Multidisciplinary Applied Research and Innovation Vol. 1 No. 1 (2020) 38-44

MARI

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN : 2773-4773

Biodegradable Banana Peels-Based Plastic – A Review

S N A Razak[1,2]*, NA Yahaya[1], R N A Rohmadi[1], N S Nordin[1]

[1]Department of Science and Mathematics, Center for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Muar, 84600, JOHOR

[2]Microelectronics and Nanotechnology - Shamsuddin Research Centre (MiNT-SRC), University Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, JOHOR, Malaysia

DOI: https://doi.org/10.30880/mari.2020.01.01.005
Received 00 Month 2020; Accepted 01 Month 2020; Available online 02 Month 2020

Abstract: This research purposely focused on synthesis of bioplastic material by using banana peels. To achieve the main objective, the properties of bioplastic produced in terms of its strength, chemical compositions, and physical properties is being studied. Bioplastic was prepared by using banana peels as possible replacement to the conventional plastic material. Making bioplastic from banana peels as a substitute for traditional petroleum-based plastic is believed to be a successful key to enhance efficiency of the plastic industry. Glycerol is added as plasticizer which increases its flexibility. To inhibit growth of bacteria and fungi sodium metabisulphite is used. The degradation of bioplastic starts after three to four months from the date of manufacture. The atmospheric condition also affects the degradation period of bioplastic. The result showed that the plastic produced could bear the weight one and half times more than petroleum plastic. Bioplastic film can sustain the weight near about two kilograms, and which have enough tensile strength. The bioplastic prepared from banana peels that can be used as packaging material or as a carrying bag.

Keywords: Bioplastic, biodegradable plastic, banana peels.

1. Introduction

Bioplastic is a plastic made from renewable sources such as plants like corns, tapioca, potatoes, algae, and also bananas. Bioplastic are fully or partially bio-based and biodegradable plastic [1]. Bioplastic used starch, cellulose, or other biopolymers to substitute the polymer chain in the petroleum-based plastic. Petroleum-based plastic is a plastic that is made from petroleum and not degradable. Worldwide production of plastic has reached 200 tonnes per year [2]. This statistic shows that plastics has become one of the most important materials used on an everyday basis. All industries nowadays used plastic in many activities such as packaging, created products, and many more. The massive growth of petroleum-based plastic had led to the massive volume of non-degradable waste material [3]. This is because petroleum-based plastics took 500 years to degrade completely and release toxic

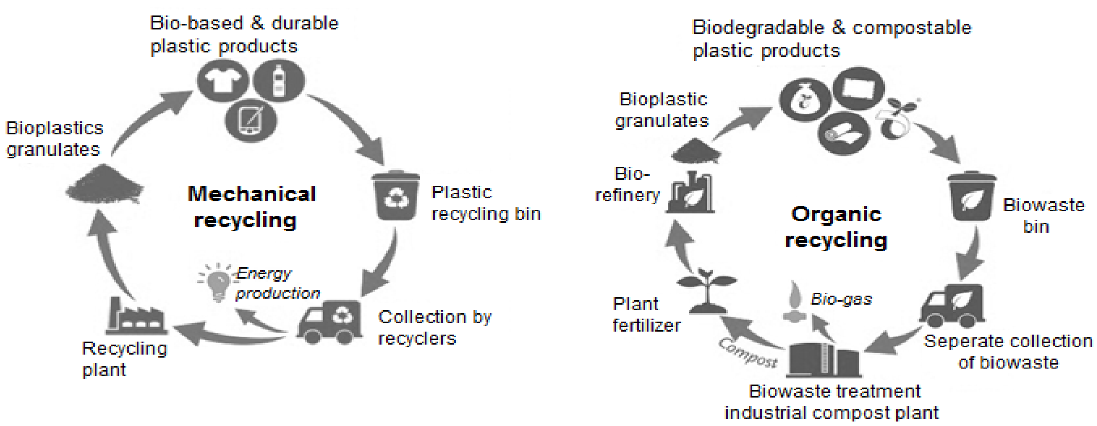
*Corresponding author: noraiza@uthm.edu.my

