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Banana peel starch to biodegradable alternative products for commercial plastics

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Abstract

Plastics offers a variety of benefits and in variety of shapes, such as sheets, panels, film which can all be flexible as application requires. Plastic is a price competitive with other materials that offer similar advantages in industrial application. It is light weight strong and cheaper. However, use of too many plastics results in massive harmful effects. It take longer time to degrade which is estimated about 500 years to degrade and will become toxic after decomposed, it will affect the environment. Thus the biodegradable plastics become promising solution to solve all this problems. The objective of this study is to produce biodegradable plastic from banana peels as a substitute for commercial plastics and to prove that the starch in banana peel could be used in production of biodegradable plastics. The strength of the plastic was determined by elongation test and by comparing with a synthetic plastic. In soil burial degradation test, the intensity of degradation was tested by comparing with synthetic plastic, biodegradable plastic degraded at rapid rate and synthetic plastic did not degrade at all. Based on the entire test, bioplastic from banana peels can be used in industry for various applications such as molding, packaging and making carry bags, at the same time rescuing the environment from potential harm by synthetic plastics.

Keywords: Banana peels; HCL; NaOH; Sodium metabisulphite; Glycerol; Bioplastics.

1. Introduction

Plastics are more useful than metals, papers and other materials because of their properties such as lightness, cheapness and durability. Therefore, they have been being used in almost every industrial field. World-wide, more than 300 million tons of plastics were consumed in 2017.The whole world; even the oceans are full of plastic wastes. In addition, plastic industry has some disadvantages related to economic and environmental problems.

In many countries, bioplastics are mostly used as cutlery, diapers, packaging materials etc. In many industrial areas, it is forecasted that bioplastic production will be 7.8 million tons in 2019 in the world. Therefore, it is thought that the future of bioplastics shows great potential. Nevertheless, the cost of the bioplastic produced from microbial resources is still higher than produced from renewable resources. For this reason, most of bioplastic manufactures have focused on the production via renewable resources (*Akiran et al., 2019).*

Biodegradable plastics are a new generation of polymers emerging on the world market. Biodegradable plastics have an expanding range of potential applications, and driven by the growing use of plastics in packaging and the perception that biodegradable plastics are “environment friendly “, their use is predicted to increase . However, issues are also emerging regarding the use of biodegradable plastics and their potential impacts on the environment and effects on established recycling systems and technologies. The banana fruit's peel was selected for this because it is a waste material rich of starch – according to Songklanakarin Journal of Science and Technology, the proximate composition of banana peel.

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Table 1 Banana peel content

ITEM	CONTENT (g / 100 g dry matter)
Protein	8.6 +/- 0.1
Fat	13.1 +/- 0.2
Starch	12.78 +/- 0.9
Ash	15.25 +/- 0.1
Total Dietary Fat	50.25 +/- 0.2

Starch consists of two different types of polymer chains, called amylose and amylopectin, made up of adjoined glucose molecules. The hydrochloric acid is used in the hydrolysis of amylopectin, which is needed in order to aid the process of film formation due to the H- bonding amongst the chains of glucose in starch, since amylopectin restricts the film formation the sodium hydroxide used in the experiment is simply used in order to neutralize the pH of the medium (Nadaraja et al., 2016).

Now a day's majority of the food industries are using bioplastic for food packaging. Since the starch is good source of nutrient there is chance of contamination during food packaging. The bioplastic made from the banana peel cannot be sterilized like commercial plastics. Food borne pathogens such as *Escherichia coli*, *Staphylococcus aureus*, *Salmonella sp* etc., create a lot of problem worldwide and are a major concern of food producers and consumers.

To protect the food from spoilage due to microorganisms, antimicrobial packaging is one of the most promising active packaging systems. Environmental concerns associated with plastic waste emphasized the development of packaging film from natural polymers such as starch. Addition of cinnamon oil during the plastic casting can improve the antimicrobial properties. Cinnamon oil and their components shows antimicrobial activity against Gram positive and Gram negative bacteria responsible for infectious diseases and degradation of food or cosmetic.

2. Material and methods

Banana peel, Glycerol, Hydrochloric acid, Sodium Hydroxide, Sodium metabisulphite, distilled water.

