INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY
IJARIIT

ISSN: 2454-132X
Impact Factor: 6.078

(Volume 7, Issue 2 - V7I2-1480)
Available online at: https://www.ijariit.com

Bioplastic from Banana Peel

Jerlin Vinodh
jerlinvinodh@gmail.com
Kumaraguru Institutions, Coimbatore, Tamil Nadu

Subasree P.
subashree.17bt@kct.ac.in
Kumaraguru Institutions, Coimbatore, Tamil Nadu

Mausheimi G.
mausheimi.17bt@kct.ac.in
Kumaraguru Institutions, Coimbatore, Tamil Nadu

Sanju Vikashni R.
sanju.17bt@kct.ac.in
Kumaraguru Institutions, Coimbatore, Tamil Nadu

ABSTRACT

Plastics play a major role in several industrial applications owing to their properties such as elasticity (plastikos-elasticity), cheap availability, durability, convenience in packaging, and various other features. However, in current times; its usage has posed severe irreversible threats to the environment and its species owing to its non-biodegradable nature. The development of bioplastics and its commercialization has thus become the need of the hour. The ideology of producing bioplastics from agro-based wastes proves to be an innovative solution to the aforementioned issue. This article reviews the production of bioplastic from banana peel via various methodologies and its applications. The additives used for its production and the testing methods revealed that the end product met all standard requirements to act as a replacement for synthetic plastic.

Keywords— *Plastic, Biodegradable, Banana Peel, Bioplastics*

1. INTRODUCTION

In the modern world, dependency on petroleum-based polymers has extensively increased over the years. Synthetic polymers like polypropylene (PP), polyethylene (PE), nylon, polyester (PS), polytetrafluoroethylene (PTFE), and epoxy are derived from petroleum hydrocarbons. Synthetic plastics are non-biodegradable. Since they remain in the environment for long, they cause landfill deposition problems, toxicity, deposition in water bodies thereby increasing the Biological Oxygen Demand (BOD), disturbing the carbon chain, and adversely affecting biodiversity. Hence, there is a consistent need to change the current lifestyle and industrialization to a sustainable way by preventing excessive plastic usage (Piemonte, 2011). Renewable biomass sources are obtained from plastic materials, such as wood chips, vegetable fats and oils, sawdust, corn starch, straw, and recycled food waste. These plastics disintegrate into gases like CO2 and organic matter over time [2]. The degradation of bioplastic is said to start after 3 to 4 months from the date of production [14]. Making bioplastic from banana 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%) [2]. Wastes are generated in massive amounts due to the huge number of unused peels which represent about 30%-40% of the fruit mass [4]. 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 [17]. 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 plastics [16].

Table 1: Composition of elements in Banana Peel

Parameters in banana peel	Value (wt%)
Cellulose	12.17 ± 0.21
Hemicellulose	10.19 ± 0.12
Acid-Detergent) Lignin	2.88 ± 0.05

Sucrose	15.58 ± 0.45
Glucose	7.45 ± 0.56
Fructose	6.2 ± 0.4
Protein	5.13 ± 0.14
Pectin	15.9 ± 0.3
Ashes	9.81 ± 0.42

2. CO-POLYMERS

Table 2: Various copolymers and their properties

Co-polymers	Properties
Glycerol/ Glycerin (Glycerin is the commercial name of glycerol which contains about 95% of glycerol in it, which are both names of the same molecule)	Glycerol is one of the main components that produce the property of plasticity or flexibility also prevents brittleness in bioplastics.
Polyvinyl chloride (PVC)	The Polyvinyl chloride (PVC) when added with glycerin [3], forms cross-links making it thermoset plastics of increased durability.
Zinc oxide	Glycerol (0, 50, 10 mL) and zinc oxide (1,3,5%) increase the antimicrobial activity and biodegradability of bioplastics. [7]
Cassava starch	1% of Cassava starch in combination with 1% glycerol [9] solution provides biocompatibility, its non-toxic property makes it ideal in food packaging and it is also employed due to its low cost and ease of availability.
Potato starch, sage, Corn starch	Given the non-toxicity of polymers which are greatly preferred in food industries Potato starch, sage [10], tapioca starch [11], Corn starch [12] are used with a combination of glycerol to produce natural-based bioplastics
Citric acid	The addition of Citric acid [13] with glycerol increases the fluidity and flexibility of the material.
Wheat flour (gluten)	The combination of glycerin with equal amounts of catalyst (sulphuric or acetic acid) with 100% wheat flour (gluten) [15] has good rheological properties, water sensitivity, sound absorption, thermal behavior, and easy availability at low cost.
Vinegar	Vinegar [19] in combination with glycerol helps break down starch chains to dissolve easily and enhances pliability.
Propan-1,2,3-triol	In addition to the majority use of glycerol, propan-1,2,3-triol [1,4] itself acts as a potent plasticizer widely.
Poly-hydroxybutyrates (PHB)	Poly-hydroxybutyrates (PHB) are value-added, biocompatible, hydrophobic, biodegradable thermoplastic that can be synthesized by microbes utilizing the polysaccharides from banana peel and bear similar mechanical property to that of polypropylene or polyethylene.
Corn starch, Cellulose & Chitosan	About 1% corn starch [12], 25% cellulose [3], or 4% chitosan [7] individually gives the bioplastic its slight stiffness and increases degradability. The addition of chitosan helped improve the anti-microbial properties of the bioplastic.[19]
Bio-resins, Epoxy resins	The bio-resins derived from the banana peels themselves can be noted to increase the densities of bioplastic [7].

