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Assess the Possibility of Producing Bioplastics from Leaf Extract of *Ricinus Communis*- A Preliminary Study

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Abstract

The continuous utilization of petroleum-based various form of plastics are creating severe environmental pollution and causing less reversible damage to the ecosystem. Hence in this study, the possibilities of producing the bioplastics material from the leaf extract of *Ricinus communis* was studied. The physical properties of the hot water extract and pealed film of bioplastics derived from the mix of *R. communis* along with 0.75 g of glucose, 1.125g of gelatin, 0.565g of agar and 1.8 mL of glycerol (agitated on the magnetic stirrer at 60°C for 2 h) have studied by various assays such as solubility assay, swelling assay, density assay, and soil burial assay. The results of the swelling assay showed that the swelling ratio of the bioplastic was as 14.28%. Furthermore, the density assay was calculated as 0.17g. The two solvents namely, sulphuric acid and ortho-phosphoric acid, have completely solubilized the bioplastics at 40% and 20% of each solvent respectively. Significant volume or mass of degradation was observed in soil burial assay in 15 days of study. Finally, the preliminary results attained from this study concludes that the extracts of *R. communis* along with aforementioned blending components could be useful to produce a biodegradable bioplastic with the possibility of mass fabrication.

Keywords: Leaf extract, *Ricinus communis***,** Bioplastic, Solubility, Biodegradable

1 Introduction

In the entire globe, the plastics blended with the lifestyle of people in everyday life due to its affordability and versatile nature [1, 2]. Hence the complete eradication of this plastic from human life and environment is not possible [3, 4]. The customizing properties of this synthetic polymer materials and ease with high flexibility, high fabrication and low cost products [5, 6, 7, 8]. The excess and frequent utilization of synthetic polymers could create severe environmental pollution such as soil, water, and air pollution [9, 10, 11]. Thus finding an alternative for the replacement of this synthetic polymer is an essential timely need. The cost of bioplastic fabrication through the traditional methods are costly than the plastics produced from petroleum products [12, 13]. The biopolymers derived from microbiological biomass has attained more attention and can be used in the edible stuffs packaging and biochemical products [14, 15].

To avoid the environmental issues, the bioplastics from agriculture residues (green technology) has received more attention recently among the researchers, government institutions and funding agencies [16, 17, 18]. The development of infrastructure for the recycling of the petroleum-based plastics could be replaced with the investment of effect on green technology development [19]. Since the biodegradability nature and flexibility in various applications as similar to the petroleum-based products with eco-friendly could be an excellent opportunity to minimize the pollutions generated by petroleum-based polymers [20, 21]. A recent report stated that more than 350 million tons of petroleum-based plastics had been produced each year around the world [22]. Unfortunately, only 5-10% of synthetic plastic is retained in the economy; more than 70-80% is disposed of directly into the environment that causes severe damage to the ecosystem [23, 24]. Approximately, 5-10% of used synthetic plastics are recycled. This 70-80 % of released plastics into the ground creates adverse impacts and retain undegradable for prolonged (more than 100 years) period and collapse the biogeochemical activity in water and soil ecosystems [25, 26, 27] . The significant demerits are that low water vapour transmission and non-degradable; thus it causes pollution. The non-renewable and degradable synthetic plastics can be minimizable through the optimized bioplastic fabrication technology as green technology [28, 29]. The polymers produced from microbial biomass and green technology (polymeric components from plant sources) are renewable, compostable (could be used as a fertilizer) through various enzymatic activities of native microorganisms [30].

Furthermore, these biodegradable polymers hydrolysed as CO_2, CH_4, and inorganic compounds or biomass [2, 3]. The

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starch based biopolymers are produced by starch gelatinous compounds along with glycerol as plastizer and could be more flexible and durability in nature [12, 18]. Recently researchers are focused on making polymeric components from plant sources due to its compostable, biocompatibility, and flexibility in various application as a substitute to minimize the petrochemical plastics [27, 31]. A commercialized bioplastic namely K-60 has been developed by blending of the various ratio of keratin extracted from chicken feathers [10, 13]. The alternate agriculture materials such as vegetable oil, corn starch, and starch from potato, pineapple fibres, henequen leaves, jute, hemp, and banana stems have been documented as suitable for biodegradable polymer production with biodegradability, a renewable source, and suitability to use in food production and packaging [26, 28]. The various industries have been using bioplastics viz. Packaging industry (39%), building and construction industry (20.6%) or automotive industry (7.5%) [5, 31] . The agriculture biomass and resources based biopolymer fabrication play significant contribution as around 66% of the global bioplastics market. The conversion of food and agriculture wastes as value-added products can be an ideal and practical end use as bio plastics [17, 21]. The fabrication of biodegradable polymers from agricultural feedstock is replenishable as like microbial sources. Based on the contexts mentioned above, the present study was focused on studying the possibility of producing biodegradable bioplastics from leaf extract of *Ricinus communis*.

