SYNTHESIS AND CHARACTERIZATION OF STARCH BASED BIOPLASTIC FROM ELEPHANT FOOT YAM AND ITS APPLICATION IN MEDICAL INDUSTRY

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ABSTRACT

The word plastic derives from the Greek word 'plastikos,' which implies fitted for being shaped or moulded. Plastic has become a catch-all word relating to the wide range of materials made utilizing polymers and additional chemicals that may be moulded and projected into diverse shapes. Polymers can be natural or synthetic; natural polymers include cellulose, protein fibre (silk, wool), and starch. This article describes the production of bioplastics from elephant foot yam using a casting technique and glycerol.

Keywords: *Elephant foot yam, bioplastics, biofilm.*

I. INTRODUCTION:

Plastics are organic materials just like wood, paper etc. The raw source or material used for the production of plastics are natural products like cellulose, coal, natural gas etc. Plastics is the term commonly used for describing a wide range of synthetic or semi synthetic materials that are used in huge range of applications. Plastics are synthetic macro molecular substance mostly originating from petroleum-based plastics and are mostly non degradable. The common types of petroleum-based plastics are classified as polyethylene, polystyerene, polyethelyene terephthalate (PET). The plasticity of the plastics makes possible for the plastics to be moulded into a specific shape or form in which it is needed. The adaptablility and wide range of properties of plastics like flexibility, light weight of material, inexpensive quality has led to the widespread of the plastic use in all fields (L.S.Romero et al., 2019).

Elephant foot yam (Amorphophallus paeoniifolius) is an important starchy tuberous vegetable with high nutritive and medicinal values. (M. Sharangat et.al 2020). Dry matter and starch contents of organic corms were significantly higher than those of conventional corms by 7% and 13%, respectively. Organic corms had 12% higher crude protein and 21% significantly lower oxalate contents. It serves as a source of protein as well as starch.. (M. Sharangat et al., 2020)

The bio-plastic is now been used mostly in all fields replacing the conventional plastic. Bio-plastic can be made from agricultural by-products and by using microorganisms. Bio-plastics are used for disposable items such as food packaging, crockery, pots, bowls etc. Biodegradable plastic bags can be synthesized by this method and can be replaced with the polyethene bags for shopping which can be degraded easily. Bio-plastics will soon be replaced with the conventional plastic in the markets and researchers are on the process for that (Hakan Karan et al., 2019).

NOMENCLATURE:

- **Scientific Name**: Amorphophallus paeoniifolius
- **Common Name**: Elephant foot yam
- **Taxonomic Tree**:
  Order : Alismateles
  Family : Araceae
  Genus : Amorphophallus
  Species : A. paeoniifolius

II. MATERIALS AND METHODOLGY

Materials required for the synthesis and characterization of composite bio-plastic from elephant foot yam starch are listed below.

- Elephant foot yam
- Hot air oven
- Glassware
- Heating mantle
- Mortar and Pestle
- Steel tray
- Glycerol (Propane - 1,2,3 triol)

METHODOLOGY

COLLECTION OF SAMPLES

The sample -Elephant foot yam was collected from nearby market.
a) Preparation of elephant foot yam starch
b) Bioplastic produced by film casting method.

A) Preparation of elephant foot yam starch:

The starch used is extracted from the elephant foot yam tubers. They were peeled, washed and grated.

- ❖ The grated tubers are made to paste and the liquid is extracted and 200 ml of water is added.
- ❖ The solution is centrifuged at 5000 RPM for 10 minutes. The starch is present in the pellet.
- ❖ The pellet is removed and dried to get the powdered starch.

Fig1 Elephant foot yam tuber.

Fig 2 Finely cut tubers

Fig 4 Powdered starch

Fig 3 Starch solution

b) Bioplastic produced by film casting method:

- Biofilms were produced using film casting method.
- 4g of Elephant foot yam tuber starch powder was used to produce film by dissolving it in 200 ml of distilled water and 2g glycerol are added, glycerol is functioned as a plasticizer to improve film's flexibility.
- The solution is degassed in a heating mandle for an hour and is cooled at room temperature. Fig 5.
- The solution is poured in a casting tray into 30cm diameter. Fig 6
- The tray is placed in a hot air oven for 50°c for 48 hours. Before peeling the dried film, it is kept at room temperature. Fig 7

Fig 5. Solution in heating mandle.