2.1. Extraction of Starch from Banana Peel

Banana peels were converted into small pieces then it was soaked in sodium metabisulphite (0.2M) solution for 45 minutes. It is used as antioxidant and preservative. This would increase the biodegradation period of bioplastics. Banana peels were boiled in distilled water for about 30 minutes. The water decanted from the beaker and the peels were left to dry on filter paper till it gets completely dried. After the peels were dried, they were placed in a beaker and using blender, the peels were made into paste.

2.2. Production of Biodegradable Plastic

25g banana paste was placed in a beaker 2 teaspoon of cinnamon powder was added which increases the antimicrobial property of bioplastics. 3 ml of (0.5N) HCL was added to this mixture which helps in film formation. 2 ml of Glycerol was added which act as plasticizer. 3 ml of NaOH was added to maintain pH. The mixture was poured in a mold and put in the oven at 130`C at least for one hour (*prof. Manasi Ghamande et al.)*

Figure 1 Fresh Bananas were taken

Figure 2 Banana Peels were taken

Figure 3 Sodium metabisulphite

Figure 4 Banana peels were soaked

Figure 5 Peels were boiled with water

Figure 6 3ml of (0.5M) HCL and 3 ml NaOH

Figure 7 Cinnamon powder was added

Figure 8 Mixture was baked in oven at 130`C for one hour by using a mold

2.3. Biodegradation test

The initial weight of the biodegradable plastic was taken and then it was buried in 5 cm depth. At regular time interval, water was sprinkled. About 2 days time interval, the specimen from the soil was taken and washed with distilled water, after that specimen was dried and the weight was taken (*Deeneshwaran et al*., 2016)

Figure 9 Initial weight was taken

Figure 10 Buried in Soil

2.4. Biodegradation test

The initial weight of the biodegradable product was taken and then it was buried in 5 cm depth. At regular time interval, water was sprinkled. About 2 days time interval, the specimen from the soil was taken and washed with distilled water, after that specimen was dried and the weight was taken (*Deeneshwaran et al*., 2016).

2.5. Solubility test

Solubility studies were conducted to check persistence of these product samples from banana peels were cut into small pieces and were inserted into a beaker containing different solvents and it was kept for two weeks, after two weeks sample were taken out to check the solubility.

2.6. Molding test

Molding is the process of manufacturing by shaping liquid or raw material using a rigid frame called mold. This may have been made using a pattern or model of final object. Once the paste is formed it is forced into mold cavity. Once the material gets rigid, it can be ejected.

2.7. Microbial load test

Microorganisms can be found everywhere. In order to store things using this biodegradable product it should be free from microbial load to certain extent, addition of cinnamon and sodium metabisulphite to the product prevents the microbial growth on the product to a certain extent. Two type of biodegradable products were made, one with sodium metabisulphite and cinnamon another without sodium metabisulphite and cinnamon. Nutrient broth and potato dextrose broth were prepared and biodegradable products were inserted and subjected for incubation. OD values of the broth are checked after 24, 48 and 72 hours.

2.8. Antimicrobial property test

There are several methods to evaluate the antimicrobial property. This research was disc diffusion (Kirby Bauer) test as antimicrobial activity test for biodegradable product. Biodegradable products were placed on Muller Hinton agar plates which contains suspension of microorganisms swabbed evenly on its surface. Then, petri dishes were incubated for 18-24 hours. After the incubation period, the inhibitory zone has to be determined around the biodegradable samples on agar plate.

2.9. Plant growth test

Plastic pots are commonly used to grow plants, biodegradable plant pots can be used as alternatives for plastic pots. Plants are grown in biodegradable pot as well as commercial plastic cover and water is poured daily to check the viability of the biodegradable pot.

3. Results

3.1. Biodegradation test

The initial weight was recorded as 9.22 g and weight reduction was occurred as number of days increased. Rapid degradation was occurred during initial 10 days, as weight decreased to 6.28 g. Later the weight reduction occurred gradually as number of day's increases.