2 Materials and Methods

2.1 Collection of Plant Sample

The fresh, disease-free leaves of *Ricinus communis* was harvested from herbal and nursery garden of Periyar University campus, Salem, Tamilnadu, India. The collected leaves were washed thrice with clean tap water followed by deionized distilled water to remove attached dust particles, and excess wet was removed by drying for 1 hour at room temperature. The excess water removed leaves were grounded by clean mortar and pestle.

2.2 Preparation of Leaf Extract

About 5 g of grounded *R. communis* leaves was blended with 100 mL of distilled water and boiled at 100°C for 2 h in a heating mantle. The boiled extract mixture was sieved by a kitchen filter and stored at room temperature for further study.

2.3 Bioplastic Development

The biodegradable bioplastic from extracts of *R. communis* was made by using 10 g of plant extract blended with 0.75 g of glucose, 1.125g of gelatin, 0.565g of agar and 1.8 mL of glycerol and agitated on the magnetic stirrer at 60°C for 2 h. The agitated blend was poured on an aluminium foil and kept undisturbed for 48 h for dying. This dried slime layer was peeled from aluminium foil paper for the development of bioplastics (Kavitha and Shankari et al. [3].

2.4 Biodegradable Property of Bioplastics

2.4.1 Swelling assay

The water-absorbing nature of these extract peal was studied by swelling assay (%) by following the protocol of Shellikeri et al. [1]. Briefly, about 1.2 × 1.2 cm diameter of the pealed film was weighed initially and weighed film piece was incorporated into the container containing distilled water and kept undisturbed for 24 h at room temperature. After incubation, the film was removed and weighed again to record the percentage of swelling ratio and it was calculated as following equation (1).

$$Swelling\ ratio\ (\%) = \frac{Wet\ weight - dry\ weight}{Wet\ weight} \times 100 \quad (1)$$

where dry weight and wet weight are the initial and swelling weight of bioplastic (pealed film) correspondingly [1].

2.4.2 Density assay

The density of produced bioplastic was studied by cutting about 1.2 × 1.2 cm size of film and measured the films mass using an analytical balance. The density of this film was calculated according to the formula derived by Chandra et al. [5]. Concisely, the mass divided through the quantity (volume) of density is usually denoted and measured as follows (2).

$$Density\ (\%) = \frac{Mass}{Volume\ (cm^3)} \quad (2)$$

2.4.3 Solubility assay

The retention and sustainability nature of attained molecules were studied through the solubility assay. Pre-weighed *R.communis* pealed film was submerged in various solvents such as chloroform, methanol, Ortho-phosphoric acid, sulphuric acid, ethanol, acetic acid, acetone, and ammonia with two concentrations as 20 and 40% and treated for 2 h. The solubility was noted, and results were tabulated [1].

2.4.4 Soil Burial assay

The biodegradable nature of around 1.2 cm of the peeled film of *R. communis* was cut into small (1.2cm) pieces and buried in the normal soil for 15 days. The commercial plastic (0.25 mm) paper pieces (1.2cm) was used as an internal control for same days of treatment, and the observed the degradation of buried bioplastic and compared with buried commercial plastic at after 15 days of treatment [1].

Figure 1: Steps involved in bioplastic preparation

3 Results

3.1 Initial observation of bioplastic films

The dark brownish color fluid was extracted from the *R. communis* through hot extraction process (Fig. 1a), a slime layer was formed after the evaporation of water from the poured extract on aluminium foil paper (Fig. 1b). Approximately 0.10mm sized thin film layer was peeled from the aluminium foil paper as like thin plastic material (Fig. 1c) with brownish. The screening assays were performed to determine the plastic nature of this pealed film material.