Fig 6. Solution casted in tray

Fig 7. Biofilm produced

CHARACTERISTICS TEST

THICKNESS

The thickness of the bio-plastics is measured by screw gauge, by selecting different position of the film and its value is calculated.

WATER SOLUBILITY

The bio-plastic material is prepared for the study of solubility. The test was done to check the persistence of the bio-plastic materials by following procedures. The samples were chopped into small pieces and inserted into test tubes containing different solvents like ammonia, acetic acid, acetone, sulphuric acid and alcohol. The solvent was chosen in such a way that the activity of material with parameters like polar solvent, non-polar solvent and weak acid were determined.

COLOUR

To check the colour of bio – plastic.

DEGRADATION TEST

To check the bio-plastic degradation in natural conditions like hot water, fire, and soil. Bio-plastic sample (2×2) were buried in compose soil at 8 cm depth, then incubated at room temperature for 10 days with sampling time every two days. The buried samples were cleaned and weighed.

ANTI – MICROBIAL ACTIVITY

To check the anti –microbial activity of the bio-plastics.

ANTIMICROBIAL ACTIVITY

The antibacterial activity was performed by agar well diffusion method (Perez et al., 1999). Molten Mueller Hinton agar was inoculated with the 100 µl of inoculum (1×108Cfu) as shown in table 1 and poured into petri plate. Using cork –borer the wells were punched in the plates (0.85). In each well, test sample of 100µl were introduced. Incubation for each plate was done in overnight at 37 °C for bacteria and 27°C for fungi. Microbial growth was determined by measuring the diameter of zone of inhibition. For each bacterium and fungi, the controls were maintained. By measuring the diameter of zone of inhibition the results were obtained. The experiment was done three times and then respective mean values are calculated.

COMPOSITION OF MULLER HINTON AGAR MEDIUM FOR THE DETERMINATION OF ANTIMICROBIAL PROPERTY

Table. 1 - Ingredients and quantity of materials used in antimicrobial property

Ingredients	Quantity (g /L)
Beef extract	2.0
Acid Hydro lysate of casein	17.50
Starch	1.50
Agar	17.00
Distilled water	1000ml
*pH	7.3

III. RESULT AND DISCUSSION

THICKNESS:

The thickness of the bio- plastics is measured at different places using a screw gauge and their average value is calculated. The thickness of bio –plastic sample was found to be 0.5 mm (700 microns). The results revealed that the prepared bio-plastics have a thickness of 700 microns, hence it can be used for preparing packing covers.

Fig.5 - Biofilm used for thickness test

SOLUBILITY TEST

Solubility test done from the produced biofilm are discussed below. Solubility test of synthesized bio-plastic from elephant foot yam. The studies revealed that the material was insoluble in water, so it becomes eligible to be a bio-plastic material. It was insoluble in acetone and acetic acid (polar solvent), ethyl alcohol (non polar solvent) and partially soluble in ammonia (polar solvent) and its completely soluble in sulphuric acid (strongly acidic solvent). For selecting bio-plastic material, solubility plays an important role because if the material becomes soluble in water and in other organic solvents as shown in fig.6 and table 2, it cannot be declared as bio-plastic. So, results from the solubility test reveals that the material is insoluble in water and other organic solvents makes it more efficient to become bio –plastics.

