



PRODUCTION OF BIOPLASTICS USING BANANA PEELS

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Abstract: Plastic is a major global concern because of its environmental impact. Plastic requires more processing time for degradation and causes endocrine disruption. The scientific community is constantly looking for alternatives to lessen this molecule's negative effects. Bioplastic is one such substitute. Bioplastics are polymers that resemble plastic but contain a lot of starch. The biodegradability rate of bioplastic is much better as compared to conventional plastic which makes them environmentally friendly. Currently, Bioplastic from fruit wastes is gaining importance because of two major reasons which include waste management and its biodegradability. In this study, banana and potato peels were used as a raw material for bioplastic synthesis because of its high starch content. The different concentrations used for different samples of bioplastic preparation. The current study covers SDG-12. In this study, HCl served as the binder and glycerol as the plasticiser. To identify its uses, the bioplastic's moldability and biodegradability were assessed. Its ability to mould into any shape indicates that it is safe for the environment and can be used in a variety of applications. Its biodegradability ability indicates that it is biodegradable in nature. This bioplastic could also be used as food packaging in different food and feed industries as an alternative food packaging material which has a great environmental impact

Key words: Bioplastic, Biodegradation, Banana peel, Eco-friendly plastic, Pollution

INTRODUCTION

Petroleum-based plastic has been rapidly produced in recent decades. However, its biodegradability resistance has created a serious environmental issue for solid waste management. Humans are completely reliant on plastic products ranging from plastic toys to luxury items. Similarly, every year, about 400 million tons of plastic products are produced around the world (Amankwa, *et al.* 2021). Plastic is a bunch of polymers, which is non-biodegradable. However, plastic waste hurts the environment and is linked to health problems such as lung cancer, asthma attacks, low birth weight, childhood leukaemia, cardiovascular disease, and chronic obstructive pulmonary disease (Arjun, *et al.* 2023; Beloe, *et al.* 2022; Gbangbo, *et al.* 2023). Researchers discovered a solution for this issue by using biodegradable products as an initial source for the manufacture of plastic. As per SDGs Bioplastics from organic waste is an alternative approach for responsible consumption and production. It is the most innovative approach as the materials used in it are biobased and biodegradable including from waste, biomass and renewable sources. The biomass from jackfruit, banana, empty palm fruit bunch, sugarcane, corn starch, potato starch, rice straw, rapeseed oil, and organic waste

include agricultural waste, newspaper waste, used vegetable oil, other cellulose and starch-based plants waste, cotton, bacteria, algae and sometimes from several nanosized particles like carbohydrate chains (polysaccharides) used for the bioplastic synthesis. The major blessing of bioplastic is its environmentally friendly nature because it is degradable by bacteria, algae and fungi (Hawas, *et al.* 2016; Kalita, *et al.* 2021; Lea, 1996; Mamiya, *et al.* 2020; Maquart, *et al.* 2022; Mose, & Maranga. 2011). Similarly, two methods for reducing plastic waste are landfilling and incineration (Onen Cinar, *et al.* 2020) [11]. Although it is an option, recycling. However, only 9% of it is recycled. Additionally, it is impossible to recycle medical waste. Due to the higher cost of the process, the use of recycled plastics is extremely restricted and inefficient. It is also difficult to eradicate diseases. In comparison, bioplastic is a kind of plastic made from renewable biomass as opposed to plastic with a petroleum base. In the same way, it lowers the cost of waste management, cleans up the environment of bulky plastic waste, and increases soil fertility. Additionally, *Aspergillus niger*, a saprophytic fungus, is also permitted. This fungus produces some enzymes that are needed in the pharmaceutical and food industries. There are still some

difficulties, though. This processing is expensive. Additionally, it needs time to gain more strength and elasticity. Due to the fungus and other bacteria present, it may cause respiratory problems in the future.