3.2 Swelling and Density assay

The moisture adsorbing nature of the pealed film was studied by the swelling assay (Fig. 2) and calculating the swelling percentage of the swelling ratio by using the formula (1). The results stated that the rate of swelling ratio was 14.28% which was derived from the obtained values as follows.

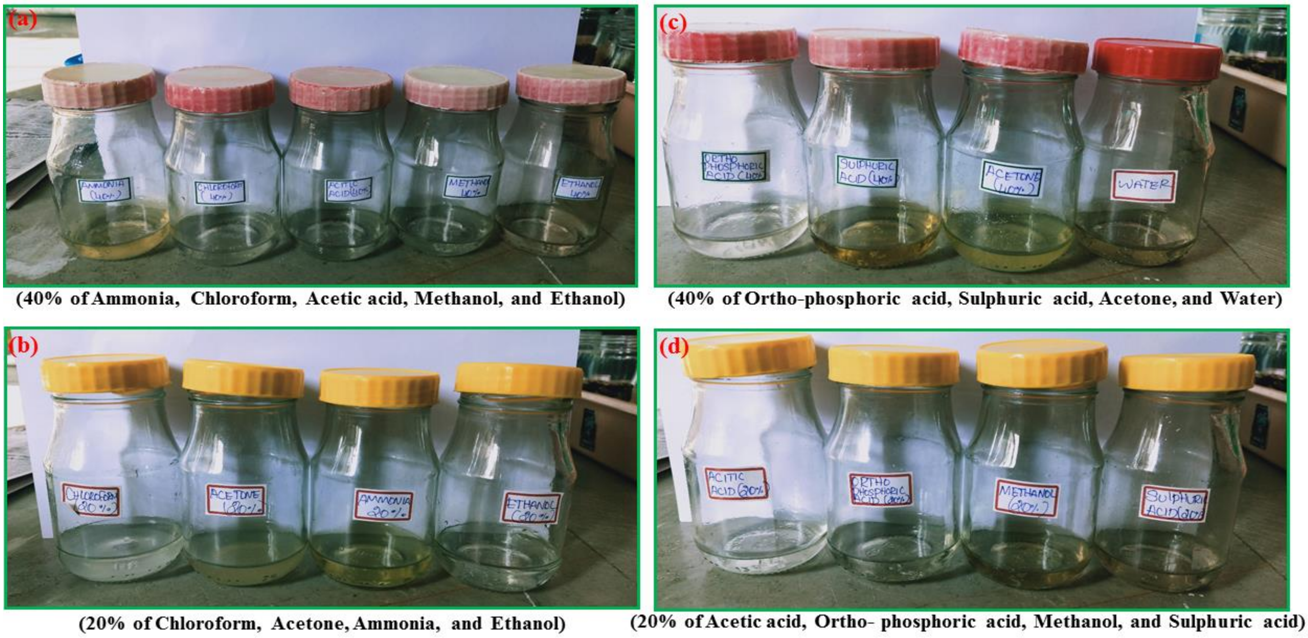
Swelling ratio (%) = 0.07g -0.06g / 0.07g x100 = 14.28 %

The density of the pealed bioplastic film was calculated as 1.17 g derived from 0.3 g mass divided by the volume of extract 1.728.

3.3 Solubility assay

The solubility nature of attained bioplastic film was studied against various concentrations (20 and 40%) solvents such as chloroform, methanol, Ortho-phosphoric acid, sulphuric acid, ethanol, acetic acid, acetone, and ammonia (Fig. 3a, b, c, and d). The attained results stated that 20 and 40 % of Ortho-phosphoric acid and sulphuric acid were completely solubilized the bioplastic film of *R. communis.* Underwater solubilisation study the weight of the bioplastic was increased instead of decreasing, it states that this pealed film could be stable at the water and might adsorb few percentages of water too (Table 1). The remaining solvents were almost solubilized the bioplastic contents within 2 h of treatment (Table 1).