Table.2. - Solubility Test

S.NO	SOLVENTS USED	SOLUBILITY TEST		
		INSOLUABLE	PARTIAL PRESSURE	COMPLETELY SOLUBLE
1	AMMONIA	-	+	-
2	ACETIC ACID	+	-	-
3	ACETONE	+	-	-
4	WATER	+	-	-
5	ETHYL ALCOHOL	+	-	-

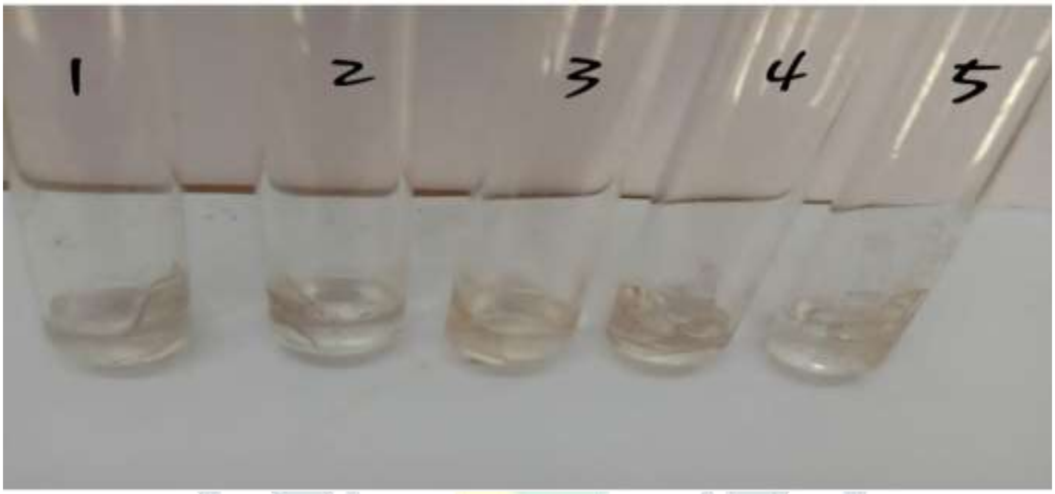


Fig.6- Solubility test in different solvents

DEGRADATION TEST:

IN HOT WATER:

The bio degradability test done in hot water from the produced biofilm are discussed below. The bio-plastics is degradable in hot water at 90 °C.

Fig.7 - Degradation test in hot water

IN SOIL:

The bio-plastics is made up of only natural source from the starch of Elephant foot yam with the addition of water and glycerol. Starch and glycerol are degraded naturally and day by day the film loses its weight as shown in Fig 8.

BEFORE

AFTER

Fig.8 – Soil burial test

ANTIMICROBIAL ACTIVITY:

Antibacterial activity of BIO- PLASTIC (Extract of Elephant foot yam) against the tested pathogens namely E. coli, Pseudomonas aeruginosa, Streptococcus aureus, Bacillus thuringiensis and the zone of inhibition is discussed below.

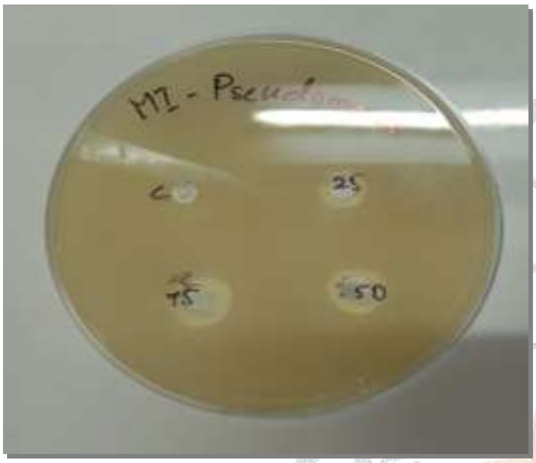
Zone of inhibition (mm)

S. NO	PATHOGENS NAME	ZONE OF INHIBITION (mm)		
		25 µl	50 µl	75 µl
1	E .Coli	1.2 cm	1.4 cm	1.5 cm
2	Pseudomonas aeruginosa	1 cm	1.3 cm	1.4 cm
3	Streptococcus aureus	Less active	1.1 cm	1.3 cm
4	Bacillus thuringiensis	0.9cm	1.1cm	1.3cm

- In E.Coli, Pseudomonas aeruginosa, Streptococcus aureus, Bacillus thuringiensis zone of inhibition, the highest activity is seen in 75 µl, and less activity is seen in 25 µl.
  From the antibacterial test values listed in the table.
  - **E. coli** is more active that is 1.5 cm in 75 µl
  - **Streptococcus aureus** and B**acillus thuringiensis** are less active that is 1.3 cm in 50 µl.

