Poll Res. 41 (3) : 964-969 (2022)

ISSN 0257–8050
DOI No.: http://doi.org/10.53550/PR.2022.v41i03.029

BIOPLASTIC FROM FRUIT PEELS - WASTE TO WEALTH

K. KEERTHANA[1*], R. SWAMY[2*] AND P. SRILATHA[3*]

Department of Food Process Technology, College of Food Science and Technology, PJTS Agricultural University, Rudrur 503 188, Telangana State, India

(Received 18 November, 2021; Accepted 31 December, 2021)

ABSTRACT

In the present study the experiment was conducted in the Department of Food Process Technology Lab and Department of Food Safety and Quality Assurance Lab to synthesize bio plastic from selected fruit peels (Banana and Orange peels) in different concentrations by the addition of different essential oils namely lime oil and clove oil which acts as a preservative and aroma agent which serves as potential alternative to the conventional plastic material. In the experiment bioplastic is made from banana and orange peels in different concentrations i.e., banana peels (100 g), orange peel (100 g) and combination of banana (50 g) and orange peel (50 g). The bioplastic made from orange peel was observed with some gaps as starch content in orange peel is less when compared to banana peel. Bioplastic made from the combination of both peels in the concentration of banana peel (50 g) and orange peel (50 g) was little bit stiff with some gaps and when tried with the concentration of banana peel (70 g) and orange peel (30 g) bioplastic was obtained. The synthesized bioplastic was subjected to mould test, swelling test, solubility test, Biodegradable test and elongation test. On experiment the mould test revealed that it can be moulded into different shapes like conventional plastic. Swelling test showed that there is a slight increase in weight of the bioplastic when soaked in water as a medium and this is a desirable result because most of the additives are prepared by using organic solvents, certainly it will help in stabilize product synthesis and development. From the solubility test it was revealed that none of the samples were soluble in different mediums which shows that the bioplastic material prepared is stable. Biodegradability test showed that the obtained bioplastic is degradable within 15 days. The bioplastic made with the combination of banana and orange peels showed more percentage of elongation i.e., 20.4% where as the bioplastic made from banana peel showed 10% and from orange peel showed 3% which indicates that the bioplastic synthesized from combination of fruit peels has more strength compared to individual peels.

KEY WORDS: Bioplastic, Banana peels, Orange peels, Biodegradation, Concentrations, Essential oils.

INTRODUCTION

"Plastic" is the term derived from the Greek word "plastikos" meaning fit for molding, and "plastos" meaning molded. It refers to the materials malleability or plasticity during manufacture that allows it to be cast, pressed, or extruded into a variety of shapes, such as films, fibers, plates, tubes, bottles, boxes, and much more. Plastic is the general common term for a wide range of synthetic or semi-synthetic materials used in a huge, and growing, range of applications. They are derived from organic products, the same as wood, paper or wool. The materials used in the production of plastics are natural products such as cellulose, coal, and natural gas, salt and of course, crude oil. (Orezzoli *et al.*, 2018).

Environmental pollution is caused due to the plastic because of having nonbiodegradable characteristics and they are full of harmful by-products and chemicals which are released during their break down process. It's been estimated that 400,000 barrels of oil are used each day to make plastic packaging in the world. The oil-based plastics

cannot be rid easily and create problems in landfills or environmental pollution (Pudji Astuti *et al.,* 2014). Making bioplastic from fruit peel instead of petroleum-based plastic is an effective solution that leads to a reduction in the use of non-renewable raw materials. Although the peel contains minerals like Calcium, Magnesium, Potassium, Sodium, Zinc, and Iron, its main component is Starch (18.5%). Wastes are generated in massive amounts due to the huge number of unused peels which represent about 30%-40% of the fruit mass. Since bioplastics are 100% degradable, the large emissions of carbon dioxide that occur during plastic production are reduced with the production of bioplastics between 0.8 and 3.2 tons. The materials which are synthesized using banana peel have the properties of pliability, user-friendliness and most importantly these materials are degradation tractable. Nowadays, it is crucial to have a potential bioplastic material in alternate over conventional plastic (Jerlin Vinod *et al.,* 2021).