elements to the environment and affect human health by destroying thyroid hormone [2]. In short, petroleum-based plastic is almost impossible to terminate once it is produced. Due to this situation many industries had promoted the incineration of this plastic to dispose of it. However, an incineration is quite expensive. Moreover, incineration can lead to producing dioxin compounds such as nitrous oxide, hydrogen chloride, fluoride and particulate matter which can lodge permanently in the lung [1]. Furthermore, petroleum plastics are also made up from non-renewable sources. Even though only 5% of petroleum is used to make plastics, the renewability of the sources is often a concern as it takes millions of years to replenish [4].

Summarizing, petroleum-based plastic caused various side effects once it is used but until today people still use petroleum-based plastic rather than bioplastics because of its strength and colourful features. Table 1 shows the comparison between conventional plastic with bioplastics. Thus, researchers have shown interest in conducting bioplastic studies to overcome the global problems as stated previously. A bioplastic takes a very short time to break down when composted, with fewer toxic effects into the soil, as shown in Figure 1. A plant-based biodegradable plastic has been widely used during this extensive study. In this review paper, the composition and other special features of banana peels to make bioplastics is being studied as a substitute for petroleum-based plastic. This review also discusses the properties of bioplastics produced in terms of its strength, chemical compositions, and physical properties.

Table 1: The differences between conventional plastic and bioplastic

Conventional Plastic	Bioplastic
• Unsustainable • Eco-toxic • More energy usage during production (~65%) • Increases global warming • Leads to abiotic depletion • Reduces soil fertility	• More sustainable • Non-toxic • Less usage of energy • Eco-friendly • No harm to abiotic factors • Increases soil fertility



(a) **(b)**

Figure 1: End-of-life options for bioplastics by (a) mechanical recycling and (b) organic recycling [5]

2. Preparation of Banana Peels

Materials needed to produce bioplastic from banana peels generally are similar, but there will be slightly different materials added such as chemical substances that can change the chemical structure of the bioplastic either for it to be stronger or more durable. The materials used are important as it will influence the bioplastic produce. The main apparatus used to produce bioplastics are beaker, weight balance, pH meter, measuring cylinder, stove, oven, pipette, stirrer rod, blender, and petri dish [6]. Next the raw material use is banana peels. Banana peels is the main substance used to produce this bioplastic. Other than that, there are also a few chemical uses in this experiment such as hydrochloric acid, glycerol natrium hydroxide and sodium metabisulphite [1-2].

The first significant steps of making bioplastic from banana peels is to prepare the banana skins [7]. The banana skins will first be removed by using a stainless steel knife [4]. Approximately 300 g of banana peel were dipped in sodium metabisulphite solution and the peels were then placed into a beaker containing 800 ml water and then the peels were kept for boiling for 30 minutes. After boiling for 30 minutes, the water was then decanted off and the peels were left out on filter paper for drying for 30 minutes at room temperature.

2.1 Preparation of Bioplastic Film

After a 30 minutes process of drying, the banana peels were mashed using mortar and pestle to form a fine paste. Approximately 25 ml of banana paste was placed into a 50 ml beaker. In about 3 ml of 0.5 M HCl was added and the mixture was stirred using a magnetic stirrer at moderate speed. Next, 2 ml of 15% glycerol solution was added and the mixture was stirred continuously. The mixture was added with 3 ml of 1% corn starch as co-biopolymer and the mixture was stirred again. Following that, 3 ml of 0.5M NaOH was added to the mixture and stirred. The mixture was poured into a mould and then it was placed in the oven for 130 ºC and baked for 30 minutes. After 30 minutes it was taken out and kept for cooling. After proper drying, the bioplastic film was scraped off from the mould.