Strepococcus Aureus

E- Coli



Pseudomonas aeruginosa

Bacillus thuringiensis

IV.PRODUCT FORMATION:

The product formed from the starch-based biofilm is the bio-plastic medical cover used for the tablet capsules as shown in the Fig.10.

Fig.10 – Bioplastic medical cover

V.SUMMARY AND CONCLUSION

According to the review and experimental research, we came to know a conclusion that biofilms produced from the starch content of elephant foot yam is transparent and smooth. Elephant foot yam has starch content and they are good dietary sources. They have the main content of protein, carbohydrate, fat, mineral and water. Due to the presence of glycerol concentration, it becomes more easier for degradation. Solubility test was done with various organic solvents. Antibacterial activity was done against pathogens. Now the need of bio - plastics is most needed as they are degradable. It is widely used in daily products like shopping bag, food packaging and now plays a major role in the medical field as it used as the materials for pills and capsules.

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VII.REFERENCE:

1. Suja, G., Sundaresan, S., John, K. S., Sreekumar, J., & Misra, R. S. (2012). Higher yield, profit and soil quality from organic farming of elephant foot yam. Agronomy for sustainable development, 32(3), 755-764.
2. Ray, R. C. (2015). Post-harvest handling, processing and value addition of elephant foot yam-overview. International Journal of Innovative Horticulture, 4(1), 1-10.
3. Álvarez-Chávez, C. R., Edwards, S., Moure-Eraso, R., & Geiser, K. (2012). Sustainability of bio-based plastics: general comparative analysis and recommendations for improvement. *Journal of cleaner production*, *23*(1), 47-56.
4. Tummala, P., Liu, W., Drzal, L. T., Mohanty, A. K., & Misra, M. (2006). Influence of plasticizers on thermal and mechanical properties and morphology of soy-based bioplastics. *Industrial & engineering chemistry research*, *45*(22), 7491-7496.
5. Reddy, C. K., Haripriya, S., Mohamed, A. N., & Suriya, M. (2014). Preparation and characterization of resistant starch III from elephant foot yam (Amorphophallus paeonifolius) starch. *Food chemistry*, *155*, 38-4.4.
6. Jerez, A., Partal, P., Martínez, I., Gallegos, C., & Guerrero, A. (2007). Protein-based bioplastics: effect of thermo-mechanical processing. *Rheologica Acta*, *46*(5), 711-720.
7. Marichelvam, M. K., Jawaid, M., & Asim, M. (2019). Corn and rice starch-based bio-plastics as alternative packaging materials. *Fibers*, *7*(4), 32.
8. Pathak, S., Sneha, C. L. R., & Mathew, B. B. (2014). Bioplastics: its timeline based scenario & challenges. Journal of Polymer and Biopolymer Physics Chemistry, 2(4), 84-90.
9. Hwang, K. R., Jeon, W., Lee, S. Y., Kim, M. S., & Park, Y. K. (2020). Sustainable bioplastics: Recent progress in the production of bio-building blocks for the bio-based next-generation polymer PEF. Chemical Engineering Journal, 390, 124636.
10. Luengo, J. M., García, B., Sandoval, A., Naharro, G., & Olivera, E. R. (2003). Bioplastics from microorganisms. Current opinion in microbiology, 6(3), 251-260.
11. Méité, N., Konan, L. K., Tognonvi, M. T., Doubi, B. I. H. G., Gomina, M., & Oyetola, S. (2021). Properties of hydric and biodegradability of cassava starch-based bioplastics reinforced with thermally modified kaolin. Carbohydrate Polymers, 254, 117322.
12. Gaspar, M., Benkő, Z., Dogossy, G., Reczey, K., & Czigany, T. (2005). Reducing water absorption in compostable starch-based plastics. Polymer Degradation and Stability, 90(3), 563-569.
13. ÖZDAMAR, E. G., & Murat, A. T. E. Ş. (2018). Rethinking sustainability: A research on starch based bioplastic. Journal of Sustainable Construction Materials and Technologies, 3(3), 249-260.
14. de Azêvedo, L. C., Rovani, S., Santos, J. J., Dias, D. B., Nascimento, S. S., Oliveira, F. F., ... & Fungaro, D. A. (2020). Study of Renewable Silica Powder Influence in the Preparation of Bioplastics from Corn and Potato Starch. Journal of Polymers and the Environment, 1-14.
15. Sukhija, S., Singh, S., & Riar, C. S. (2016). Isolation of starches from different tubers and study of their physicochemical, thermal, rheological and morphological characteristics. Starch‐Stärke, 68(1-2), 160-168.
16. Gironi, F., & Piemonte, V. (2011). Bioplastics and petroleum-based plastics: strengths and weaknesses. Energy sources, part a: recovery, utilization, and environmental effects, 33(21), 1949-1959.
17. Domenek, S., Feuilloley, P., Gratraud, J., Morel, M. H., & Guilbert, S. (2004). Biodegradability of wheat gluten based bioplastics. Chemosphere, 54(4), 551-559.
18. Jiménez-Rosado, M., Bouroudian, E., Perez-Puyana, V., Guerrero, A., & Romero, A. (2020). Evaluation of different strengthening methods in the mechanical and functional properties of soy protein-based bioplastics. Journal of Cleaner Production, 262, 121517.
19. Jiménez-Rosado, M., Zarate-Ramírez, L. S., Romero, A., Bengoechea, C., Partal, P., & Guerrero, A. (2019). Bioplastics based on wheat gluten processed by extrusion. Journal of Cleaner Production, 239, 117994.