3. TESTING METHODS AND ANALYSIS

Table 3: Various testing methods, its explanation, and inference

Testing Methods	Explanation	Inference
Molding test	Flexibility is one of the important parameters to be considered while designing the bioplastic to have its application in various industries. A molding test should be done to ensure that the designed bioplastic is flexible enough to use for commercial purposes [1].	Nil.
Degradation test	The amount of glycerin used for bioplastic production has a greater impact on the degradation of the plastic and it will also help to increase its elasticity. Therefore higher amount of	Complete degradation of bioplastic was found to be at 350-490C when measured using the thermal analyzer.

	glycerin, quicker the process of degradation [1]. Degradation percentage (%) = (Final weight (g)-Initial weight (g)/Initial weight) *100 [2]. The weight loss was observed due to the presence of microorganisms in the natural environment. It was found that biopolymer got degraded in 12 days [9]. Aerobacter and Clostridium contribute higher to the degradation of bioplastic [11].	(TG-DTA).[9] A bioplastic sample of 40 wt.% banana peel demonstrated the highest weight loss percentage of 65.1% whereas the sample of 5 wt.% banana peel showed the lowest weight loss percentage of 45.2%.[11] 0.0474 mm thickness was found to be ideal for bioplastics.[15]
Elongation test	Tensile strength is defined as the force it can withstand under pressure without breaking [1]. Tensile strength was determined by using the Universal Testing Machine and observed that the tensile strength increased when the residence time was increased from 5 to 15 minutes and then it started decreasing which shows that the optimum residence time for hydrolysis is 15 minutes.[5]The studies revealed that the chemical-based bioplastics have a higher tensile strength of 228KPa.But when Young's modulus was calculated, Natural based bioplastic has higher elasticity of 1.88MPa.[10].10% banana peel concentration showed a higher resistance of 35.147N/mm. Therefore, lower the starch content, the higher the tear resistance [11]. The strength and modulus increase only for some proportion of the weight fraction of filler [18].	Vehicle bumper obtained from banana peel waste showed a tensile strength of about 120(MPa/kg.m3).[3] The bioplastic film obtained with the following composition of 25ml banana paste in 0.1 and 0.5 mol concentration of HCl and NaOH solution was found to have the maximum tensile strength [4]. Biopolymeric films obtained from banana peels were found to have a tensile strength of 2Mpaand a the tear strength of 5 kN/m [9] Biocomposite obtained from banana peels showed a tensile strength of 150Kpa and a young's modulus - 1.88Mpa[10] The natural-based have only 13.97% of the share of elongation. While the chemical-based achieved 18.77% of percentage elongation [10].
FTIR	The secondary structures of bioplastic sheets were studied in Mid IRrange (4000-400cm-1). The results indicated the presence of hydroxyl and carbonyl groups.[2][12]. The functional groups present in the bioplastic were studied. Sharp peaks at 2920.31cm-1 and 2853.5 cm-1 indicated the presence of CH and CH2 groups in the starch structure [12]. There is an additional peak in the banana peel filler at 1281 cm−1 corresponding to the O-H phenolic of lignin. The FTIR analysis of the banana peel filler indicates its lignocellulosic nature [18].	The result obtained from FTIR showed O–H stretching peaks at 3363.67, C–H stretching peaks at 2922.90, C=C stretching peaks at 1633.94, and C–O stretching peaks at 1076.08 cm–1.[2][12]
X-ray diffraction	X-Ray Diffraction uses X-ray beams for the rapid analysis of surface morphology and elemental composition of the film. From the results, we can conclude that the plastic film is amorphous [2].	Bioplastic sheets with the dimension of 1cm X 1cm were scanned at a scanning rate of 0.2°min and diffraction angle from 20° to 80°.[2]
UV visible spectrophotometer	UV Visible spectrophotometer allows the light to pass through the sample and the intensity of transmitted light was detected through the detector. It is mainly used to check the transmission of light through the sample for its application in food packaging [2].	Nil.
SEM	SEM analysis is very effective in determining the chemical composition and the surface morphology of bioplastic. The results revealed that the surface was smooth with little blemishes. As the concentration of banana extract increases, the surface shows uneven distribution [11].	Lower concentrations of the filler (starch) lead to the formation of a smooth film without any blemishes [11].
Water absorption capacity	The bioplastic has a higher swelling index of 50-55% which might enhance the biodegradability but it restricts its usage in food applications [2]. So bioplastic in general has a higher	Banana peel-based bioplastic used for the production of vehicle bumper showed a water absorption capacity of

