An Eco-Friendly Approach To Bioplastic Production Using "Prosopis Juliflora Starch"

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Abstract- *As syenthetic orpetroleum based plastics create a severe environmental impact, An attempt is made to develop sustainable bioplastic from the invasive plant species. starch extract from the prosopisjuliflorastarch. Aneco-friendly bioplastics to satisfy the requirements of industrial and commercial applications, a common limitation has been their reliance on edible agricultural resources such as corn, potatoes, rice and some other food grains.The research provides a sustainable solution by extracting starch from the pods of Prosopis juliflora, a plant species widely recognized for its invasive water solubility and absorption test to assess hydro-instability, and a water contact angle test to evaluate surface characteristics. Crucially, the environmental viability of the materials was determined through a rigorous biodegradability test and a morphological analysis was conducted to examine their microstructural integrity. The findings from these analyses conclusively reveal that the bioplastics developed from Prosopis juliflora starch possess properties that position them as a superior alternative to conventional plastics for packaging applications. The adoption of this material offers a dual environmental benefit. The result reveals that the starch based bioplastics would be better alternative material to be used in several packaging industries, Not only does it provide a sustainable and biodegradable substitute for synthetic polymers, but it also leverages a problematic invasive species as a valuable raw material, thereby contributing significantly to environmental remediation and resource management.*

Keywords: Bioplastic, Starch, Prosopis juliflora, Sustainability

I. INTRODUCTION

The usage of plastic is inevitable in the modern era. Global plastic production has skyrocketed, exceeding 430-460 million metric tons (Mt) annually, having more than doubled since 2000. Driven by packaging and synthetic fibers, production is projected to reach up to 884 Mt by 2050. China is the largest producer, while only about 9% of plastic waste is recycled the future usage expected upto nearly necreased by 70% in 2040. The packaging sector is the largest contributor to plastic wastage.

Prosopis Juliflora is hard and withstands different environmental condition such as high temperature, water or soil quality,humidity etc..,they are growing at a faster rate as they have a higher success rate of germination success. It exract more amount of water from the ground and kills other plants. The intrusive growth of Prosopis juliflora affect the biodiversity and many other impact. Researchers have extracted starch from prosopisjuliflora and analysed their properties. Prosopis juliflora is available abundantly in many countries like India. Hence, the objective of the present work is to extract the starch from the Prosopis juliflora to produce a sustainable bioplastics.

Due to the simplicity and better tensile and other properties, most of the researcher developed bioplastics in Corn (M. K.Mariselvam, Mohammad Jawaid, Mohammad Asim in 2019) Corn and Rice Starch-Based Bio-Plastics as Alternative Packaging Materials.

(Manoj Kumar Gurunathan, Rajesh Jesudoss Hynes Navasingh, Jebaraj David Raja Selvam, Robert Cep, et al.2025) Development and Characterization of Starch Bioplastics as a Sustainable Alternative for Packaging.

(Melissa B. Agustin, Bashir Ahmmad, Shanna Marie M. Alonzo, Famille M. Patrian2014) Bioplastic Based on Starch and Cellulose Nanocrystals from Rice Straw.(Pradip K. Wankhade, Fsaha Ahmad, Dhanshree Joshi, Neha Kale 2025) Bioplastic from Corn Starch; Characteristic and Biodegradable Performance.(Yennam Rajesh a,Neha Gautam a, Panchal Saloni a, Vaidehi Deore a, Priyanka Shivde a, Ganesh Dabhade in 2024) Agricultural Resources in Focus: Eco-Friendly Bioplastic Synthesis from Corn Starch.(Gayatri D. Gawande, Tanmay Khiratkar, Yugal Urkude, Sangharatna Bombarde, 2024) Bioplastic Production from Corn and Potato Starch and Its Industrial Applications.

Approximately 50% of all bioplastics produced globally are made from starch or starch blends. Starch-based materials, including thermoplastic starch (TPS), represent the most common type of bioplastic, widely used for packaging, it has Starch-based materials offer significant advantages as eco-friendly alternatives to traditional plastics, featuring full biodegradability, high abundance, and low-cost production. It doesn't have any explicit taste or smell, is biologically absorbable, nontoxic, semi permeable to CO2 and insoluble in cold water or alcohol. Based on the nature of plant,The amylose composition would differ from 20 % to 25% and the amylopectin content varies from 75 to 80% by weight Amylopectin is a larger molecule than amylose.