Banana peel (*Musa paradisiaca*), which is produced in an estimated 26 million tonnes annually (Saleh & Utami, 2021) [12], is a material that has the potential for additional uses. Banana peels were chosen as the raw material for bioplastic production because they are a cheap source of raw materials and contain high amounts of cellulose and starch, the main components of bioplastic production. The production process of bioplastic made from banana peel is environmentally friendly as it reduces pollution and promotes recycling. These alternative aims to replace conventional plastic with a sustainable and eco-friendly material. In the current study, Banana peel was hydrolyzed and converted into a bioplastic.

MATERIALS AND METHODS

Raw material Preparation

Banana and potato peels was washed carefully followed by boiled in water for 30 minutes. The sample was decanted after that and water was removed carefully. The sample was grinded further to make a uniform paste. The sample was stored in refrigerator for further use.

Bioplastic Formation

Sample #	Preparation method
1.	The 25 gm of banana peel was weighed and add 3 ml of 1N HCl. The sample was stirred for 30 minutes till completely loose fibril could be observed. 2 ml glycerol add into the mixture and mixed to obtain a thick consistency. The sample was further neutralized using 1N NaOH and note the pH of the sample. The sample was transferred into mould and kept at 60°C upto 24 hours.
2.	25 gram banana paste weighted and 3.0 ml 0.5M HCL. The sample was stirred for 30 minutes till completely loose fibril could be observed. 2 ml glycerol add into the mixture and mixed to obtain a thick consistency. 3.0 ml starch added in solution. The sample was further neutralized using 1N NaOH (3ml NaOH) and note the pH of the sample. The sample was transferred into mould and kept at 60°C until it dry.
3.	25 gram banana paste weighted and 3ml acetic acid. The sample was stirred for 30 minutes till completely loose fibril could be observed. 2 ml glycerol add into the mixture and mixed to obtain a thick consistency. 20-30ml glycerine added. Leave it in oven until it dry.
4.	25 gram banana paste weighted and 3ml acetic acid. The sample was stirred for 30 minutes till completely loose fibril could be observed. 2 ml glycerol add into the mixture and mixed to obtain a

	thick consistency. Leave it in oven until it dry.
5.	13.5 gm potato peels weighted and add 135 ml distilled water. Stir it properly. 16.2 ml vinegar added. 10.8 ml glycerine added and allow mixture to dry in sunlight.
6.	2.25 gm potato peels weighted. 25ml distilled water and 3ml HCL. Stair it properly. 2 ml glycerol add into the mixture and mixed to obtain a thick consistency. Adjust ph by NaOH, dry in sunlight.
7.	12.5 gm potato peels and 12.5 gm banana peels weighted. 50ml distilled water added. 15ml HCL and 3.50ml glycerol add into the mixture and mixed to obtain a thick consistency. Treat it NaOH for Ph neutralize and allow sample to dry in oven.
8.	The 25 gm of banana peel was weighed and add 3 ml of 1N HCl. The sample was stirred for 30 minutes till completely loose fibril could be observed. 2.5 ml glycerol add into the mixture and mixed to obtain a thick consistency. The sample was further neutralized using 1N NaOH and note the pH of the sample. The sample was transferred into mould and allow it to dry in oven.

Characterization of Bioplastic

The following tests were performed in order to determine the properties of bioplastics:

Solubility test

Two grams of bioplastic sample was soaked in 50ml of solvents including water and bio enzyme solution (bio enzyme is a solution used to enhance activity of soil and bacteria which can be used for growth of plants as a fertilizer, the above bio enzymes are banana peels based having nutrients and enzymes in the solution). This test was performed to find the solubility of sample after 3.0 hours soaking.

Elongation test

Elongation test was performed by simple holding the bioplastic sheet in hand at one end and the other end was slowly pulled with another hand until it broke down. Ruler was used to measure the initial and final length.

$$\% \text{ Elongation} = \Delta L / L^{\circ} \times 100$$

Where L = Change in length Lo = Original length

Folding endurance test

The bioplastic sheet was folded equally until it breaks. Followed by unfolding it and the number of folds were counted.

