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Biogenic Preparation of Biopolymer from the Ipomoea Batatas (Wheel Worm) Food Waste A Sustainable Approach

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Degradable test
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Abstract

Bioplastic or Biopolymer is an eco-friendly alternative to conventional plastics. Bioplastic production will lead to the decrease in consumption of fossil fuel as well as reduce the plastic waste generation. Biodegradable plastic are two types: one is plastic material which will be decomposed in natural aerobic process and another is decomposed in anaerobic environment. In this research work the bioplastic were prepared using starch from Ipomoea batatas. The plant is one among the yam family this is an excellent source of high quality proteins. Starch from the grated peels obtained through solvent extraction method was effective potential quantitatively. Further, the biopolymer was casted based on the different concentration under spin coater and characterization studies - FTIR analysis, SEM analysis research could be extend to study the mechanical property and its level of food packaging material.

Cite

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1. INTRODUCTION

Plastics are more valuable than metals and other materials because of their properties such as lightness, cheapness and durability, it has been majorly utilized in industrial and cooperate sectors. Worldwide, more than 300 million tons of plastic were consumed every year (Mekonnen et al., 2013). Plastic accumulation in the whole world is drastic, even in the oceans. In addition, the plastic production industry has facing some drawbacks related to economic and environmental problems (Zárate-Ramírez et al., 2014). The first drawback related to the environment is the shrinking of the landfill capacity because of the huge collection of the plastic waste in the landfill areas (Philp et al., 2013). Increasing of the plastic waste leads to a crisis in the landfill due to the rising costs and strong legislation. On the other hand, due to plastic get dropped into oceans, instigating damage to the marine ecosystem is the second drawback. The third drawback with waste management policy 3R process becomes inadequate to control the plastic waste accumulation. On the other hand, incineration method of plastic treatment causes the emission of toxic gases such as carbon dioxide and methane, the greenhouse gases (GHGs) affect the worldwide climate change negatively (Barker et al., 2007). Plastic non-degradability or durability becomes the fourth drawback. It was known that plastics are not biodegradable and it can remain in the environment for hundreds of years (El Kadi,

2010). In addition, the price of fossil fuel become more expensive and volatile to supply had drawn the solution to find out the ecofriendly, low cost and degradable plastic as green approach with environmental/ economic social concern in recent years. Many researches have been conducted to reduce the use of such plastics of petrochemical origin by discovering eco-friendly alternatives to plastics, known as Bioplastics, which when disposed into the environment, are easily degraded and decomposed by the actions of microorganisms and microbial enzymes. Decomposition of biodegradable plastics produces gases like methane, carbon dioxide and other biomass which can be eliminated easily. A huge number and wide variety of bio-based plastics and their equivalent products have been developed, which will create an entirely new era of plastics. Renewable, sustainable and biodegradable raw materials such as fruits, vegetables and stems of plants rich in cellulose and starch can be used for the synthesis of bioplastics. Bioplastics can be categorized into various types based on the raw materials they are derived from, namely; natural polymers (agro-polymers) that may or may not be modified (e.g., starch or cellulose based bioplastics), microbial fermentation based bioplastics (e.g., polyhydroxyalkanoates-PHAs) and renewable raw materials based chemically synthesized bioplastics (polylactic acid – PLA, bio-polyethylene – BPE, bio-nylons and bio-polyurethanes) (Biotec, 2003). Natural polymers and polysaccharides such as starch, cellulose, pectin, hemicelluloses and proteins involves cross linking between constituents of polymers result in the formation of semi-rigid three dimensional network film (Barker & Safford, 2009). Biopolymers from the biological raw materials are completely reusable and easy compostable, very fit to the environment. Mostly Bio-based plastics or polymers are derived from renewable resources containing starch, protein and cellulose (Álvarez-Chávez et al., 2012). Biopolymers or bio plastics has been extensively utilized as food packaging material nowadays (Jabeen et al., 2015). Starch based bioplastic promotes the rate of microbial degradation after usage thrown into environment. The studies reported that the starch blended with PCL/ PHB/ PES exhibits increased degradability by an enzyme α amylase (Noomhorm & Tokiwa, 2006). The bioplastic from agriculture waste Cassava peel starch blended with chitosan as plasticizer showed best mechanical property of tensile strength of value 1.36 MPa (Fathanah et al., 2013). Due to high starch content of the jackfruit seed utilized for the bioplastic production with glycerol as plasticizer showed low opacity, moderate water permeability and relatively high mechanical stability (Lubis et al., 2017). The research work deals with food waste management and generation of biopolymer from the Wheel worm. In Worldwide the food waste generation becomes huge due to development of Industries, Education institution and various Government and Non- Government sectors. As we sustain our life it is essential to ingest food for 3 times a day, the food cooking process – vegetable cleaning sets the prime waste. Even though the vegetable wastes are bio compostable and can be reused as bio fertilizer in organic way. The situation is to find the way to produce biodegradable plastic/ polymers from the renewable resources to endure ecologically. *Ipomoea batatas* (wheel worm) is economically important tropical root and tubers crop, rich in amylose and amylopectin starch derivatives. The *Ipomoea* genus belongs to Convolvulaceae family which grows as weeds and cultivated as medicinal and ornamental plants distributed worldwide (Austin et al., 2015). It is commonly known as sweet potato as a source of energy and presence of various bioactive compounds as significance in human nutrition and animal feeding as traditional folk medicine (Mbouche Fanmoe et al., 2021). The aim of the study is to develop biopolymer film from the wheel worm waste peels as renewable product.