Figure 2: Swelling assay



(40% of Ammonia, Chloroform, Acetic acid, Methanol, and Ethanol) (40% of Ortho-phosphoric acid, Sulphuric acid, Acetone, and Water)

(20% of Chloroform, Acetone, Ammonia, and Ethanol) (20% of Acetic acid, Ortho- phosphoric acid, Methanol, and Sulphuric acid)

Figure 3: Solubility assay

Table 1: Solubility test of bioplastics (gram) using different chemicals

Solvents	Before (40%)	After (40%)	Before (20%)	After (20%)
Chloroform	0.11±0.002	0.02±0.00	0.08±0.001	0.02±0.00
Ammonia	0.12±0.003	0.03±0.001	0.06±0.00	0.01±0.00
Acetone	0.04±0.001	0.01±0.00	0.11±0.004	0.03±0.00
Ortho phosphoric acid	0.09±0.002	**Completely Soluble**	0.03±0.001	**Completely Soluble**
Methanol	0.14±0.050	0.03±0.002	0.13±0.008	0.03±0.001
Sulphuric acid	0.12±0.005	**Completely Soluble**	0.06±0.001	**Completely Soluble**
Water	0.06±0.00	0.07±0.001	0.06±0.001	0.03±0.00
Ethanol	0.08±0.002	0.03±0.001	0.11±0.004	0.03±0.00
Acetic acid	0.11±0.008	0.02±0.002	0.10±0.006	0.02±0.00

Legend: The mentioned values are mean and standard errot of triplicates

3.4 Soil burial assay

The natural degradation nature of this prepared bioplastics was studied by soil burial assay. The amount of degradation was measured based on dry weight loss of material. The dry weight of the degraded material of bioplastic was 95%, and commercial plastic (0.25mm) was 22% on 15 days of soil burial assay (Fig. 4a, b). This dry weight loss indicated that the degradation nature of bioplastic produced from the significant ingredient of *R. communis* was significantly greater than commercial plastic. Hence it suggests that the *R. communis* based bioplastic fabrication might be possible with reasonable plastic properties.

4 Discussion

The results attained from this study showed that the odourless, transparent and smooth polymeric extracts produced from *R. communis*. Absence of bubbles was noted on poured extracts on aluminium foil. It might be the presence of starch and cellulose-based biomolecules in the poured blend [28, 32, 33]. The supplementation of glycerol on starch and cellulose nanoparticle blended bioplastic molecules might show clear color extracts [32, 34]. Another report stated that the increased water adsorption on plant-based bioplastics which were blended with 25% Sorbitol [29, 35]. Cellulose has strong hydrogen bond characteristics that have the difficulty to bond with water. Another report stated that the blending of glycerol with plant extract could make the blended solution as a more transparent film [36, 37, 38]. Since the glycerol amplifies the content of air in the mixtures. The adsorption nature of the present study states that bioplastic attained from *R. communis* has water adsorption nature, the swelling assay confirmed it. It might be the excess addition of cellulose could increase the water adsorption capability on bioplastic due to the the intramolecular hydrogen bonding characteristics of fabricated material [7, 39, 40].

Yamaguchi et al. (41) stated that under the controlled temperature condition, the binary solution density had been increased along with fractions of TEG molecules. The physical factor such as temperature and pH might show the impacts on physical and chemical properties, including the density of the bioplastics [42, 43, 44]. In some bioplastic molecule preparations, the density might be decreased while the temperature has increased. The oxidized starch derived from cassava plant extract have blocked pores on their flatten surface, and it could minimize the yield volume of bioplastics [44, 45, 46]. Since it, creates air bubbles in the biopolymer film material and it might increase the density and mass of film [1, 5, 7]. The addition of optimized quantity of oxidized starch could improve the tearing and tensile strength of the bioplastic derived from agriculture residues [15]. The bioplastics, which has lower density, leads to allow the fluids such as water, oxygen, CO_2 across the bioplastic film. Another report suggested that lower swelling capacity could create strengthened material and it could be directly proportional to the water uptaking capacity of bioplastic material. It might be due to the acid reaction existing the acidic chemicals supplemented to the compost with soluble [47, 48, 49].