3. Results and Discussion

In this section, various analytical methods from previous researchers and their results are discussed in detail. The following results obtained are from load testing, water absorption, Fourier Transform Infrared Spectroscopy (FTIR), and biodegradability test.

3.1 Load Test

A load test can give us various important values such as maximum load that can withstand the sample, maximum elongation of the sample and the tensile strength. Table 2 shows the result of the load test. The tensile strength can be measured by using Universal Testing Machine [7]. It was reported that a bioplastic produced can accommodate up to 15 kg of highest maximum load [8] and bioplastic with 4 % of cornstarch as co-biopolymer can hold the lowest maximum load which is 0.48 kg [9]. Bioplastic with the highest tensile strength is the bioplastic made up with a ratio of 2.72:1 of starch; glycerol which is 1 MPa. The lowest tensile strength is the bioplastic produced by Abhijit et. al., (2014) with the value of tensile strength 0.25225 MPa [10]. The varied value of the maximum load, maximum elongation and tensile strength was caused by the different material that added up in the process of making the bioplastic. Hence, each bioplastic that was produced will have different durability.

Table 2: The comparison result for the load test

Materials of bioplastic	pH	Max load (kg)	Max elongation	Sample area (cm^2)	Tensile strength (MPa)	Thickness (mm)	Ref.
Banana	-	1.78	10.1 cm	1.4994	0.8169	8.33	[7]
Banana	-	0.84	7.1 cm	0.168 c	0.4903	1.05	
	-		6.5 cm	-			[8]
4% corn starch	-	0.48		1357		-	[9]
	Neutral		-	0.1424	0.343511	0.58	[10]
	Basic		-	0.1288	0.252257	0.644	
	Acidic		-	0.1256	0.274844	0.628	
	-	15		903.224		0.06	[11]
Starch: glycerol 3.5:1	-		5.5%	-	2.57	-	[12]
Starch: glycerol, 2.72:1	-		32%	-	1	-	

3.2 Water Absorption

Water absorption is used to measure the amount of water that got absorbed under certain conditions and specifications. Table 3 shows the result of the water absorption test of bioplastic with different percentages of corn starch as a-biopolymer and various types of solvent. A sample with 1 % of corn starch has the highest water absorption water uptake which is 108.98 % while the lowest water adsorption was recorded at 60.65 % with 3 % of corn starch present in the bioplastics [9]. As for different types of solvent used, highest water adsorption happens when water was used as a solvent at 43.48 % and the lowest is at 7.14 % for the sample of banana peels with chloroform as a solvent [13]. From Table 3, it can be concluded that the amount of water adsorption of the bioplastic was related to its concentration of corn starch used [9]. In addition, the percentage of water adsorption can also be affected by the types of solvent used [13]. Bioplastic with the lowest water absorption will have longer shelf life.

Table 3: The water absorption of the bioplastic

Sample	Tensile property average maximum load	Initial weight of the sample (g)	Final weight of the sample (g)	Water absorption (%)	Ref.
0% corn starch	1.6 ± 0.0288	-	-	63.95	[9]
1% corn starch	1.47 ± 0.0440	-	-	108.98	
2% corn starch	1.07 ± 0.0666	-	-	73.76	
3% corn starch	3.00 ± 0.2886	-	-	60.65	
4% corn starch	4.17 ± 0.3333	-	-	63.87	
5% corn starch	3.50 ± 0.2886	-	-	65.50	

Banana peels with water as a solvent	-	0.12	0.23	43.48	
Banana peels with chloroform as solvent	-	0.13	0.14	7.14	[13]
Banana peels with methanol as solvent	-	0.12	0.13	7.69	

3.3. Fourier Transform Infrared Spectroscopy Analysis

The chemical characterization of the bioplastic produced can be analyzed by using Fourier Transform Infrared Spectroscopy (FTIR). Table 4 shows the chemical characterization of the bioplastic. According to Fatimah et al., (2017), C-O, O-H, C-H, OH, C=O, C=C and =C-H will be found by using spectrum 100 Perkin Elmer FTIR with the spectra were taken in 256 scans between 4000 and 400 cm^{-1}. The C=C and =C-H were only found in the sample of bioplastic with 4 % of corn starch. The OH (deflection of water) also can only be founded by the bioplastic produced by [9]. There is no presence of OH (deflection of water) in any other sample of bioplastic.