Glycerol was used as a plasticizer, and it was reported that the addition of citric acid would improve the soluability of starch. The consequences of citric acid on the properties of corn starch based bioplastics were addressed. And the mechanical properties were improved by adding the MCC and sorbitol. The effect of glycerol on the mechanical and moisture absorbtion properties of corn strach based bioplastics.

They developed different bioplastics by various amount of glycerol using in it to determined the tensile strength, dentsity and moisture content. In the starch film from cassava, corn, potatoes has obtained that the moisture content decreased whereas the density was increased with an increase in the amount of glycerol. Mechanical strength is investigated in six different levels.

Researchers attempted to extract the cellulose from the process Juli Flora because it contain more amount of cellulose. They reported that the bioplastics film with 75 % cellulose and 25 % of fiber provided better physicochemical properties. Cassava starch composite film was prepared by the addition of different loading of sugar palm fiber and found that the sugar palm fibre increased the thickness and to decrease the density, water content, water solubility and water absorption.

II. MATERIALS AND METHOD

The prosopisjuliflora plant was obtained at southern districts of TamilNadu , India . The prosopisjuliflora starch contains 10.32% moisture, 0.32% of protein, 0.38% of fat, 0.22% ash and 29.34% amylose. The analytical grades of chemicals used for the extraction of starch. The starch pullout from the Prosopis juliflora. Citric acid, the gelatine powder, The glycerol and purified Water was required to manufacture the bioplastics film.

III. EXTRACTION OF STARCH

In this work, an attempt was made to extract starch from prosopisjuliflora(PJ), The Prosopis juliflora tree pods were converted into a powder. The powder was stirred with distilled water and heated at 60°C with Constant stirring Provided By a magnetic stirrer. The mixture was allowed to mix at a constant speed of 180 rpm for 10 minAfter the mixing the solution is transferred to the hot plate which is maintained at 100°C.The solution is heated for 10 to 15 min untill it turned out like a gel like substabce. The gel is removed from the beaker and poured onto the glass plate and spread the gel to get the uniform thickness. The glass plate is dired for 3 to 4 days and then the palstics film is separated from the galss plate.

IV. CHARACTERIZATION

A. Tensile Test:

To determie the amount of load carried out by the bioplastics film was measured by conducting the tensile test as per ASTM D882 Standard Using Testomeric Machine M350 10CT. A cross head speed of 5mm/min was used while operating the machine. Tensile Strength (MPa) was recoded at the time of stretching.

TABLE 1

Tensile strength comparision of different samples.

Sample No.	**Tensile strength (MPa)**
Sample1(S1)	2.65
Sample2(S2)	2.47
Sample3(S3)	1.90
Sample4(S4)	5.81
Sample5(S5)	4.15
Sample6(S6)	2.95

TABLE 2

Comparision of tensile properties of different starch-based bioplastic

MATERIALS USED	**TENSILE STERNGTH (MPa)**
Banana starch [45]	5.00
Cassava starch [28]	5.20
Corn starch [19]	2.40
Potato starch [48]	1.94

Sweet Potato starch [29]	3.86
Prosopis juliflora starch [10]	5.81

B. Thickness Measurement:

In this work Themicrometer is used to observe the Thickness of the bioplastic film. The thickness was obtained by holding the film in between the anvil and stylus. The thickness was to be measured at five different position and the mean value is calculated for the each sample.

TABLE 3

Film thickness comparision of different samples.

MATERIAL USED	FILM THICKNESS (Microns)
Cassava Starch [25]	124
Corn Starch [19]	755
PJS (Present Work) [10]	260

C. Water Contact Angle (WCA):

The hydrophobicity nature of the bioplastic film was measured by examining their wettability through water contact angle by using a goniometer. The sample was placed in the midst of light and a camera at a similar angle. This allowed the flat baseline to be attained for the measurement of the contact angle measurement. The contact angle changed from 0° to 180°, according to the wettability of solid material. The extreme hydrophilic nature of the material value indicates in 0° and the extreme hydrophobic nature of the material value indicates in 180°. The bioplastic sample film are cut into small pieces so that a small drop of about 0.005mL water could be poured over the piece.Thesoluability of bioplastics would be better if the WCA in around 60°.