Figure 11 Initial weight

Figure 12 It is buried in soil

Figure 13 Weight after 10 days

3.2. Degradation rate

Table 2 The bio degradation rate

Date	weight
25/1/2020	9.22g
28/1/2020	8.03g
31/1/2020	7.48g
3/2/2020	6.93g
4/2/2020	6.90g
5/2/2020	6.28g
6/2/2020	6.24g
7/2/2020	6.23g
10/2/2020	6.03g
11/2/2020	5.86g
12/2/2020	5.65g
15/2/2020	4.92g
21/2/2020	4.52g
25/2/2020	3.97g

3.3. Comparison

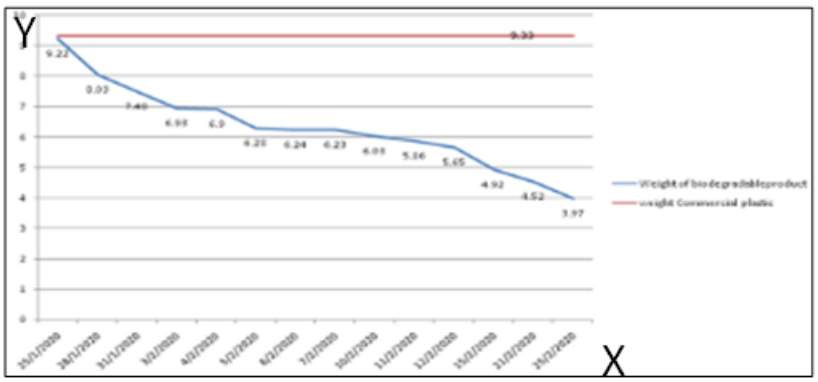

Figure 14 Graphical representation of bio degradation rates

3.4. Solubility test

Samples from banana peels were cut into small pieces and were inserted into a beaker containing different solvents and it is kept for two weeks. After two weeks the samples were taken out to check the solubility, none of the samples were completely soluble in different medium used.

Figure 151) Ammonia 2) Ethyl alcohol 3) Acetone 4) Water

Figure 16 5) Methanol 6) Acetic acid

Table 3 Results of solubility test

Solvents	**solubility**
Ammonia	Partially soluble
Acetone	Partially soluble
Ethyl Alcohol	Insoluble
Water	Insoluble
Methanol	Insoluble
Acetic acid	Insoluble

3.5. Solubility

3.5.1. Molding test

Molding is the process of manufacturing by shaping liquid or raw material using a rigid frame called mold. The formed material is molded into different shape such as pot and spoon.

Figure 17 Pot

Figure 18 Spoon

3.6. Microbial load test

3.6.1. Nutrient Broth

Table 4 Results on Nutrient broth

Hour	With sodium metabisulphite and cinnamon extract (od value)	Without sodium metabisulphite and cinnamon extract (od value)
24 HOUR	1.017	1.990
48 HOUR	1.635	2.442
72 HOUR	2.134	2.856

3.6.2. Potato dextrose broth

Table 5 Potato dextrose broth

Hour	With sodium metabisulphite and cinnamon extract (od value)	Without sodium metabisulphite and cinnamon extract (od value)
24 HOUR	0.654	0.669
48 HOUR	0.656	0.674
72 HOUR	1.224	1.367

3.7. Antimicrobial properties

After 24 hours of incubation the product shows antimicrobial activity towards several organisms