20. Nagar, M., Sharanagat, V. S., Kumar, Y., & Singh, L. (2020). Development and characterization of elephant foot yam starch–hydrocolloids based edible packaging film: physical, optical, thermal and barrier properties. Journal of food science and technology, 57(4), 1331-1341.
21. Soroudi, A., & Jakubowicz, I. (2013). Recycling of bioplastics, their blends and biocomposites: A review. European Polymer Journal, 49(10), 2839-2858.
22. Volatier, J. L., Boissonnot, R., Botta, F., Eymery, F., Fröchen, M., Hulin, M., ... & Yamada, O. (2019). La phytopharmacovigilance: une surveillance intégrée des expositions des populations et des effets indésirables des produits phytopharmaceutiques. Innovations Agronomiques, 73, 75-80.
23. Agustin, M. B., Ahmmad, B., Alonzo, S. M. M., & Patriana, F. M. (2014). Bioplastic based on starch and cellulose nanocrystals from rice straw. Journal of Reinforced Plastics and Composites, 33(24), 2205-2213.
24. Zárate-Ramírez, L. S., Martínez, I., Romero, A., Partal, P., & Guerrero, A. (2011). Wheat gluten-based materials plasticised with glycerol and water by thermoplastic mixing and thermomoulding. Journal of the Science of Food and Agriculture, 91(4), 625-633.
25. Reddy, C. K., Haripriya, S., Mohamed, A. N., & Suriya, M. (2014). Preparation and characterization of resistant starch III from elephant foot yam (Amorphophallus paeonifolius) starch. Food chemistry, 155, 38-44.
26. Webb, H. K., Arnott, J., Crawford, R. J., & Ivanova, E. P. (2013). Plastic degradation and its environmental implications with special reference to poly (ethylene terephthalate). Polymers, 5(1), 1-18.
27. Karan, H., Funk, C., Grabert, M., Oey, M., & Hankamer, B. (2019). Green bioplastics as part of a circular bioeconomy. Trends in plant science, 24(3), 237-249.
28. Dilkes-Hoffman, L. S., Lane, J. L., Grant, T., Pratt, S., Lant, P. A., & Laycock, B. (2018). Environmental impact of biodegradable food packaging when considering food waste. Journal of Cleaner Production, 180, 325-334.
29. Jain, R., & Tiwari, A. (2014). Bioplastics for use in medical industry. Asian Journal of Pharmaceutics, 139.