Table 4: The chemical characteristic analysis using FTIR

Materials	**FTIR spectrum**							**Ref.**
	C-O	**O-H**	**C-H**	**OH (deflection of water)**	**C=O**	**C=C**	**=C-H**	
BP control film	√	√	√	√	√	-	-	[7]
BP with 4% of corn starch	√	√	√	√	√	√	√	[7]
Raw starch		√	√	-	√	-	-	[8]
2.5:1		√	√	-	√	-	-	[8]
2.75:1		√	√	-	√	-	-	[8]
3:1		√	√	-	√	-	-	[8]
3.5:1		√	√	-	√	-	-	[8]
Banana peels treated with Na		√	√	-	√	-	-	[13]
Untreated		√	√	-	√	-	-	[13]

3.4 Biodegradability

Biodegradability is the capacity for biological degradation of organic materials by living organisms. Bioplastic made from different materials and methods will have different time taken for it to degrade. Table 5 shows the biodegradability for each sample of bioplastic. A bioplastic produced takes only two days for it to start decaying [8, 13]. The longest time period reported for a bioplastic to decay is 30 days [14]. For bioplasticity, it is preferred to have medium time taken for it to starts decaying. This is because if the bioplastic has the highest biodegradability, it will quickly degrade before it is used to its full functions.

Table 5: Biodegradability of the bioplastic

Material	Volume of glycerin	Value of degradation of the bioplastic sample					Ref.
		Initial mass	After 2 days	After 4 days	After 6 days	After 13 days	
	20 ml	100	99.97	97.57	96.46	-	[8]
	25 ml	100	99.2	96.83	94.88	-	
	30 ml	100	99.87	96.03	93.94	-	
2.5:1		1	-	-	1/4	-	[12]
2.75:1		1	-	-	1/4	-	
3:1		1	-	-	1/2	-	
3.5:1		1	-	-	Almost all	-	
Banana treated with $Na_2S_2O_5$	-	2 g	0.58	-	0.52	0.46	[13]
Untreated	-	2 g	0.32	-	0.11	0.04	
0.1 M of HCL and NaOH	25 ml of banana peels	-	Decayed after 3 days	-	-	-	[14]
0.5 M of HCL and NaOH	25 ml of banana peels	-	Decayed after 3 days	-	-	-	
0.1 M of HCL and NaOH	25 ml of banana peels	-	-	-	-	Decayed after 30 days	
0.5 M of HCL and NaOH	25 ml of banana peels	-	-	-	-	Decayed after 30 days	
Soy protein	1 ml^{-1} of pronase	100%	-	-	17%	-	[15]
Soy protein	10 ml^{-1} of pronase	100%	-	-	8%	-	

4. Conclusion

Bioplastics has been the area of much research nowadays to lessen the usage of petroleum-based plastic and save the environment from pollution. Since banana peels have become a large amount of waste in this world, it can be used as a main substance to produce bioplastics. Banana peels are also one of the fruits that are rich in starch that can be easily extracted and form a long starch polymer chain to make bioplastics. The result from other research has proved that banana peels also can be the main substance in producing the bioplastics because it is easy to get. The renewable nature and biodegradability of banana peels bioplastics make it an appropriate source to substitute the petroleum-based plastics. Next, banana peels bioplastics also require less time to degrade compared to petroleum-based plastic which takes a hundred years to degrade. Plus, the other research has proved that banana peels bioplastics is a non-toxic plastic because it is free from chemicals and toxic substances. Furthermore, this plastic has lower energy consumption along the production process. Further prospect in using banana peels as the source to produce bioplastics need to improve in colour aspect, long life span and others to make the bioplastics produce in the future is better than the petroleum-based plastics.

