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## CHARACTERISATION AND APPLICATION OF BIOPOLYMERS FROM RENEWABLE NATURAL RESOURCES FOR FOOD PACKAGING

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### ABSTRACT

This study outlines the planned research project aimed at investigating the potential of jackfruit seed starch as a viable material for the development of bioplastic suitable for food packaging applications. The study aims to explore the feasibility of utilizing jackfruit seed starch, along with other environmentally friendly ingredients, to develop a biodegradable and sustainable alternative to conventional plastics. The research began with the collection and processing of jackfruit seeds to extract the starch component. The next step involved the formulation of the jackfruit seed starch-based bioplastic. The primary ingredients to be used in the formulation included glycerol, corn starch, water, and citric acid. The combination of these ingredients were optimized to achieve the desired mechanical, thermal, and barrier properties required for food packaging applications. The research evaluated the biodegradability and composability of the developed bioplastic. Standardized testing methods were employed to assess the degradation rate and environmental impact of the bioplastic under controlled conditions. Overall, this study contributed significant result to the ongoing efforts to find sustainable alternatives to conventional plastics in the field of food packaging.

**Keywords: Bioplastic, Jack fruit seed starch, Biopolymer, Starch**

## INTRODUCTION

Worldwide, the food industry is one of the largest growing sectors which produces alarming amount of plastic wastage to the environment. There are many risks associated with plastic pollution in the food sector, including food contamination on a physical, chemical, and biological level [1]. Microplastics created by the breakdown of plastics contaminate the soil and affect the plant growth and development. Microplastic contamination of marine systems affects marine life and eventually find their way into the human food chain [2]. Additionally, the energy and resources needed to produce plastic packaging are significant, which adds to the loss of natural resources and the warming of the planet. To stop more harm from being done to the environment, people's health, and the economy, the issue of plastic pollution in the food sector needs to be addressed immediately.

Several measures have been taken by various stake holders to reduce the plastic contamination in food business. Reducing the usage of single-use plastic products and substituting eco-friendly alternatives is one of the most successful approaches. For instance, using food packaging that degrades or decomposes naturally using ingredients like starch, cellulose, and sugar cane can lessen the amount of plastic trash

generated and mitigate the environmental pollution.

The importance of bio-plastics is found in their ability to lessen the negative effects of plastic pollution on the environment and support a circular economy. Bio-plastics, as opposed to conventional plastics, can biodegrade under certain circumstances, preventing the buildup of plastic waste in landfills and oceans [3].

Bio-plastics are excellent for a variety of applications since they may be developed to have specific qualities. For instance, to improve the performance of bio-plastics and lengthen the shelf life of food goods, researchers are looking at the incorporation of natural chemicals, such as antibacterial agents or antioxidants.

Furthermore, improvements in bio-plastic technology have made it possible to create edible and biodegradable films that may be used as food coatings, which has decreased the demand for regular plastic films goods [4].

These cutting-edge uses demonstrate how bio-plastics have the power to transform the food sector and advance eco-friendly packaging options.

In recent years many research works were made to develop various samples of bio-plastics with starch from corn and rice with additives namely glycerol, citric acid,

and gelatin. Their physical and mechanical properties of the developed packaging film were studied and the results showed that rice starch and corn starch-based thermoplastics are suitable for the application in food industry [5].

To examine its use in the packaging business, bio-plastic and its nanocomposites were synthesised using nanoclay, TiO<sub>2</sub>, and carbon fibre microelectrode (CFME). Mechanical analysis, FTIR-ATR, TGA-DTA, SEM-EDX, were used to characterise nano based bioplastics [6].

Jackfruit (*Artocarpus heterophyllus* Lam.) seeds have shown promise as a source of starch for making bioplastics. These seeds, which are usually thrown out as waste, have a lot of starch in them that may be harvested and used to make biodegradable polymers [7-12]. This study was taken with the objectives to optimise the development process of starch-based bioplastic from jack fruit seeds and analyse the material characterisation and its application in food industry.

## METHODOLOGY

The jack fruit seeds were selected from agriculture field, cleaned and used for starch extraction process and biopolymer formulation.

## EXTRACTION OF STARCH

The cleaned and peeled jackfruit seeds were dried in a hot air oven overnight

at 45° degree C, powdered using a blender and stored in air tight container. About 100g of dried jackfruit seed powder (JSP) was taken for starch extraction process. The JSP was mixed with 0.004% sodium metabisulphite solution for 3hrs and allowed to undisturbed for starch settlement. Starch that had settled down was carefully filtered using a muslin cloth and dried in the hot air oven at 45°C for 6 hrs. The presence of starch molecules was confirmed with iodine test.