Biodegradability Test

Two gram of sample was immersed in 20g of soil sample for 25 days. The final weight of sample was measured.

$$\% \text{ Degradation} = (\text{Initial weight of plastic} - \text{Final weight of sample}) / \text{Initial weight}$$

Tensile strength test

Bioplastic sheet is fixed with both ends and apply small weights on the sheet until it broke.

Morphological test

It shows the samples under observation of digital microscope at 40x and 100x

Water absorption test

Weight bioplastic film in dry form and put the film of bioplastic in 50 ml distilled water. After 3.0 hours, dry biofilm (outside) and re-weight it and observe the difference between them.

RESULTS AND DISCUSSION

Biodegradable plastics are alternative biopolymers that exist in the world. Biodegradable plastics has vast applications and it is completely alternative of conventional plastic based on nature "environment-friendly.

Banana peels were first treated with boiling water at 100 °C. This step loses the fibril structure of Banana peel so that its further processing is much easier. This study analyses the effects of glycerol and other composition of chemicals, and time period, on the structure of biopolymer. Glycerol act as a plasticizer which helps in the plastic formation from Starch present in banana peel. Starch contains two polymer chains amylose and amylopectin. HCl helps in the hydrolysis of amylopectin which promotes plastic film formation as Amylopectin resists the process (Villalobos, *et al.* 2022). Starch and cellulose due to film formation and biodegradable nature are considered an excellent material for bioplastic formation (Wachirasiri, *et al.* 2009). In this study banana and potato peels are selected because it is rich in starch and requires less time to dry as compared to other starch containing compounds. The banana peel contains approximately 12 gm starch/100 gm of Banana peel (Zimmermann, *et al.* 2020). In few studies, Sodium metabisulphite was used as antioxidant which prevents growth of microorganisms and it prevents blackening (Villalobos, *et al.* 2022).

Solubility Test of Bioplastics

Water is absorbed by the banana peel samples through the film's pores. However, they don't dissolve in water. In contrast, the sample made from potato peels dissolves in water. When a potato-based bioplastic sample is submerged in water, it loses some of its material and does not stick to the film. Both banana and potato-based bioplastic sheets began to break down when the bioenzyme solution was added, and it may be a good source of nutrient-rich fertiliser for plants. Bioenzymes were broken down more quickly by the potato-based component.

Sample #	Water solubility
1.	Insoluble
2.	Soluble
3.	Insoluble
4.	Insoluble
5.	Soluble
6.	Soluble
7.	Insoluble
8.	Soluble

Elongation Test of Bioplastics

The elongation test was performed in bioplastic and it was observed that sample 1 and 2 elongates around 0.5 cm and sample sample 4, 7,8 elongates 0.4, 0.3 and 0.5 cm. Remaining 3 samples where very liquidly and they have very less amount of mass remains due to high water composition in the preparation of samples.

Folding endurance test of Bioplastics

Folding is the process of manufacturing in which the strength of the material is determined. It has been observed that the bioplastic folds into 6 folds and is unbreakable until it stretched.

Biodegradability Test of Bioplastics

The initial weight of the sample is 20 grams. After 25 days it was observed that a 15.84-gram sample was obtained from the soil. Similarly, all samples lose their weight which shows their degradation in soil. As per % degradation approximately 22 % sample was degraded in 25 days. It has been also observed during the laboratory experiment with sample # 1 that an *Aspergillus niger* saprophytic fungus attacked a sample, indicating that banana peels degrade quickly. While this may make them useful for quick dissolving, it can also be harmful to the user's health. This suggested that it is highly biodegradable material with the ability to be mould into bioplastic. This waste could be used as potential substrate for bioplastic formation.

Tolerance test for Plastic

The term "Plastic Tolerance Test" refers to a number of techniques for assessing how a plastic material responds to various stresses, environmental factors, or temperatures in order to make sure it satisfies application requirements; it is not a single standard test. It was found that sample 4 and 8 showed maximums tolerance level followed by sample 7, 1 and 2 respectively.