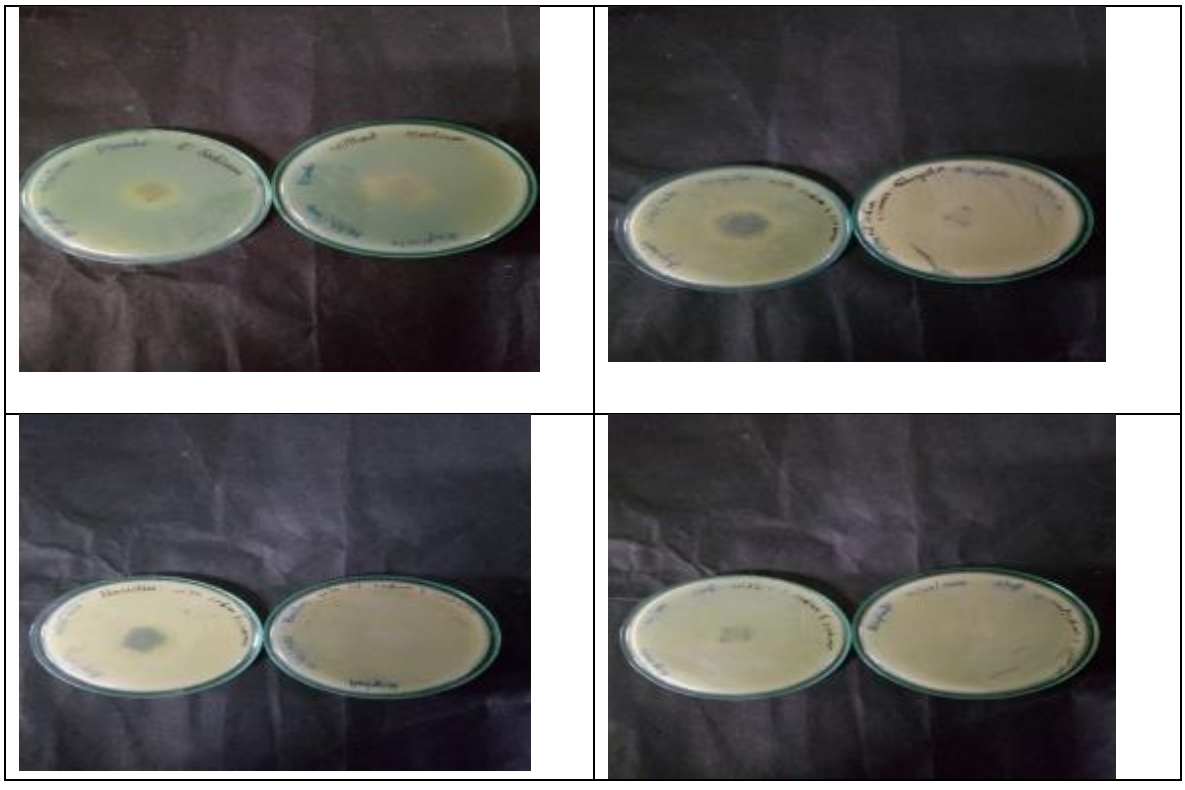

Figure 19 Results of anti microbial activity

3.8. Plant growth test

Plant is grown by using biodegradable pot and commercial plastic cover. Water holding capacity is more for biodegradable pot when compared to plastic cover it can hold water up to 1 day so water is need to be poured only one time a day no need to pour two times a day .

Figure 20 1) Plant growth in commercial plastic cover 2) plant growth in biodegradable pot

4. Discussion

In this experiment, biodegradable plastic from banana peel was produced**.** Glycerol was used as plasticizer. Starch has two polymer chains, called amylose and amylopectin, HCL was used as hydrolysis agent for amylopectin. Amylopectin resist the film formation. Sodium metabisulphite was used as antioxidant which prevents growth of microorganisms and it prevents blackening.

3 ml of (0.5M) HCL and 3 ml of (0.5M) NaOH was added along with 2 ml of Glycerol to the banana paste and it was baked at 130℃ for 1 hour. In another experiment done by *Manasi Ghamande* et al., 2018 6 ml of (0.25M) HCL and 3 ml of (0.5M) NaOH is used along with 21 ml glycerol. The plastic formed was brittle and not flexible

Starch and Cellulose are important raw materials used in biodegradable plastic industry (packaging Bulletin, 2009). Potato peels are most commonly used in biodegradable plastic production since they are rich with starch and this starch is very easy to extract, but it takes long time to get dry and also requires large amount, so for this experiment banana peels are selected because it also rich with starch and it needs only less time to get dry when compared to potato peel.

5. Conclusion

Bioplastic products were produced successfully by mixing and casting method, several tests were conducted such as molding test and degradation test. In the molding test we can observe that the bioplastic can be molded into different shapes, whereas in biodegradation test, a rapid degradation occurred in initial 6 days, the weight was reduced from 72.05 g to 44.70 g, followed by 100% decomposition can be expected in 60 days. Since the raw material used for the plastic is starch , it can be easily degraded by soil microorganisms and even though it did not reached all the properties commercial plastics further experiments can improve the quality of banana peel bioplastic and it can be used as the good alternative for commercial plastics and protect the environment.

Compliance with ethical standards

Acknowledgments

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Disclosure of conflict of interest

No conflict of interest.

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