheet Formation of the Sample

Experiment	Sample	Starch (g)	Glycerol (mL)	NaOH (mol)	HCl (mol)	Sheet Formation
2	5	25.0	3.0	0.1	0.1	Formed
	6	25.0	4.0	0.1	0.1	Partially Formed
	7	25.0	5.0	0.1	0.1	Not Formed
	8	25.0	6.0	0.1	0.1	Not Formed

3.3. Effect of Water Absorption

Table 4 shows the percentage of water absorption for the samples at different concentration of NaOH and HCl. The starch films prepared in water solubility test only for the first four samples, as the sheet formed was literally adequate. The water absorbed by the films increases gradually at the ranged of 55% to 75%. Sample 1 absorbed the lowest percentage of water of about 56.95%, followed by sample 3, sample 2 and sample 4 at the percentage of 66.79%, 67.88%, and 72.66%, respectively. The lower the concentration of glycerol used, the lower the percentage of water absorption of the sample [13]. This result may have been due to phase separation and crystallization of glycerol by making the film more soluble which high in absorption capacity. The addition increases the water content of material through sorption/desorption mechanisms which tends to uptake water molecules from the environment into the film [14].

Table 4: Mass of Starch Film and Percentage of Water Absorbed by the Sample

Experiment	Sample	Starch (g)	Glycerol (mL)	NaOH (mol)	HCl (mol)	Sheet Formation	Mass (g)		Percentage of Absorption (%)
							Before	After	
1	1	25.0	2.0	0.1	0.1	Formed	4.447	10.330	56.95
	2	25.0	2.0	0.5	0.5	Formed	4.499	14.006	67.88
	3	25.0	2.0	0.1	0.5	Formed	4.077	12.276	66.79
	4	25.0	2.0	0.5	0.1	Formed	2.748	10.053	72.66

Other than glycerol concentration, different concentration of acid-base condition also affects the differences in the solubility of the prepared starch films. High concentration of NaOH allows higher absorption of water (Sample 4) compared to high concentration in HCl (Sample 3). Based on M.A. Bertuzzi, the amylose polymer is more flexible in alkaline solution than in neutral water [15]. It is found that, the HCl used in the procedure hydrolyzes amylopectin and prevents it from making hydrogen bonds with the amylose polymer chain and forming rows of polymer chains, acquiring a crystalline structure. Figure 3 shows the before and after weight differences of the sample and the percentage of water absorbed by the sample.

