Research Article

Development of Ecofriendly Bio-Plastics from the Leaf Extract of *Manihot Esculenta*

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Abstract

The petroleum-based plastics are creating severe environmental pollution due to its less or non-degradability nature and it persists in the environment for a prolonged period and cause severe damages to the ecosystem. Hence this study aimed to assess the possibilities for producing eco-friendly bioplastics from leaf extracts of *Manihot esculenta* along with some degradable blending materials. Surprisingly, the plant extract was effectively blended with 0.75g of glucose, 1.125g of gelatin, 0.565g of agar and 1.8ml of glycerol and produced a plastic-like layer on aluminium foil. This pealed film layer was considered as a bioplastic layer and the water adsorbing potential of this isolate was studied, and result showed that absence of water adsorbing trait through swelling study. Two solvents such as sulphuric acid and ortho phosphoric acid has the potential to solubilize the prepared bioplastic material in a short duration (2 h) of study. The remaining solvents have also solubilized the components reasonably. The biodegradability nature of this bioplastic was studied by soil burial test for 15 days analysis. The results showed that the bioplastic is effectively degraded (80 to 90%) in due time compared with petroleum-based plastics. The overall results suggest that the leaf extract of *M. esculenta* could be used as an agent for bioplastic preparation.

Keywords: Bioplastic, leaf extract, *Manihot esculenta,* solubility, biodegradable nature

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Introduction

The plastics derived from the petroleum source have been merged with the life of individual, since most of the good in and around (industries and household appliances) has been made up of anyone kind of plastics [1-6]. Due to its versatile nature, it could be used in various applications as entertainment to essential human requirements (medical field) [7-9]. It has been estimated that around 400,000 barrels of oil have been used every day to produce plastic material for supplying to the world [10-12]. This excess utilization could cause a significant threat to the environment significantly the land has been severely damaged by this petroleum-based plastic pollution and followed by water pollution either by direct disposal into the water reservoir and cause ecosystem damage in both sites [13, 14]. The plastic pollution becomes a significant threat to the environment and plays a significant contribution in land pollution. The plastics alone account for nearly 20% of the total volume of landfills. This oil-based plastics cannot be rid easily and create landfills or environmental pollution [15, 17].

The excess utilization of plastics released to the landfill without proper treatment and retained for a prolonged period around more than 100 years and degraded very slowly [18]. These petroleum-based plastic polymers cause environmental pollution due to its less or non-biodegradable nature and even in slow degradation the released degraded products are full of harmful and cause critical damage to the organisms which survive on those sites [19, 20]. Furthermore, it might create severe resistant among microbes, and it might lead to developing novel trait microbes it might be harmful to the cycling of the ecosystem [21]. In recent years, the environmental awareness has risen among the people and government leads to encouraging the development of biodegradable plastic materials from renewable resources such from microbes and agriculture residues to replace conventional non-biodegradable plastic materials using in various applications [22]. Among them, the polysaccharides such as cellulose, starch based molecules having several advantages for the replacement of synthetic polymers in plastics industries and economic sector due to their low cost, non-toxicity, biodegradability, biocompatibility, availability, and eco-friendly in nature [23].

The bioplastics are biodegradable due to the presence of constituent carbon-based compounds derived from plants like starch, cellulose, and lignin also derived from animals such as caseins, proteins and lipids [24]. The bioplastic has similar structural and functional characteristics as like petroleum-based products; nevertheless, they are derived entirely or partially from biomass resources with a great diversity of polymers in use or being developed as bioplastics [25-27]. This biological-based plastic could reduce the burden of chemical-based plastics and serve as a replacement for various applications such as packaging and other biomedical applications. Development of starch-based bioplastics has been given considerable attention as an eco-friendly and biodegradable alternative to hydrocarbon-based plastics [28]. The replacement of synthetic polymers with new biodegradable materials is becoming a critical challenge now-a-days. The increasing demand for petroleum and petroleum products price have been gradually increased several folds than previous years due to political circumstances in oil-producing countries [6, 29]. From the past two decades onwards researchers from academic and industrial sector pay their attention to fabrication bioplastics from renewable sources. Their global production has reached more than 4 million metric tons in the past few years and keeps sharply increasing. The robust growth of this emerging field of industry is driven by multiple factors including environmental awareness and changing consumer preferences, new policies and legislation as well as product development. Nevertheless, the estimated market share of bioplastics still has not exceeded 1% of the global plastics production [30].