TABLE 4

Water contact angle comparision of different starch films.

Sample No.	Water contact angle (degree)	Water contact angle (degree)
	Left	Right
Corn starch	46.34 ±0.91	32.50 ±2.27
Sweet potato	42.4 ±0.00	42.4 ±0.00
Prosopis juliflora starch	75.3 ±0.32	75.2 ±0.24

D. Water soluability Test:

The test was taken to know how fast the bioplastics film dissolves in the water.

Each sample is cut into a square piece of size $2cm^2$. The dry film weight was measured and noted accurately. 250 ml beaker is filled with the 100 ml of distilled water to immerse the film sample is that distilled water. On the magnetic stirrer the beaker were kept and stirred for about to 6hr at 180rpm. The remaining portion of the film was is filtered in the after 6 h The filtered mass is dired at 110°C in a hot air oven untill a fixed dired mass is obtained. The dired mass were weighedand the reading were noted. By using the following formula the percentage of total soluable matter was computed,

WS (in %) = Wi - Wf / Wi × 100

where,

WL - a weight loss of bioplastics

Wi - the initial weight of the bioplastic in g

Wf - Final weight of the bioplastic in g

TABLE 5

Mechanical properties of prepared samples.

Sample No.	Film Thickness	Water Soluability	Water contact Angle (Degree)	Water contact Angle (Degree)	Bio-degradlity (%)
			LEFT	RIGHT	
Sample1 (S1)	360±16	66±0.16	66±0.16	74.1 ±0.82	67.8±1.36
Sample2 (S2)	370±19	72.3±0.15	75.3 ±0.32	75.2 ±0.24	65.7±1.24
Sample3 (S3)	390±16	82.6±0.14	76.4 ±0.52	76.6 ±0.68	70.3±1.32
Sample4 (S4)	260±19	51.5±0.15	68.0 ±0.92	69.2 ±0.48	53.3±1.21
Sample5 (S5)	270±18	52.8±0.16	69.5 ±0.84	68.9 ±0.66	56±1.35
Sample6 (S6)	276±17	57.2±0.17	72.7 ±0.68	72.8 ±0.58	54.6±1.12

E. Biodegradability Test:

The biodegradable nature of the film was determined by using the soil kept in a container. The square sized sample of bioplastics film were suppressed into a soil for Biodegradability test. The square peices of dimention 2cm ×

2cm are prepared from the bioplastics film and their weighed is recorded. the soil weight is about 500g close to the plant roots which contains a good amount of bacteria and moisture content was considered for the test. the sample was burried at the depth of 3cm for about to 15 days in the container under the room condition. The samples are taken from the container after the 15 days under the room condition and measured the final weight. due to the biodegradability the weight is lossed and calculated by adopting the following equation:

$$WL(\text{in }\%) = Wi - Wf / Wi \times 100$$

where,

WL - a weight loss of bioplastics
Wi - The initial weight of the bioplastics in g
Wf - Final weight of the bioplastics in g

F. Morphological analysis:

Scanning electron microscopy (SEM) machine model HITACHAI - 3400 N was used to analyze the Morphology of the biodegraded bioplastics film. A current emission of 58 mueA was applied to operate the instrument. the acceleration voltage used was 10 kV and fixed working distance was 7.4 mm. For conducting SEM analysis, the bioplastics film samples were gold coated.