2. MATERIAL AND METHOD

Collection and Preparation of Wheel worm peels based starch

The wheel worm was collected from the Local market for homemade food purpose. The Yam part have been grated off from peels and followed by cooking to serve. The grated peels were collected and washed to remove the sand and dust particles, followed by chopped into small pieces and dried.

The dried peels were weighed and ground to fine powder and soaked in water. The peels becomes swell and the mixture was boiled at 60^{o} C for 30 minutes. After heat boiling, the mixture was filtered using Whatman filter paper and collected filtrate was kept undisturbed, later the starch composition get settled at the bottom of the flask, followed by the moisture was removed starch powder was obtained from Evaporator.

Preparation of Biopolymer film from Wheel Worm

The 10g of dried starch powder from Wheel worm extract was taken in 250mL beaker with 100mL of sterile distilled water and added with 4:1 ratio of Triacetin as plasticizer. The mixture was stirred continuously and heat treated at 60^{o} C for 30 minutes gel like composition obtained and allowed to become warm conditions. The mixture was coated on a glass slide using spin coater as thin biopolymer film and allowed moisture to get evaporate.

Biopolymer Characterization studies

A. Fourier transform infrared spectroscopy Analysis

FT-IR spectroscopy analysis was carried out to assess the chemical structure of the produced biopolymer film, especially the identification of chemical functional groups in the testing samples. The FTIR analyze were carried using Mid IR range (400cm^{-1} - 4000cm^{-1}) spectrum used to scrutinize the functional groups of biopolymer film an FTIR spectroscopy (Spectrum 100; PerkinElmer, USA). The FT-IR spectra of the biofilm samples were surveyed between 400cm^{-1} to 4000cm^{-1}of % transmittance.

B. Scanning Electron Microscope Analysis

The casted biopolymer film was analyzed under the Scanning electron microscope to observe the surface morphology appearance of the film.

C. Biodegradability Test

The casted biopolymer film was characterized for its biodegradability property using soil buried degradation test. The biopolymer film sample was weighed, and the initial weight has been recorded. The samples were buried under the soil collected from Aarupadai Veedu Institute of Technology, Chengalpattu, Tamil Nadu, India using the petri dish medium in Laboratory condition. The samples were examined in time interval of after five days, 10 days, and 15 days and weight of the samples was recorded. The relative extrude percent of the samples that confirmed the Biodegradation feasibility of the biopolymer film by using (Tornqvist et al., 1985),

$$\%\ \boldsymbol{Biodegradation} = \frac{\textbf{Initial Weight} - \textbf{Final Weight}}{\textbf{Initial weight}} \boldsymbol{X}\ \textbf{100}$$

D. Water Solubility Test

The amount of water that can be sucked up by biofilm and the amount of biofilm dissolved in the water is done by immersion test for 4 hours. Water solubility was calculated by

$$\%\ \textbf{Water Solubility} = \frac{\textbf{Final Weight} - \textbf{Initial Weight}}{\textbf{Initial Weight}}\ \textbf{X 100}$$

3. RESULTS AND DISCUSSION

The starch was extracted from the *Ipomoea batatas* (Wheel worm) waste peels and processed 4:1 ratio with triacetin followed by casted a thin film on a glass slide using spin coater of 5mm thickness. The casted biopolymer film was further characterized using FTIR, SEM and biodegradability, water and solubility test.