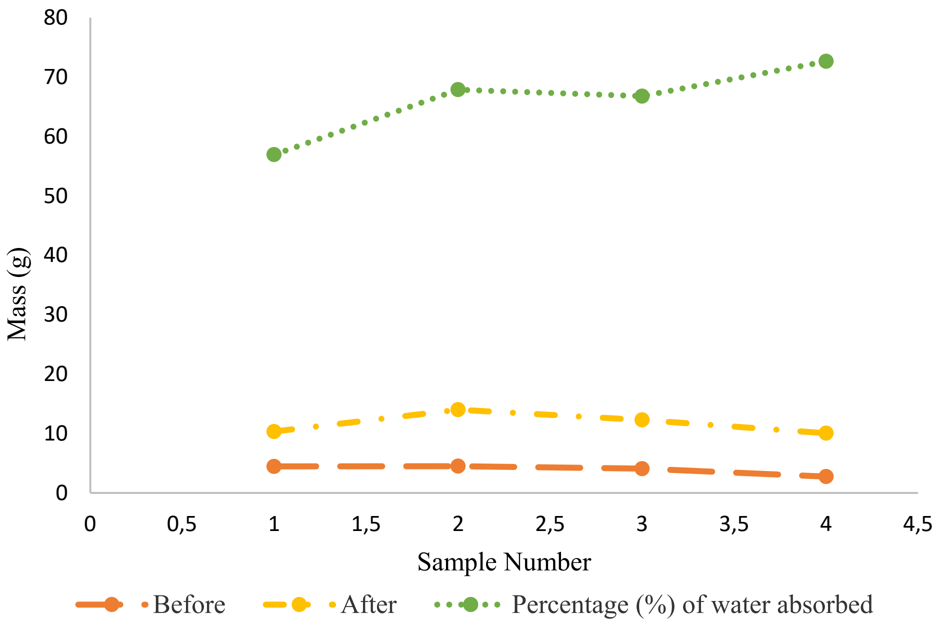


Figure 3 – Effect of water absorbed by four different samples

IV. Conclusion

The biopolymer synthesized from *Musa Acuminata* (Banana) peels provide an alternative for bioplastic production. The experiment succeeds in proving that banana peels could be one of the precursor for biopolymer production which able to reduce the adverse effect to the environment of plastic made up from non-renewable and non-biodegradable sources. Since, degradation of the biopolymer depends on the micro-bacteria occur in the sample, the banana peel was soaked with sodium bisulfite ($NaHSO_3$) prior experiment to slow down the degradation effect and increasing the time before the biopolymer degrade. Glycerol concentration and the acid-base concentration affects the percentage of water absorbed by the biopolymer samples. Higher concentration of glycerol increases the water absorption ability of the biopolymer. Alkaline concentrated biopolymer has higher water absorption ability compared to acid concentrated biopolymer. For sample 1 to sample 4, it showed that the samples have polymer characteristic in term of plastic sheet formation and water uptake. Whereas, sample 5 to sample 8 seems to be failed to form polymer also do not have polymer characteristic and the samples' color were darkening after drying. Hence, the selection of bananas is very important in order to get the large amount of starch content such as the green-yellow banana which is not totally ripe. Thus, molding container used also should take to account which it can affect the condition of the samples.

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References

[1] Ningwei Li, D. M., Seonhee Park, "Reduce, Reuse, and Replace: A Study on Solutions to Plastic Wastes", Worcester Polytechnic Institute, 2009

[2] Pudji Astuti, A. A. E., "Antimicrobial Edible Film from Banana Peels as Food Packaging", . American Journal of Oil and Chemical Technologies, 2(2), 2014.

[3] Zaki Kuruppalil, P. D., "Green Plastics: An Emerging Alternative for Petroleum Based Plastics?" . The First International Conference on Green and Sustainable Technology, 2011

[4] Soto, A. M., & Sonnenschein, C., "Environmental causes of cancer: endocrine disruptors as carcinogens. Nature Reviews Endocrinology", 6, 363-370, 2010.

[5] Shahariah Asmuni, N. B. H., Jamaliah Mhd. Khalili, Zahariah Mohd Zain., "Public Participation and Effectiveness of the No Plastic Bag Day Program in Malaysia". Procedia - Social and Behavioral Sciences(168), 328-340, 2015.

[6] Melissa Gurgel Adeodato Vieira, M. A. d. S., Lucielen Oliveira dos Santos, Marisa Masumi Beppu., "Natural-based plasticizers and biopolymer films: A review." *European Polymer Journal, 47*(3), 254-263, 2011.

[7] Piergiuseppe Morone, V. E. T., Pasquale Falcone., "Assessing the potential of biowaste for bioplastics production through social network analysis", Journal of Cleaner Production(90), 43-54, 2015.

[8] Ali Shah, A., Hasan, F., Hameed, F., & Ahmed, S., "Biological degradation ofplastics: A comprehensive review". Biotechnology Advanced(26), 246-265, 2008.

[9] Phatcharaporn Wachirasiri, S. J. a. S. W., "The effects of banana peel preparations on the properties of banana peel dietary fibre concentrate". Songklanakarin Journal of Science and Technology, 6(31), 605-611, 2009.

[10] Domenico Sagnelli, K. H. H., Eric Leroy, Agnès Rolland-Sabaté,Sophie Guilois, Jacob J.K. Kirkensgaard, Kell Mortensen, Denis Lourdin,Andreas Blennowa., "Plant-crafted starches for bioplastics production". Carbohydrate Polymers(152), 398-408, 2016.

[11] Jane Wissinger, R. H., Aaron Johnson, Carla Ahrenstroff, Laura Seifert., "Make It and Break It: Bioplastics from Plant Starch", University of Minnesota, 2015.

[12] Camila de Barros Mesquitaa, M. L., Célia Maria Landi Francoa, Sarita Leonela, Emerson Loli Garciaa, Thaís Paes Rodrigues dos Santos, "Characterization of banana starches obtained from cultivars grown in Brazil", International Journal of Biological Macromolecules 89, 632-639, 2016.

[13] A. Shafqat, N. Al-Zaqri, A. Tahir, A. Alsalme, "Synthesis and characterization of starch based bioplatics using varying plant-based ingredients, plasticizers and natural fillers", Saudi Journal of Biological Sciences, 1739-1749, 2021.

[14] Novalia Rachmawati, R. T., Roni Widianto."Mechanical properties and biodegradability of acid-soluble chitosan-starch based film", Squalen Bulletin of Marine & Fisheries Postharvest & Biotechnology, 1(10), 1-7, 2015.

[15] M.A. Bertuzzi, M. A., J.C. Gottifredi.," Physicochemical characterization of starch based films", Journal of Food Engineering 82(82), 17-25, 2007.