The agricultural organic wastes such as cassava peel and other residues have been considered for the production of starch-based bioplastic could help in reducing the environmental damages that are caused by petroleum-based conventional plastics [31]. Hence, the increased quality and value of bioplastics can be obtained by improving their properties with the most abundant and biodegradable reinforcing components such as cellulose, vegetable oil, corn-starch, potato-starch or microbes, and fibres from pineapple and henequen leaves and banana stems, rather than from petroleum. Based on the context mentioned above, the present study was aimed to develop the starch blend bioplastics from the leaf extracts of *Manihot esculenta* plant and assess their physical and chemical properties and biodegradable nature.

Materials and Methods

Sample collection and chemicals used

The plant *Manihot esculenta* leaves were collected from Ramalingapuram village, Salem, Tamilnadu and India (Latitude 11.6635°N and Longitude 78.2611°E). Since, it is commercial plant and enriched with fiber contents and antimicrobial peptides. The analytical grade chemicals such as agar, gelatin, aluminium foil, glucose, glycerol, ammonia, acetic acid, etc. were used for this study and chemicals were procured from Hi-Media, Chemical Pvt. Ltd. Mumbai, India.

Preparation of leaf extract

The fresh and healthy leaves of *M. esculenta* were collected and washed with clean running tap water to remove attached dust particles. About 25g of leaves were grinded by using mortar and pastel to make a paste along with sufficient quantity of distilled water and made the value as 1000 mL paste and boiled with a heating mantle. The boiled contents were allowed to cool and filtered through a typical kitchen filter to remove all debris. Then the extract was stored at a room temperature for 24 hours [32].

Blend preparation and Bioplastics development

About 100mL of *M. esculenta* extract was blended with 0.75g of glucose, 1.125g of gelatin, 0.565g of agar and 1.8ml of glycerol and kept on the magnetic stirrer at 60°C temperature for 2h. Then the blend was cast on a clean, dry aluminium foil and left drying for 48 hours at room temperature [1].

Swelling and Solubility Test

The sustainability and retention nature of this pealed blended film (bioplastics) were studied by swelling test. The 2 cm × 2 cm size of pre-weighed pealed film of *M. esculenta* was submerged in the solvents such as water, chloroform and methanol containing container for 2 hours. After two hours of the process the weight of pealed bioplastic film was measured in regular weighing balance and calculated (1) the weight changes and noted. Then, the solubility nature of this bio-plastic material was studied by solubility test with various concentration (20% and 40%) of different solvents such as ammonia, acetic acid, chloroform, acetone, methanol, sulphuric acid, ortho-phosphoric acid and ethanol. About 2 cm × 2 cm size of bioplastic film was placed in these solvents individually and kept undisturbed for 2h and attained results were tabulated (2) [33].

$$\text{Swelling percentage} = \text{Pre-weighed biopolymer} - \text{Weight of biopolymer after treatment} \times 100 \quad (1)$$

$$\text{Solubility percentage} = \text{Weight of biopolymer after treatment} - \text{Pre-weighed biopolymer} \times 100 \quad (2)$$

Degradation by Soil Burial method

The biodegradation nature of this peeled *M. esculenta* biopolymer was studied by soil burial method by buried 12mm sized small circle shaped *M. esculenta* biopolymer in soil. The 0.25mm thickness commercial plastic was used as control and buried for 15 days, and then the amount of degradation done on bioplastic was noted (3) and compared with control [1].

$$\text{Percentage of degradation (Soil burial test)} = \text{Pre-weighed biopolymer} - \text{Weight of biopolymer after treatment (15 d)} \times 100 \quad (3)$$

Results

Preparation of extraction and blend formation

A light brownish color extract was derived from the leaf of *M. esculenta* by hot extraction method. The prepared *M. esculenta* leaf extract was poured into an aluminium foil for 48hours. After 48hours, a slime layer was developed on the aluminium foil, and it was pealed, and it looked like a thin plastic layer (**Figure 1**). It showed the thin brownish sheet, and it’s appeared as thin bioplastics layer.