In the present study, the solvents such as chloroform and ammonia, acetic acid, and ethanol showed decreased masses at 40% and 20% concentration. [48] Nevertheless, two solvents such as orthophosphoric acid and sulphuric acid showed the excellent solubility result at both concentrations such as 40% and 20%. This solubility could be an essential factor for complete degradation of bioplastics within short course of time to avoid the generation of greenhouse gases and leachate [49, 50]. Hence, it facilitates the convenient solid waste management strategy which including composting is considered as to be a more preferable progress for the recovery of plastics [51]. In low solubility properties having bioplastics might take around 11 months of degradation process under the home-based composting process due to slow degradation process since it has less solubility nature [21]. In house based degradation process the native temperature showed fewer impacts on biodegradability on bioplastics, whereas, in industries, the optimized temperature could be maintained for the complete degradation of bioplastics by maintaining the degradation temperature until the complete degradation of bioplastics [52, 53]. Another study reported that effective biodegradation on bioplastics derived from vegetable source under laboratory condition with 65% relative humidity [14, 54]. It states that the reasonable humidity (moisture condition) itself showed optimistic degradation of bioplastics. Since under the moisture conditions, the degradation potential of microbes will be higher, and it makes the degradation of bioplastics in a short duration of time along with eco-friendly manner [35]. This degradation could enhance the other beneficial microbial activity and improve the quality of the soil. Furthermore it could improve the fertility of soil leads to an active plantation and high-quality agriculture yield [31, 55].

5 Conclusion

The extract derived from the *R. communis* has polymeric components, and it was confirmed by various assay (solubility assay, swelling assay, density assay, and soil burial assay).

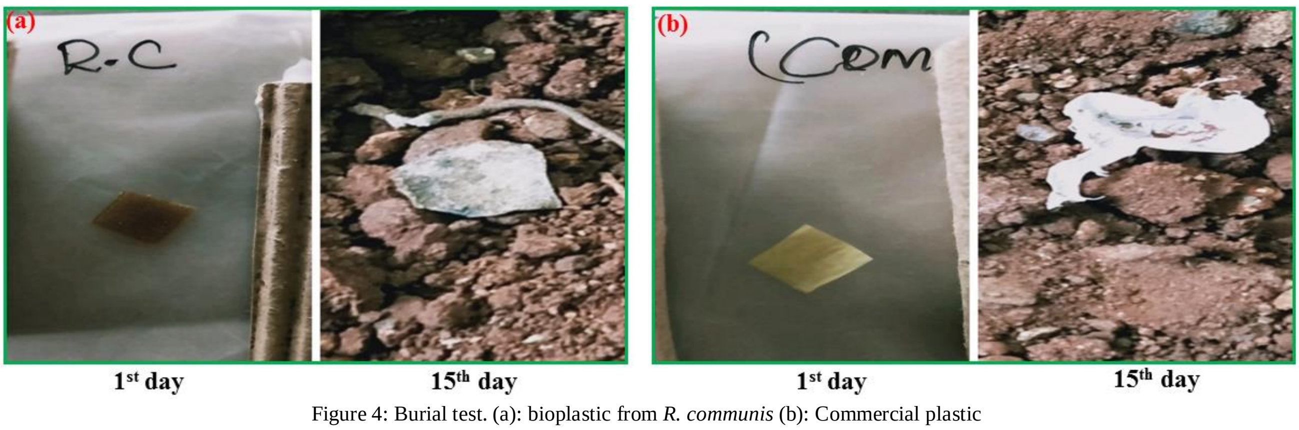


Figure 4: Burial test. (a): bioplastic from *R. communis* (b): Commercial plastic

The suitable bioplastic material preparing blending compositions have been identified in this study as 10 g of plant extract blended with 0.75 g of glucose, 1.125g of gelatin, 0.565g of agar and 1.8 mL of glycerol and agitated on the magnetic stirrer at 60°C for 2 h. The physical properties such as solubility assay, swelling assay, density assay, and soil burial assay of fabricated bioplastics were studied. The attained results of the swelling assay showed that the sustainability and retention nature of the bioplastic and the swelling ratio of the bioplastic was identified as 14.28%. The density assay result showed that the mass of a specific volume of a substance and it was calculated as 0.17g. In the solubility tests, two solvents such as sulphuric acid and ortho-phosphoric acid had higher solubility results (completely solubilized) at a different concentration such as 40% and 20% of each solvent respectively. Soil burial test result showed that rapid degradation has occurred with 15 days of burial test, and it was significantly greater than commercial petroleum-based plastics. Thus the entire results conclude that the bioplastics developed from the leaf extracts of *R. communis* along other molecules has a promising biodegradable nature and could be used as eco-friendly and renewable bioplastics to minimize the usage of petroleum-based plastics and reduce the environmental pollution. The attained results are preliminary report only, further, profound studies are required to insightful evaluation about the possibilities of commercial production.

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Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

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