Acknowledgement

This work was supported by the Research Management Center of UniversitiTun Hussein Onn Malaysia under Tier 1 Vote Number H198 Grant.

References

[1] Chodijah, S., Husaini, A., Zaman, M. and Hilwatulisan (2019). Extraction of Pectin from Banana Peels (Musa Paradiasica Fomatypica) for Biodegradable Plastic Films. *Journal of Physics: Conference Series*, 1167, p.012061.

[2] S. N. Kanoujiya (2019). Production of Bioplastic from Banana Peels. Retrieved on 7 Jun 2020.

[3] Sinan, M., (2020). Bioplastics for Sustainable Development: General Scenario in India. *Current World Environment*, 15(1), pp.24-28.

[4] Z. K. Oo, M. Thu, and Z. N. N. Tun (2019). Bioplastics from Fruit Waste. *International Journal of Advances in Scientific Research and Engineering,* Vol. 5(28), pp. 209-215.

[5] Tim Sykes (2017), Packagingeurope: *Sky is the limit*. Retrieved on 17 June 2020.

[6] S. Rusdi, R. A. Destian, F. Rahman, and A. Chafidz (2020). Preparation and Characterization of Bio-Degradable Plastic from Banana Kepok Peel Waste, *Materials Science Forum*, Vol. 981, pp. 132–137.

[7] Gaonkar. M.R, Palaskar. P, N. R. (2018). Production of bioplastic from banana peels. *International Journal of Advances in Science Engineering and Technology*, Vol. *6*(1), pp. 36–38.

[8] Deeneshwaran, S. M., Kavin, R. N, John, V., Vinoth, F., Kalaiarasen, K. & Zamri, Y. (2016). Production of Biodegradable Plastic from Banana Peel. *Journal of Petrochemical Engineering, 1*(1), pp. 1-6.

[9] Fatimah, N., Sultan, K., Lutfi, W., & Johari, W. (2017). The development of banana peel/corn starch bioplastic film: a preliminary study. *Bioremediation Science and Technology Research*, Vol. 5(1), pp. 12–17.

[10] Abhijit, M., Shruti, P., & Hemant, S. (2014). Thesis: Bioplastics- Utilization of Waste Banana Peels for Synthesis of Polymeric Films.

[11] Khoo, H. H., Tan, R. B. H., & Chng, K. W. L. (2010). Environmental impacts of conventional plastic and bio-based carrier bags. *The International Journal of Life Cycle Assessment*, Vol. *15*(3), pp. 284–293.

[12] Dawam Abdu, A. H., Pudjirahar, S., Karina, M., Dwi Putri, O., & Fauziyyah, R. H. (2019). Fabrication and Characterization of Sweet Potato Starch-based Bioplastics Plasticized with Glycerol. *Journal of Biological Sciences*, Vol. *19*(1), pp. 57–64.

[13] Jayachandra, Y., Vinay, P., Sharanabasava, G., Nagaraj, B., Anand, H., & Ashok, S. (2016). Biodegradable Plastic Production from Fruit Waste Material and Its Sustainable Use for Green Applications. *International Journal of Pharmaceutical Research & Allied Sciences, Vol. 5*(4), pp. 56-66.

[14] Ibrahim, A., & Ahmed, M. (2016). Banana peels based bio-plastic. *Polymers*, *1*(2), 183–192.

[15] Yamada, M., Morimitsu, S., Hosono, E., & Yamada, T. (2020). Preparation of bioplastic using soy protein. *International Journal of Biologic Macromolecules*, *149*, 1077–1083.