Fig. 1. *Starch extracted from the waste peels of ipomoea batatas*



Fig. 2. *Powdered form of starch obtained from evaporation process*



Fig. 3. *4:1 ratio of wheel worm starch: triacetin*

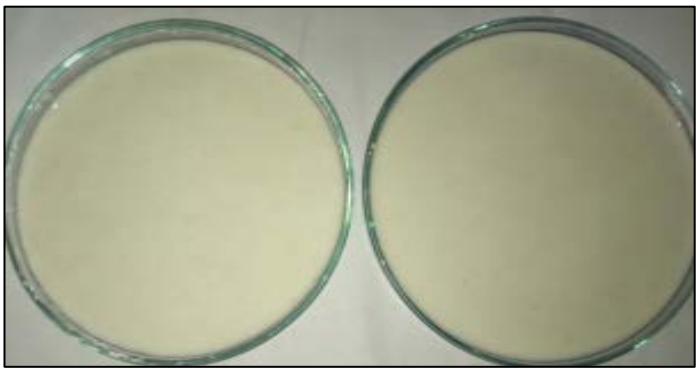


Fig. 4. *Casted biopolymer film from wheel worm starch*

The FTIR analysis showed the presence of peaks at 3282.64cm^{-1}, 2883.72cm^{-1}, 2109.43cm^{-1}, 1648.72cm^{-1}, 1315.13cm^{-1} and 927cm^{-1} corresponding functional groups present such as O-H stretching, N-H stretching, C=C bonding, O-H bending, C=N stretching and C-H bonding. The FTIR analysis of bioplastic film from combination of coconut husk fiber, kaffir lime peel powder and potato starch powder showed peaks at 3307.40cm-1 was due to O-H stretching vibration, the peak at 1646.78cm-1 due to C=O stretching vibration, peak at 1026.48cm-1 due to C-O stretching (Mbouche Fanmoe et

al., 2021). It concludes the synthesized biopolymer film is feasible material and biodegradable due to presence of strong Hydro- carbon bond and alkene groups which naturally breaks to degrade the material (Pavithra et al., 2022).

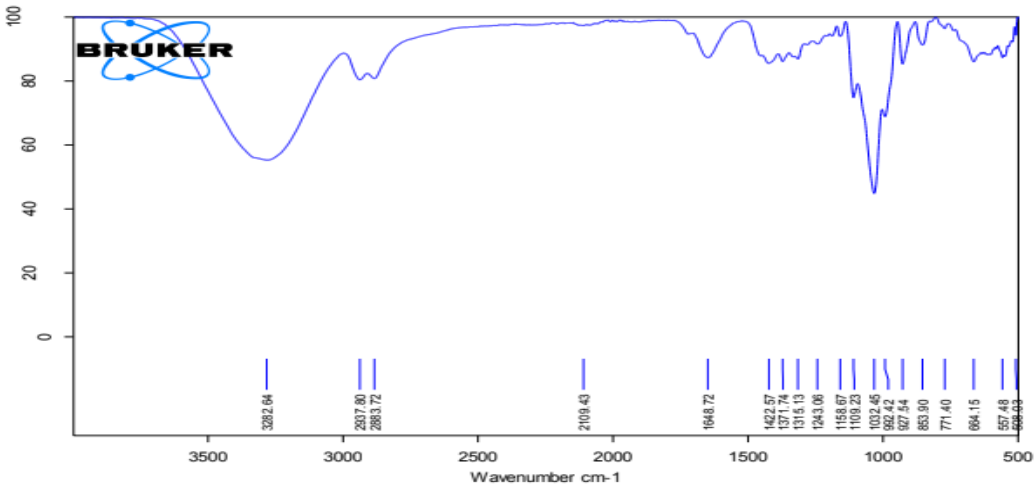


Fig. 5. *FTIR spectra of Ipomoea batatas waste peels starch Casted Biopolymer film*

The SEM image of the *Ipomoea batatas* waste peel starch casted Biopolymer film appears as in the form thin film like nature. And film thicknesses measured were found to be 0.24 mm using Air Wedge Shearing Interferometer technique.