## FORMULATION OF BIOPOLYMER

Biopolymer based on thermoplastic starch was formulated with the addition of citric acid, glycerol and corn starch in different ratios. The glycerol acts as a plasticizer which enables the starch-based bio-plastics more flexible and elongate and increases their durability and crack resistance. Glycerol is a safe and effective additive for food packaging applications because it is a non-toxic and biocompatible substance. The citric acid is non-toxic material present in fruits, acts a crosslinking agent in bioplastic synthesis. When added on starch, it interacts with the molecules of starch to form cross-links that make the bio-plastic material more durable and water resistant. Different ratios of selected ingredients were mixed together to formulate the bioplastic given in **Table 1**.

Table 1: Experimental formulation of starch-based biopolymer

Jack fruit seed starch (g)	Corn Starch (g)	Water (ml)	Glycerol (ml)	Citric acid (ml)
15	-	100	10	20
10	-	70	5	4
8	2	70	5	4
12	2	70	5	4

Jackfruit seed starch and corn starch were mixed in the above ratio with 70mL R.O. water and heated to low flame until it thickened. Measured glycerol and citric acid were added as per the table and mixed thoroughly. The starch solution was brought down to room temperature and carefully poured on Teflon sheet evenly for uniform thickness.

The sheet is then placed in the hot air oven at 55°C for 3 hrs and the formulated bioplastic film was removed carefully and stored for further analysis.

## CHARACTERIZATION OF BIO-POLYMER

The prepared bio-polymer was tested to determine its capability to be used for the intended purpose of food packaging. The following morphological and mechanical characteristics were analysed for the developed biopolymer with accepted physical characteristics.

- Thickness test
- Biodegradability test
- Solubility in water
- Tensile strength
- Tear Test
- Seal ability
- Application for packaging

- Field Emission Scanning Electron Microscopy

## RESULT AND DISCUSSION

The bio-polymer was formulated in four different variations to standardize the process. Out of the four variations, the one with an 8:2 ratio of jackfruit seed starch to corn starch was found to have acceptable physical characteristics and subjected morphological studies and mechanical properties analysis.

### Thickness

The thickness of the bioplastic film plays a critical role in determining its barrier properties, such as oxygen and moisture resistance. The thickness of the formulated bio-polymer was found to be 0.25mm. A thickness of 0.25 mm was found to provide sufficient barrier protection to maintain the freshness and quality of the packaged food items over a reasonable shelf life. Furthermore, the 0.25 mm thickness offered a desirable level of flexibility, enabling the film to conform to the shape of the food products during packaging. The results of this study demonstrate the suitability of the 0.25 mm thickness for the starch-based bioplastic film in food packaging applications, providing a valuable alternative to

conventional plastics with comparable barrier properties and improved sustainability aspects.

### **BIODEGRADABILITY TEST**

The biodegradability of the jackfruit seed starch bio-plastic was assessed through a 10-day soil burial test. A total weight loss of 55% was observed, indicating a significant level of bio degradation within the test period. A sample weighing 1g of formulated bio-plastic film was kept buried under the soil for a total period of 10 days. Observing the after 10 days, only 0.45g of the buried sample remained, indicating a weight loss of 55%. This substantial weight loss demonstrates the ability of the bioplastic to undergo microbial decomposition and return to the environment in a relatively short time frame.

The high degree of bio-degradation observed is attributed to the inherent biodegradable nature of the jackfruit seed starch, which serves as the primary raw material for the bio-plastic. The results of this biodegradability test indicate that the jackfruit seed starch bio-plastic exhibits promising environmental characteristics. It shows that it has the potential to contribute to the reduction of plastic waste and environmental pollution associated with traditional petroleum-based plastics.

### **TENSILE STRENGTH**

Tensile strength is a crucial parameter for evaluating the material's ability to withstand

stretching or pulling forces without breaking or deforming. The tensile strength of the jackfruit seed starch-based bioplastic was determined using the ASTM D 882 method and found to be **11 MPa**. The obtained tensile strength value of 11 MPa indicates the mechanical strength of the jackfruit seed starch-based bioplastic for food packaging. This result suggests that the bioplastic can withstand moderate forces without experiencing significant deformation or failure.

### **TEAR STRENGTH**

The tear strength of the jackfruit seed starch-based bioplastic, determined using the ASTM D 1004 method, was measured to be 6N. The tear strength of 6N obtained for the jackfruit seed starch-based bioplastic suggests that it possesses reasonable and good mechanical integrity for food packaging applications. While it may not be the highest tear strength observed among bioplastics, it still demonstrates a level of strength that makes it suitable for handling and usage in packaging scenarios.