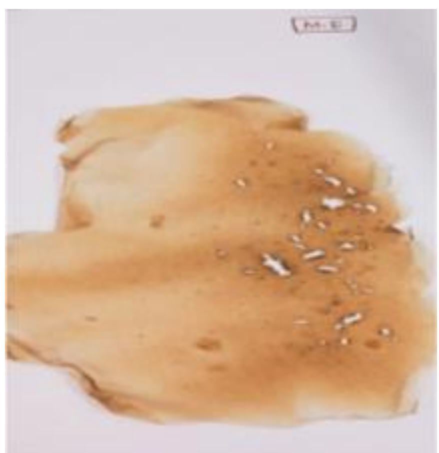

Figure 1 Blend prepared by using *M. esculanta* leaf extracts

Swelling test

The water adsorbing properties of pealed film material derived from *M. esculanta* leaf extract was studied through the swelling test. The acquired results showed absence of swelling noted on bioplastic film material at the 2 h swelling test. It could be considered a significant result and promote the utilization possibilities of this attained plastic materials.

Solubility test

The solubility nature of this bioplastic derived from leaf extract of *M. esculanta* was tested by solubility assay with various concentration of various solvents. The results showed that among various solvents 20 and 40% of sulphuric acid and orthophosphoric acid has effectively solubilize the bioplastics within 2 h of immersion. The remaining solvents such as ammonia, sulfuric acid, acetone, etc. were also showed significant solubilization process on bioplastics produced from *M. esculanta* leaf extract with 20 and 40% concentration. The range of solubilization was compared with control. Furthermore, during the solubilization process color of the solvents were changed mostly as yellow to brown and morphology of the bioplastic film also changed to irregular (**Figures 2-4**). It might be the activity of solvents applied for solubilization. The results of the solubility test declared that the concentrated solvents (20% and 40% of orthophosphoric acid and sulphuric acid) were partially and fully solubilized the bioplastic prepared from cassava leaf extract.

Figure 2 Solubility tests on 40% of acitic acid, ethanol, methanol, orthophosphoricacid, ammonia, sulphuricacid, acetone (colourchanges), chloroform

Figure 3 Solubility tests on 40% of methanol, acetone, orthophosphoricacid, water, ammonia, ethanol, sulphuricacid, acitic acid, chloroform, ammonia, and chloroform

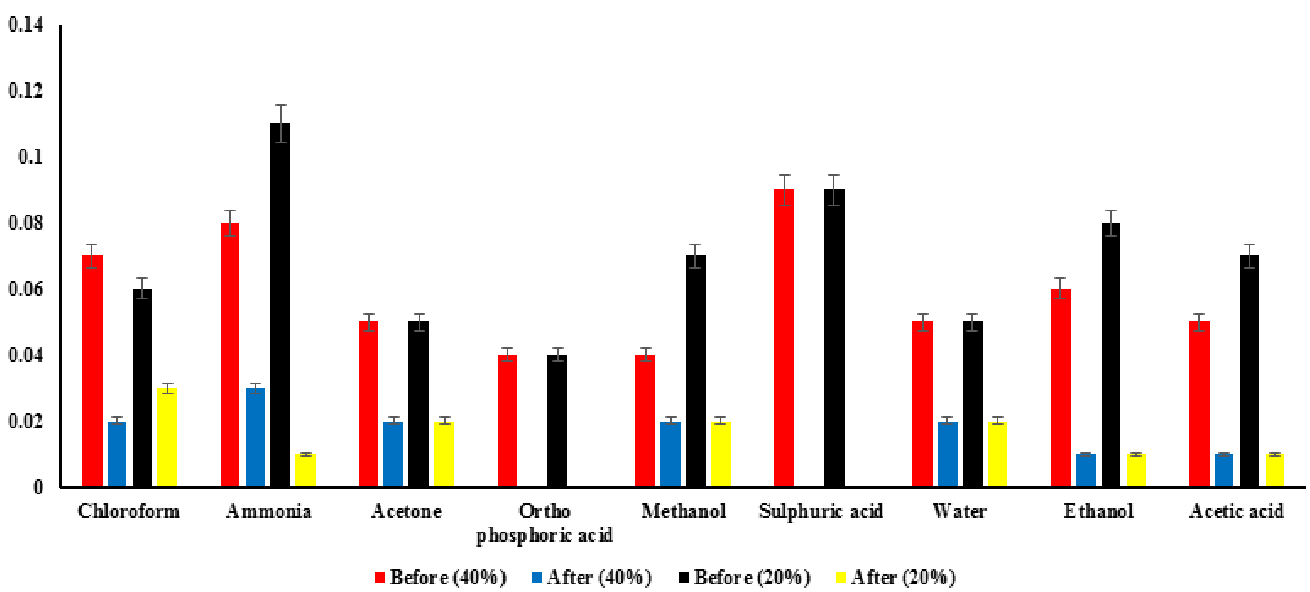

Figure 4 Solubility test with various concentrations (20 and 40%) of different solvents

Soil burial test

In the soil burial test, the prepared bioplastic and commercial bioplastic (as control) were adopted for biodegradability test. Since ecofriendly degradation of synthesized plastics are more important for commercial utilization. The attained results showed that on 15th days analysis almost 85 to 90% of bioplastic material was degraded. Furthermore, it was recognized as the most significant results while compared with control (**Figures 5** and **6**).