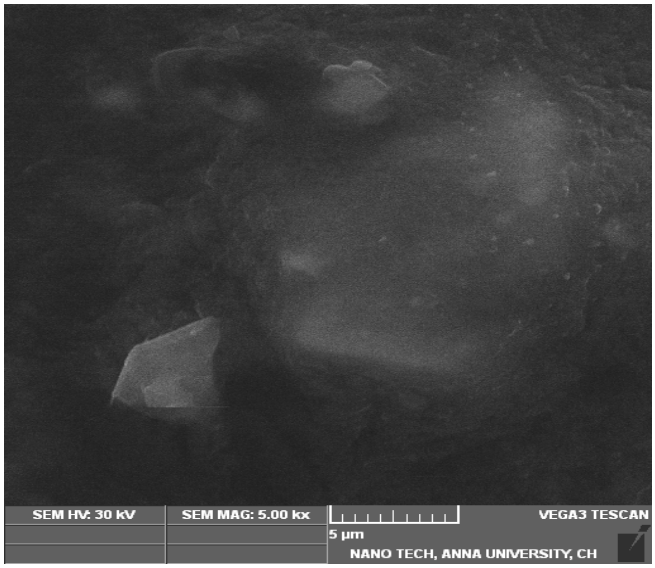


Fig. 6. *SEM image of the Ipomoea batatas starch casted biopolymer thin film*

The degradability and water solubility test were performed to access the capability of the casted biopolymer film in the *invitro* condition. 26% of biodegradation achieved in 5 days, 50% of biodegradation achieved in 10 days and 80% of biopolymer degradation was achieved in 15 days of soil buried test. *Solanum tuberosum* Starch based biodegradable plastic showed 22.86% biodegradability in 10 days incubation (Momotaz et al., 2022). In comparison the synthesized biopolymer showed excellent biodegradable film. In water solubility test, the piece of biopolymer soaked in 50mL of distilled water for incubation five days, the < 50% swelling of polymer occurs in comparison to its actual weight and Size. Similarly the work carried water permeability test for

Solanum tuberosum starch based biodegradable plastic (0.4ft^2 of weigh 7.26 gm) at fixed level of humidity 52% and Temperature at 32^{o}C showed 1.86gm/ hr. ft^2 (Momotaz et al., 2022).

4. CONCLUSION

The *Ipomoea batatas* (wheel worm) waste peel casted biopolymer film has shown promising alternative for the conventional petroleum plastics materials. It was observed the casting has to be done carefully to achieve unique thickness of the film. The research work investigated the presence of functional groups with casted biopolymer film showed hydro-carbon and alkene groups and surface morphology were characterized using SEM appears thin film were confirmed with thickness measured using Air Wedge Shearing Interferometer technique. And the biopolymer film showed 80 % degradability in 15 days of soil buried test which promises the tremendous alternative for the conventional plastic material. Due to application triacetin as a plasticizer the biopolymer film appears as soft and flexible, and one more advantage of using triacetin plasticizer has antifungicide property can be utilized for food packaging material. The research findings achieved the development of novel biopolymer from the food waste grated peels of *Ipomoea batatas* is biodegradable and high water soluble for its versatile to use.The research also enlighten over the food waste into wealth product can possible to use for food packaging materials to overcome the fossil fuel based carry bags in future.

CONFLICT OF INTEREST

The author declares that they have conflict of interest.

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No funds received for this work.

AUTHORS CONTIRBUTION

Mohanapriya Purushothaman - Methodology, Formal analysis and investigation, Writing – original draft preparation; Kalaivani - Resources, Statistical Analysis, Supervision; Vikram Sha - Conceptualization, Writing - review and editing, Funding acquisition, Supervision;

DATA AVAILABILITY

Data is made available on reasonable request.

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