	water absorption capacity of 50%. Bioplastic with 3% corn starch has a lower percentage of water uptake WA= final weight - initial weight /initial weight *100[12].	0.03% [3].
Burning test	A burning test was conducted for the visual observation of the color of the flame and the time taken for the burning.[3]	Bioplastic bio bumper showed the following characteristics when undergone the burning test Low odor, Yellow-orange flame, Speed of burning -Slow [3].
Visual inspection	Visual inspection was carried out to detect the presence of defects like low thickness and visible tears in the sample [5]	Nil.
Antimicrobial activity test	The antimicrobial activity of the plastic was tested using the Kirby Bauer method. The film was incubated with gram-positive and negative bacteria for 24 hours. It was found that antimicrobial activity decreased with the increased concentration of starch and glycerol. The addition of zinc oxide exhibited a higher antimicrobial effect on bioplastic [6].	Zone of clearance was found to be high at 5% zinc oxide and 5ml glycerol [6].

4. APPLICATIONS

The use of banana peels in making films has found potential applications in food packaging industries owing to their ability to improve the food quality, biodegradable properties [7] while protecting the packed content from environmental conditions thereby increasing its shelf life [1]. When blended with chitosan these banana peels-derived films show anti-microbial properties or the ability to inhibit bacterial growth which has helped them find applications in the medicine and healthcare industries [7]. Banana peels are also used as a bio adsorbent in wastewater treatment by removing various organic and inorganic (heavy metals and dyes) contaminants [8]. Banana peels act as reserves of large quantities of antioxidants along with other macronutrients (carbohydrates) and are used as additives in the preparation of fresh fruit juices [8]. Banana peel plastics are flexible and durable and are used in the manufacture of bags and tubes (Prof.Manasi Ghamande et al). Bio Resins developed from banana peels are used in the development of biocomposites [7]. Nano cellulose fibers and bioplastics from banana peel residues play a major role in various areas of automobile applications like tire development and other vehicle manufacture [3], stabilizers in food industries, facilitate mechanical reinforcements in drug delivery systems, acts as enzyme support, biosensors, and tissue scaffold engineering applications [9]. Fibers obtained from banana peel residues have been conventionally used in making paper, ropes, table mats, and handbags [8]. Banana peel-derived composite films were observed for their antimicrobial properties and protection against bacteria like *Staphylococcus aureus* [19]. Banana peels have also found their applications in biofuel and biogas production on account of the high values of energy (18.89MJ\kg) produced from their dried forms.[8]. Whole banana residues are found to generate about 80–95 MW annually. Banana peels were capable of generating 12–25 MW per year. Banana peels are recently researched for their ability to act as a bio adsorbent with a removal efficiency of about 60–80% [8]. The development of biodegradable planting bags has been achieved using the starch and nanocellulose films obtained from banana peels [11].

5. DISCUSSION

Bananas are annual plants and their peels are available at all times of the year [12]. Raw green banana peels have been identified as potent producers of bioplastics owing to their higher starch content, better transparency, and several other features that meet standard requirements for commercial bioplastic production [2]. The fermentation of banana peel wastes yields polylactic acid (PLA); a renewable polyester material in nature that is also studied for its applications in bioabsorbable fixation devices, drug delivery systems, and several other biomedical applications [2]. Various additives have been used to enhance the properties of the banana peel bioplastic; which includes the usage of citric acid, a co-plasticizer in increasing the tensile strength of the final product.[12], usage of starch to polythene help improve biological degradation [2]. Studies regarding the methods to improve the standard requirements of bioplastic production can be pursued shortly, as it would be of great benefit to the environment and the species occupying it [12].

6. CONCLUSION

Bioplastic from banana peels equalizes the standards of synthetic plastic. This has already found its way as an alternative to synthetic plastic in various industries. The commercialization of bioplastic from banana peel would be of great potential to help save the environment and the species occupying it from facing the aftermaths caused by the usage of synthetic plastics. Therefore, the approaches to introduce them in the global market must be considered at this point.