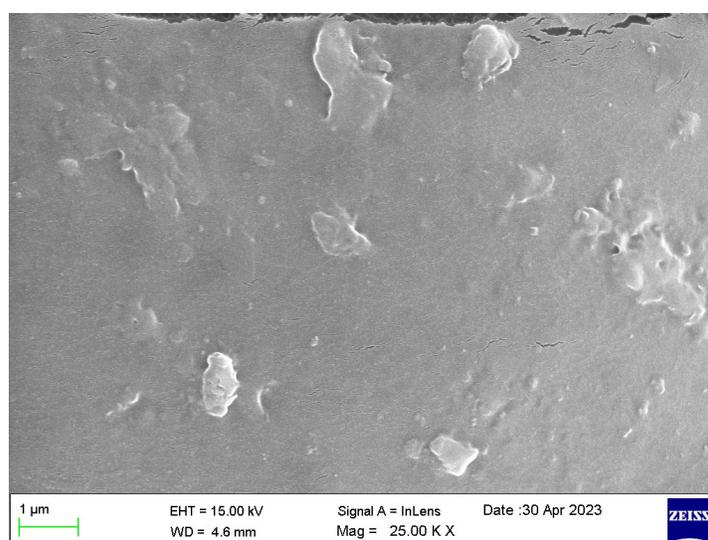
### **FESEM ANALYSIS**

Field Emission Scanning Electron Microscopy (FESEM) was employed to investigate the surface morphology and microstructure of the jackfruit seed starch-based bioplastic film. The imaging was performed using a FESEM instrument operating at an accelerating voltage of 15.00 kV (EHT), a working distance of 4.6 mm

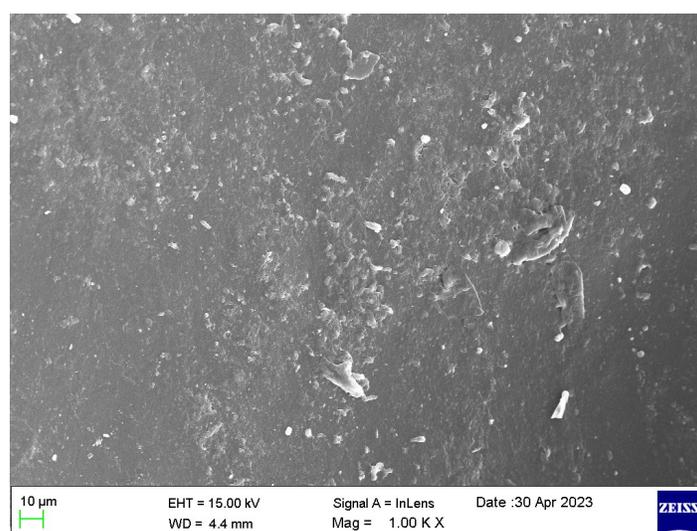
and 4.4mm (WD), and a magnification of 2.5 thousand times and 1 Thousand times (MAG 2.5 KX and 1.00 KX) in **Figure 1** and **Figure 2** respectively. These parameters were carefully selected to capture detailed information about the film's structure and surface characteristics.

The FESEM analysis aimed to provide insights into the physical properties and

composition of the bioplastic film. By examining the sample at a high magnification, the study aimed to observe the surface features, particle distribution, and overall homogeneity of the film. The selected EHT and WD values ensured optimal imaging conditions for obtaining clear and high-resolution images.



**Figure 1: Morphological characteristics of biopolymer from Jack fruit seed starch**



**Figure 2: Surface texture of biopolymer from Jack fruit seed starch**

**Figure 2** exhibited a fairly smooth surface across the sample, indicating a uniform and consistent film formation. The presence of very few pronounced roughness or irregularities suggests a well-processed and fairly evenly distributed bioplastic matrix. This smooth surface is indicative of good film integrity, which is crucial for applications requiring a visually appealing appearance and potential for barrier properties. The spots observed **Figure 5** may correspond to surface texture variations or roughness features. These spots can arise due to irregularities in the deposition or formation process of the bioplastic film. The presence of both a smooth surface and spots in the FESEM images indicates areas for optimization in the film fabrication process. By studying the factors contributing to surface texture variations, such as deposition conditions or particle distribution, improvements can be made to achieve a more uniform surface and enhance the overall quality of the bioplastic film.

## CONCLUSION

The development of a jackfruit seed starch-based bioplastic for food packaging shows promising results in terms of tensile strength, tear strength, biodegradability, and thickness. The obtained tensile strength of 11 Mpa and tear strength of 6 N indicate the material's potential suitability for certain packaging applications. Additionally, the biodegradability rate of 55% aligns with the

growing demand for environmentally friendly packaging alternatives. However, the seal ability test results revealed an issue with the material's ability to form a reliable seal. This limitation poses a challenge for its practical application in food packaging, as a proper seal is essential to maintain product freshness and prevent contamination. Further research and development are necessary to address the seal ability concern and improve the overall performance of the jackfruit seed starch-based bioplastic.

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