Table 1. Banana peel proximate composition (Zamri Bin Yusoff *et al.,* 2016)

Item	Content (g/100 g dry matter)
Protien	8.6+0.1
Fat	13.1+0.2
Starch	12.78+0.9
Ash	15.25+0.1
Total dietary fibre	50.25+0.2

Table 2. Orange peel proximate composition (Fadaka Adewale *et al.,* 2014)

Parameters	% Composition
Moisture content	10.30+0.01
Ash content	5.51+0.02
Fat	2.78+0.01
Protien	16.51+0.40
Crude fibre	12.47+0.54

MATERIAL AND METHODS

Experimental materials

The raw materials used were Bananas and Oranges procured from local market Bodhan, Nizamabad dist, Telangana state. The chemicals such as HCl, NaOH, Glycerol, KMS and essential oils like clove and lime oils were used.

Experimental Procedure

Preparation of Fruit Peel mass

Three samples were prepared i.e.,

Banana peel mass (100 g) Orange peel mass (100 g) Banana and Orange peel mass (70 g and 30 g)

1. Peels were sliced using stainless steel knife and weighted using weighing balance
2. The peels were dipped in 0.5% $Na_2S_2O_5$ solution for 45 minutes separately prior to the boiling processes.
3. Three 800 ml beakers are filled with distilled water and placed on a induction stove. The peels were placed in the beakers and were boiled for 30 minutes.
4. After the boiling process, the beakers are removed from the induction stove and the peels were decanted off the water and placed on filter paper and left to dry for 30 minutes.
5. Using a hand blender, the peels were pureed until a fluid paste was formed.

Production of Bioplastic

1. 25 g of each peel paste from earlier experiment was placed in a beaker.
2. Then HCl with the volume of (3 ml) was added to the paste and stirred using glass rod. Similarly (1 ml) of plasticizer (Glycerol) with purity of 99.9% was added and stirred for a desired residence time of (5 minutes) and after the desired residence time of hydrolysis 3 ml 0.5 N NaOH is added according to the volume of HCl added to neutralize the mixture.
3. 2% of Essential oils like clove oil and lime oil are added at the end.
4. The mixture is spread on three different petriplates.
5. Then put into oven at 130 °C for 3 hrs.
6. After it is dried the films are scrapped off the surface and placed at a room temperature.

Reaction Mechanism

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 in the experiment is simply used to neutralize the pH of the medium.

Acid hydrolysis changes the physiochemical properties of starch without changing its granule structure. If the amylopectin content is higher in the starch, the recovery of starch decreases. Plasticizers or dispersants are additives that increase the plasticity or fluidity of a material. The dominant applications are for plastics, especially polyvinyl

chloride (PVC) glycerol, sorbitol

The sodium metabisulfite ($Na_2S_2O_5$) is used as an antioxidant here. It prevents the microbial growth in the peels (Jayakishan chandrana *et al.,* 2021).

Qualitative Characteristics

Mould Test

Moulding is a process of forcing melted plastic into mould cavity. Mould test is conducted to check whether bio-plastic can also be moulded into different shapes as such conventional plastic (Zamri Bin Yusoff *et al.,* 2016).

Swelling tests

Swelling study is generally conducted to check whether developed material retains the original properties when it was formed during the preparations. A pre-weighed piece of samples were prepared and were taken in the test tube to check the protuberance and other morphological changes, it was carried out on the medium containing various solvents such as water chloroform and methanol medium where the deliberated samples were kept in the medium for about 2 hours and the results were recorded accordingly (May Zon Kyawt Oo *et al.,* 2019).

Solubility Test

Bioplastic were prepared and solubility studies were conducted to check persistence of these bioplastic materials. Samples of bioplastic from peels were soaked in sodium metabisulfite solution and samples of bioplastic of peels which was obtained by a process described.