TABLE 5
Compositions of prepared samples

Sample NO.	STARCH	GELATIN	CITRIC ACID	GLYCEROL	DISTILLED WATER
	WEIGHT (in g)				
Sample1 (S1)	10	3	2	4	100
Sample2 (S2)	10	3	3	4	100
Sample3 (S3)	10	3	3	5	100
Sample4 (S4)	10	2	1	3	100
Sample5 (S5)	10	2	2	3	100
Sample6 (S6)	10	3	2	3	100

V. RESULTS AND DISCUSSIONS

The result and discussion are presented below

A. Tensile Strength:

The comparison of tensile strength of different starch based bioplastics films. The tensile strength of PJS film with 2g of gelatine, 1g of citric acid and 3g of glycerol is 5.81 MPa (sample 4). with the increase of glycerol the tensile strength decreases. the tensile strength of sample 3 is 1.9 MPa Only because of the presence of more citric acid and glycerol. The tensile strength and PJS is compared with banana starch [45], cassava starch [28], corn starch [19], sweet potato [29], potato starch +TiO2 [20]. the best value of the tensile strength in the respective papers is considered for the comparison. the result comparison is presented in Table 3. Banana starch [45] has the tensile strength of 5.00. The tensile strength of cassava starch [25] is 5.20. corn starch [19] has the tensile strength value of 2.40. the tensile strenth of sweet potato starch [29] is 2.50. the tensile strength of potato starch [48] is 1.94. The PJS has the tensile strength of 5.81.

The tensile strength of PJS is 11.73% better than the cassava starch. The tensile strength of PJS is 50 % more than potato starch. From the above results, it is clear that the PJS has better tensile strength than many other starch film reported in the literature. The tensile strength is one of the important basic properties required for bioplastics which is used for packaging material.

B. Bioplastics film thickness:

The film thickness value of the different bioplastics film sample. The table is noted that all the bioplastics film have thickness greater than 50 microns. The average film thickness is 260±18 mue meter. bioplastic which has the thickness of above 50 microns are stronger, and more durable and also that can be recycled. The film thickness of the PJS film compared with cassava starch and corn starch. the film thickness comparision of different samples is presented in the above table 5. The film thickness of cassava starch is only 50 % of PJS starch. The corn starch has better film thickness. This may be due to the method used for producing the film.

C. Water Solubility of PJS:

The water solubility of different samples are shown in above table 4. The water solubility of PJS film is much better than the corn starch. Corn starch has the water soluability of 27.5 ± 0.81%. The better water solubility of PJS film indicates its suitability in plastics application in packaging sector.

D. Water Contact Angle:

The water contact angle of different samples of the table were observed that the prepared PJS film samples Have better Water Contact angle. More than the 60°the water solubility is increased. The PJS film have better Water contact angle than corn starch and sweet potato Starch. The hydrophilic nature of the PJS film indicates that it Would be more suitable for the bioplastics which is used for packaging as it better resistance to bacterial adhesion.

E. Biodegradability of PJS:

The Biodegradability value of different samples, the 3rd sample has the highest Biodegradability value (70.3%)and the 4rth sample has the lowest Biodegradability value (53.3%). The Biodegradability of samples is increased with the increase in the weight of gelatine, citric acid and glycerol. This PJS based bioplastics will reduce a significant percentage of municipal waste.

F. Scanning Electron Microscopy (SEM):

SEM was used to characterize the micromorphology of the PJS films. the sample 3 has less amount of glycerol, citric acid, and gelatine shows poor surface integrity. It is the greater number of flaws, coarse granuels, and irregularities. Many starch granules were observed due to the presence of less concentration of plasticizer. And Sample 3 has better surface integrity and uniform appearance. And the remaining samples has moderate amount of plasticizers and hence a medium level of surface integrity.

VI. CONCLUSION

The Prosopis Julifloracreats the severe environmental impact. In this Work, Starch is extracted from Prosopis juliflora and mixed with glycerol, citric acid, gelatin and distilled water at different ratio to produce bio plastics film. The average strength of the Starch based bioplastics films was 5. 81 MPa which is greater than the other bioplastics. The statistical result reveals that the film thickness, Water solubility, Water contact angle, and Biodegradability properties of PJS are also impressive. The film thickness was more than 50 microns and the water contact angle of the bioplatics was greater than 60°. It would be an interesting future scope of this work is to investigate the biodegradability of the PJS films under different environmental condition. The usage of Starch based bioplastics not only reduce the impact of prosopisjuliflora but also reduce the effect of Petroleum based bioplastics. Identification of effective fabrication technique is another future scope of this work.

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