7. REFERENCES

[1] Manimaran, D. S., raj Nadaraja, K., peter Vellu, J., Francisco, V., Kanesen, K., & Yusoff, Z. B. (2016). Production of Biodegradable Plastic from Banana Peel. *J. Petrochemical Engineering*, *1*(19), 2.

[2] Comparative study of bioplastic sheets from different varieties of banana peel Riya Singh

[3] Hossain, A. S., Ibrahim, N. A., & AlEissa, M. S. (2016). Nano-cellulose-derived bioplastic biomaterial data for vehicle bio-bumper from banana peel waste biomass. *Data in brief*, *8*, 286-294.

[4] Banana peels based bio-plastic Ahmed Ibrahim Mohamed Ahmed

[5] PRODUCTION OF BIOPLASTIC FROM BANANA PEELS 1M.R.GAONKAR, 2PRASHANT PALASKAR, 3RISHIKESH NAVANDAR

[6] Agustin, Y. E., & Padmawijaya, K. S. (2017, July). Effect of glycerol and zinc oxide addition on antibacterial activity of biodegradable bioplastics from chitosan-kepok banana peels starch. In *IOP Conference Series: Materials Science and Engineering* (Vol. 223, No. 1, p. 012046). IOP Publishing.

[7] Mwesigwa, R., Mwasiagi, J. I., Githaiga, J. T., Nzila, C., & Oyondi, E. N. (2016). The study of the factors affecting the viscosity of locally made bio-resin from raw banana peels. *Research and Review in Polymer*, *7*(2), 1-9.

[8] Redondo-Gómez, C., Rodríguez Quesada, M., Vallejo Astúa, S., Murillo Zamora, J. P., Lopretti, M., & Vega-Baudrit, J. R. (2020). Biorefinery of Biomass of Agro-Industrial Banana Waste to Obtain High-Value Biopolymers. *Molecules*, *25*(17), 3829.

[9] Naing, H. H., Shwe, H. H., Pe, N. N., & Tun, Y. Utilization of Waste Banana Peel for Synthesis of Biopolymeric Film.

[10] Azieyanti, N. A., Amirul, A., Othman, S. Z., & Misran, H. (2020, April). Mechanical and Morphology Studies of Bioplastic-Based Banana Peels. In *Journal of Physics: Conference Series* (Vol. 1529, No. 3, p. 032091). IOP Publishing.

[11] Huzaisham, N. A., & Marsi, N. (2020). Utilization of Banana (Musa Paradisiaca) Peel As Bioplastic for Planting Bag Application. *International Journal of Advanced Research in Engineering and Technology (IJARET)*, *11*(4).

[12] Sultan, N. F. K., & Johari, W. L. W. (2017). The development of banana peel/corn starch bioplastic film: A preliminary study. *Bioremediation Science and Technology Research*, *5*(1), 12-17.

[13] Oliveira, T. Í. S., Rosa, M. F., Ridout, M. J., Cross, K., Brito, E. S., Silva, L. M., ... & Azeredo, H. M. (2017). Bionanocomposite films based on polysaccharides from banana peels. *International journal of biological macromolecules*, *101*, 1-8.

[14] Shrirakshaya, S. S., Vignesh, M., Dhananandhini, M., Kavya, N., & Poongothai, M. Cellulose and Starch as the Source of Bioplastic.

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

[16] Yaradoddi, J., Patil, V., Ganachari, S., Banapurmath, N., Hunashyal, A., Shettar, A., & Yaradoddi, J. S. (2016). Biodegradable Plastic Production From Fruit Waste Material And Its Sustainable Use For Green Applications. *INTERNATIONAL JOURNAL OF PHARMACEUTICAL RESEARCH AND ALLIED SCIENCES*, *5*(4), 56-65.

[17] BIOPLASTIC BASED ON BANANA PEEL Ruth Castillo, Eliasury Escobar, Dianeth Fernández,Ramón Gutiérrez, Jonathan Morcillo, Neryana Núñez and Sandra Peñaloza.

[18] Kumar, T. S. M., Senthilkumar, K., Chandrasekar, M., Subramaniam, S., Rangappa, S. M., Siengchin, S., & Rajini, N. (2020). Influence of Fillers on the Thermal and Mechanical Properties of Biocomposites: An Overview. In *Biofibers and Biopolymers for Biocomposites* (pp. 111-133). Springer, Cham.

[19] Pitak, N., & Rakshit, S. K. (2011). Physical and antimicrobial properties of banana flour/chitosan biodegradable and self-sealing films used for preserving fresh-cut vegetables. *LWT-Food science and technology*, *44*(10), 2310-2315.