All the samples were cut into small pieces and were inserted into a test tube containing different solvents (May Zon Kyawt Oo *et al.,* 2019)

Biodegradability

Pre-weighed piece of bioplastics were taken and placed in soil at a depth of 5 cm from the surface. Some amount of water was sprinkled on the soil so that bacterial enzymatic activities could be enriched. These samples were kept for about 15 days and each 3 days of interval weight of the sample was recorded. And then, we observed the decrease in the weight of the bioplastic material and results were recorded accordingly (Zamri Bin Yusoff *et al.,* 2016).

Elongation test

Bioplastic was cut and was stretched out on the ruler. Initial and final length was measured (Zamri Bin Yusoff *et al.,* 2016). % Elongation= ((Final length – Initial length)/Initial length) × 100

RESULTS AND DISCUSSION

Experiments conducted

The experiment was conducted with three samples i.e., Banana peel, Orange peel and combination of banana and orange peel. The thickness of the film obtained is about 1 mm made with banana peel and combination of banana and orange peel and 1.5 mm made with orange peel and the weight of the dry film obtained is given below

Mould test

Hence it is proved that bioplastic can also be moulded into different shapes as conventional plastic.

Swelling test

The results for swelling test are given below. We can observe that there is a slight increase in weight of the bioplastic when soaked in water as a medium and this is a desirable result because most of the additives are prepared by using organic solvents, certainly it wil help in stabilize product synthesis and development.

Solubility test

Solubility is the main property to check whether the synthesized bioplastic material is sustainable or not. If the bioplastic material possess the property of less or zero engorgement that can be considered as excellent material with stability. It is observed that none of the samples were soluble in different

Table 1. Weight of the dry film

Fruit peel	Amount of paste taken (g)	Concentration of HCL	Concentration of NaOH	Final weight (g)
Banana peel	25g	0.5M	0.5M	3g
Orange peel	25g	0.5M	0.5M	5g
Banana+Orange peel	25g	0.5M	0.5M	4g

Plate 1. Banana peel bioplastic

Plate 2. Banana & Orange bioplastic

Plate 3. Orange peel bioplastic

Table 2. Swelling test results for bioplastics

Bioplastic derived from	Solvent medium	Quantity (ml)	Initial weight of the sample (g)	Final weight of the sample (g)	Difference in weight (g)
Banana Peel	water	10	1	1.35	0.35
Orange Peel	water	10	1	2.21	1.21
Banana+ Orange Peel	water	10	1	1.54	0.54

mediums which shows that the bioplastic material prepared are stable.

Biodegradable test

It is observed that there is a reduction in weights of the bioplastic material as days are passing. The results show that the synthesized bioplastic is degradable to a large extent within 15 days which is helpful in preparation of environmentally friendly product.

Elongation test

The results showed that there is more percentage of elongation in bioplastic made with combination of banana and orange peel i.e., 21.4% which indicates that it has more strength. Bioplastic made with

Table 3. Solubility test results for bioplastic

Solvents used	Sample	Insoluble	Partially soluble	Completely soluble
Water	Banana peel bioplastic Orange peel bioplastic Banana+orange peel bioplastic	Yes	-	-
Sulphuric Acid	Banana peel bioplastic Orange peel bioplastic Banana+orange peel bioplastic	Yes	-	-
Ethyl Alcohol	Banana peel bioplastic Orange peel bioplastic Banana+orange peel bioplastic	Yes	-	-

Table 4. Biodegradable test results for biolastic

Bioplastic derived from	Initial weight of the sample(g)	Observation after 3 days	6 days	9 days	12 days	15 days
Banana Peel	1.5g	1.12	0.98	0.87	0.65	0.52
Orange Peel	1.5g	1.23	1.04	0.93	0.88	0.61
Banana+Orange Peel	1.5g	1.15	0.92	0.80	0.55	0.46

orange peel has less strength as it contains less amount of starch in it

Table 5. Elongation test results for bioplastic

Bioplastic derived from	Initial length	Final length	% Elongation
Banana peel	6.7	7.4	10
Orange peel	6.0	6.2	3.3
Banana+ orange peel	5.5	6.5	21.4