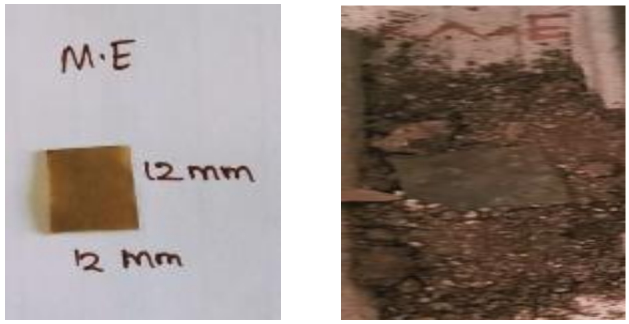

Figure 5 Burial test: Initial stage of plastic (left), Burial results of after 15th day (Right)

Figure 6 Commercial plastic 0 day (left), Commercial plastic 15th day (Right)

Discussion

The extracts derived from the leaf of *M. esculanta* showed light brownish in color due to the presence of the huge amount of starch molecules. Among the various carbohydrate the starch is one of the major and most economical value molecules made up of amylose and amylopectin in the ratio of 1: 3 and the ratio might varies among the plants and types of starch molecules [34, 35]. The test plant *M. esculanta* (cassava bark) has 15/73 volume of amylose and amylopectin [36-38]. The considerable volume of starch content from the plant such as cassava bark could be used as a source for biodegradable plastics film fabrication. The skin layer of cassava plant could serve as a matrix; from this a matrix nature biopolymers will be producible with plasticizer nature [39-41].

The present study partially found that the leaf extract of *M. esculanta* has flexibility and elasticity properties as suitable for bioplastics development. It was interconnected with the findings of Sanyang et al. [42] they reported that the starch derived from potato has the efficiency to produce the biodegradable bioplastics. The starch blended nanoparticles also have excellent polymeric nature compounds could be used for the production of bioplastics, and it was decomposed clearly with 14 days of soil burial test [43]. On the other hand, another report stated the after the two weeks of production the weight of the starch-based bioplastic was reduced and it might be the deep drying of the material [44-46]. The biodegradability nature of this bioplastic was studied by soil burial test method for 15-day analysis. The results showed that a certain percentage of degradation was recorded in the bioplastic in a short period of burial test. The present finding was strongly interconnected with findings of Yusoff et al., [47] reported the plant-based bioplastics buried in soil for 15 days is enough to reduce more than 50% of bioplastics. It might be due to the presence of soil microbes present in the soil could degrade the bioplastics.

Similarly, Harnist and Darni, [48] reported better biodegradability plastic from the leaf of *M. esculanta* leaf. The rapid degradation was noticed due to hydrolysis reaction and leads to breakdown of particles. Further, the higher concentration of glycerol enriched bioplastic could be easily degraded due to hydrophilic nature. The physicochemical properties such as pH, temperature, humidity, oxygen content etc. and soil microbial diversity present in the soil play a most significant role in the degradation and decompose of bioplastics and maintain the soil structure and fertility [49-51]. Several bacterial species such as *Pseudomonas* sp., *Streptococcus* sp., *Staphylococcus* sp., *Bacillus* sp., and *Moraxella* sp. present in soil have been reported as the most suitable and potential agent for the degradation of bioplastic [18].

Conclusions

The extract derived from the cassava plant has polymeric substances and while it blended with other degradable components such as 0.75g of glucose, 1.125g of gelatin, 0.565g of agar and 1.8ml of glycerol it showed reasonable elastic nature bioplastic material. The synthesized bioplastic components had no swelling activity on the water. The synthesized bioplastic was completely solubilized by two solvents such as sulphuric acid and orthophosphoric acid. The remaining solvents too solubilized the components gradually and significant results comparable with commercial plastics. The soil burial tests confirmed that the synthesized bioplastics from leaf extract of *M. esculenta* has effectively degraded in a short duration (15 days) of soil burial test. It concludes that the produced bioplastic are ecofriendly in nature with reasonable plasticity nature. However, further insightful study is needed to get possible information about mass production with fine plasticity nature and commercialization possibilities.

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