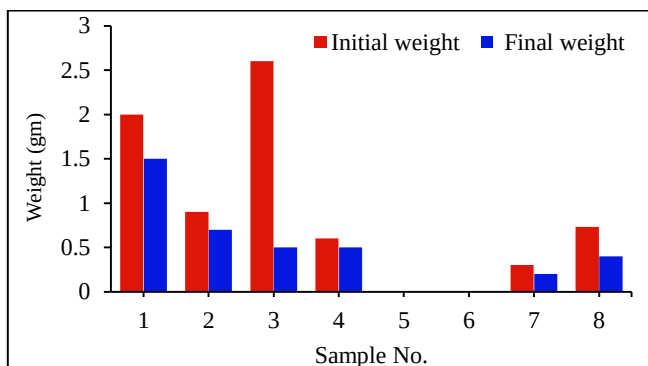


Fig 1: Biodegradability Test of Banana peel.

Morphological test of plastic

The morphological test of a Scanning Electron Microscope (SEM) looks at the surface structure and properties of plastic materials at a microscopic level, providing information about their texture, shape, and other attributes to help with

identification, analysis, failure analysis, and quality control. SEM creates signals that offer fine-grained pictures of the micro-scale morphology by moving a concentrated electron beam over the surface of the plastic. This helps determine the material's composition, integrity, and behaviour or degradation.

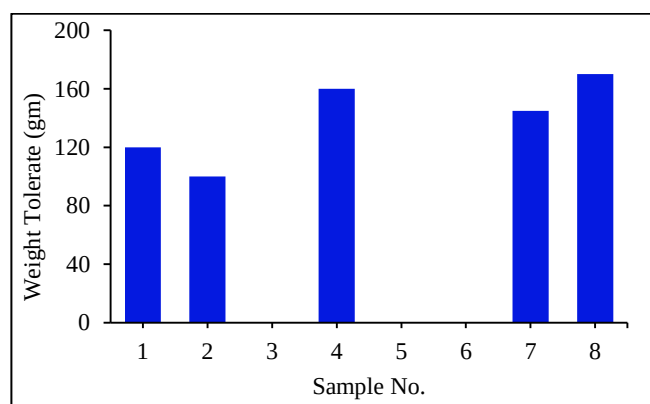


Fig 2: weight tolerate of bioplastic sheets

Morphological test of plastic

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Resolution	1	2	3	4	5	6	7	8
100X								
40X								

Fig 3: Bioplastic films under Scan electron microscope at 40x and 100x

Water absorption test

Every banana peel sample absorbs water through the sheet's pores. They began to break down quickly and retained water droplets in the tiny holes in the film.

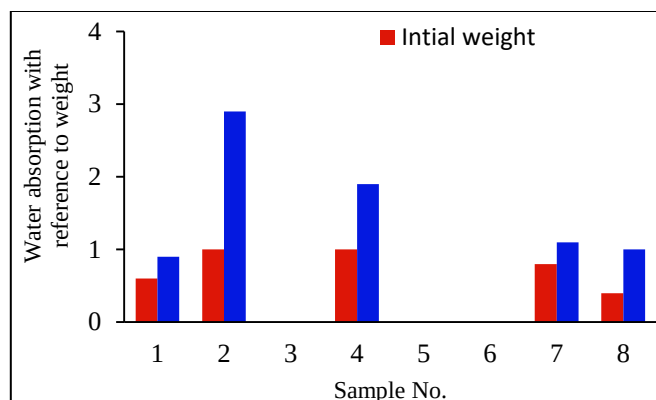


Figure 4: Water absorption capacity of different plastic

CONCLUSIONS

Bioplastic is made from starch, which can be found in the peels of potatoes and bananas. Bioplastic sheets are prepared using carefully selected protocols. The ideal glycerol concentration was found to be 2.0 ml. HCl and NaOH were added to maintain stability and pH. A mix of potatoes and bananas is also a good choice and yields better results than plastics based on corn starch, which decompose during preparation. Future research will focus on multi-layer presses to create more stable and long-lasting sheets. These environmentally friendly bioplastic are used in packaging.

Conflict of interest

Authors declare no conflict of interest.

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