CONCLUSION

The raw material selected, i.e., banana peels and orange peels were obtained from the local market. In the experiment three samples were prepared one with banana peels [100 g], orange peel [100 g] and the third one with the combination of banana [70 g] and orange peel [30 g]. The standard solution of 0.5% sodium meta bisulphate was prepared and the peels were soaked in the solution of Sodium meta bisulphate for half an hour. When strained from the solution, the peels were ready for further heat treatment. The peels were then boiled in distilled water for 0.5 hour by gas burner. The boiled peels were then strained off and then subjected to drying for 0.5 hour. This will remove the extra water which may increase the time in the process. The peels were ground by small home mixer grinder or motor and pestle to a fine paste. The amount of 25 ml of fruit peel mass was measured and placed in 500 ml beaker. After that 3 ml of HCL and NaOH was added and the mixture was mixed using a glass stirring rod. And then 2 ml of Glycerol was added to beaker. The mixture was stirred again. The mixture was poured into a petridish and put in the oven at 110 °C for 3 hours. The bioplastic was obtained.

The obtained bioplastic was subjected to mould test, swelling, solubility, biodegradability and elongation test. The mould test proved that the obtained bioplastic can be moulded into different shapes like conventional plastic and there is a slight increase in weight of the bioplastic when soaked in water as a medium and this is a desirable result because most of the additives are prepared by using organic solvents, certainly it will help in stabilize product synthesis and development. Solubility test confirmed that the synthesized bioplastic is insoluble in different mediums like water, ethyl alcohol and Sulphuric acid that it can be considered as excellent material with stability. Biodegradable test showed that the bioplastic is degradable within 15 days indicating it is a environmentally friendly and elongation test showed the strength of bioplastic made with the combination of banana and orange has more strength than the other two.

LITERATURE CITED

Andreas Künkel, J. B. 2016. Polymers, Biodegradable. *Ultimate Encyclopedia of Industrial Chemistry*. pp 1-29.

Andualem, S. G. 2017. Ethiopia eyes shifting from importing to exporting plastic products. *Manufacturing*. pp. 1-8.

Brodin, M., Vallejos, M., Opedal, M. T., Area, M. C. and Chinga-Carrasco, G. 2017. Lignocellulosics as sustainable resources for production of bioplastics - A review. *Journal of Cleaner Production.* 162: 646-664.

Buchholz, O. 2012. *European bioplastics*. Retrieved March 25, 2019, from European bioplastics website: https://www.european-bioplastics.org/bioplastics/

Chen, Y. J. 2014. Bioplastics and their role in achieving global sustainability. *Journal of Chemical and Pharmaceutical Research.* 6(1): 226-231.

Chen., G. Q. and Patel, M. K. 2012. Plastics derived from biological sources: Present and future: technical and environmental review. *Chemicals Reviews*. 112(4): 2082-2099.

Chris, B. 2010. Environmental Problems with Plastic. *http://www.ehow.com/about_5045721_environmental-problems-plastic.html-,* Pp 4-11.

Gaonkar, M.R. 2017. Production of biplastic from banana peels: Jawaharlal Nehru Engineering College, Hyderabad.

Goodall, C. 2011. Bioplastic: An important component of global sustainability. *Carbon Commentary.* 10(1): 10-18.

Jamróz, E. and Kopel, P. K. 2019. The Effect of Nanofillers on the Functional Properties of Biopolymer-Based Films*: A Review. Polymers (Basel).* 11(4): 675.

Jayachandra Yaradoddi, 2016. Biodegradable plastic production from fruit waste material and its sustainable use for green applications*: International journal of Parmaceutical research and Allied Sciences*. 5(4): 56-66.

Jayakshan Chandrana, 2021. Production of bioplastics from banana peels: *Department of chemical engineering, Anurag group of institutions,* Ghatkesar, Hyderabad, India.

Jerlin Vinodh, 2021. Bioplastic from Banana Peel: *International Journal of Advance Research, Ideas and Innovations in Technology*. 7: (2) https://www.ijariit.com

Johansson, C., Bras, J., Mondragon, I. and Nechita, P. 2012. Renewable fibers and bio-based materials for packaging applications - A review of recent

developments. *Bioresources.* 7(2): 2506-2552·

Jouhara, H., Czajczynsa, D., Ghazal, H., Anguliano, L., Reynolds, A. and spencer, N. 2017. Municipal waste management systems for domestic use. *Journal of Energy.* 139(1): 485-506.

Khadiga Mohamme, 2021. Production of Bioplastics from agricultural Waste, Mainly Banana Peels, Musa Sapientum, Using Batch Reactor: *Department of Chemical Engineering, Faculty of Engineering, University of Khartoum.*

Lackner, M. 2015. Bioplastics - Biobased plastics as renewable and/or biodegradable alternatives to petroplastics.

Luzi, F., Torre, L. and Puglia, J. M. 2019. Bio- and Fossil-Based Polymeric Blends and Nanocomposites for Packaging: Structure-Property Relationship. *Materials (Basel).* 12(3): 471.

Martien van den Oever, K. M. 2017. *Bio-based and biodegradable plastics - Facts and Figures*. Wageningen Food & Biobased Research, institute.

May Zon Kyawt Oom 2019. Bioplastics from fruit waste: *International Journal of Advances in Scientific Research and Engineering (IJASRE), ISSN:2454-8006*, 5(8): 209-215. https://doi.org/10.31695/IJASRE.2019.33504

Neal, A., Andrady, L. and Mike, A. 2009. Applications and societal benefits of plastics. *Philos Trans R Soc Lond B Biol Sci.* 364(1526): 3-8.

Orezzoli, A., Zavaleta, E., Pajares-Medina, N., Adolfo, S. and Linares, L. L. 2018. Physicochemical and Mechanical Characteristics of Potato Starch-Based Biodegradable Films. *Asian Journal of Scientific Research.* 11(1): 56-61.

Ottman, J. A. (2011). In J. A. Ottman, *The New Rule Of Green Marketing* (First Edition ed., pp. 23-26). San Francisco: Berret- Koehier Publichers Inc.

Pathak, S., Sneha, C. and Mathew, B. 2014. Bioplastics: Its Timeline Based Scenario and Challenges. *Journal of Polymer and biopolymer Chemistry*. 2(4): 84-90.

Patil, N. 2018. Developments in Polymer Science and Engineering. *Journal of Polymer Sciences.* 4(2): 149-157.

Peelman, N. and Devlieghere, F. 2013. Application of bioplastic for packaging. *Trends in food Science & Technology*. 32(2): 128-141.

Pudji Astuti, 2014. Antimicrobial Edible Film from Banana Peels as Food Packaging*: American Journal of Oil and Chemical Technologies.* ISSN (online): 2326-6589; ISSN (print): 2326-6570 V 2, I (2).

Raschka, A., Carus, M. and Piotrowski, S. 2013. Renewable Raw Materials and Feedstock for Bioplastics. *Bio-Based Plastics*. 331-345.

Reddy, R. L., Reddy, V. S. and Gupta, G. A. 2013. Study of Bio-plastics As Green & Sustainable Alternative to Plastics. *International Journal of Emerging Technology and Advanced Engineering*. 3(5): 82-88.

Sharmila, S. 2021. Production of biodegradable plastics using starh and waste fruit peels: *Research Journal of Science and Technology*. 13(1).

Syed, A. A. 2016. *Introduction to Bioplastics Engineering* (1st ed.). William Andrew Tran, T. H. L. 2019. Five different chitin nanomaterials from identical source with different advantageous functions and performances. *Carbohydrate Polymers*. 205(3): 392-400.

Yates, M. R. 2013. Life Cycle Assessments of Biodegradable, Commercial Biopolymers - *A Critical Review. Resources, Conservation and Recycling.* 78: 54-66

Zamri Bin Yusoff, 2016. Production of biodegradable plastic from banana peel : *Journal of Petrochemical Engineering,* V 1, I (1).