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Production of Biodegradable Food Packaging Material from *Musa (*Banana plant) leaves byEcofriendly methods

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Abstract:
Background:*Advent of online food ordering and delivery systems and ease of availability of packaged foods has also raised concern over the accumulation of disposable food boxes as litter. Single use plastic boxes are preferred for their utility values such as light weight, water proof and ease of use. They also harm the environment in a big way by filling land, choking water bodies and harming marine life. There is an urgent need to look for alternative ways of packaging food which are environmentally friendly and sustainable too.*
Materials and Method:*In this study, banana (Musa spp.) leaves and sheath were used to make biodegradable food packaging sheet by ecofriendly methods. Xylanase enzyme was used which was immobilized in calcium alginate beads to optimize its usage. The process involved biopulping, biobleaching and finally layering on mould and deckle. The whole process took upto 14 days for completion.*
Results:*Thick coarse board like sheet on layering and drying was formed. To improve the pliability, the banana leaf sheetswerecoated with bioplastic developed in our laboratory and cut into template of a box. The coating improved the pliability of these paper sheets. The bioplastic coating used in this sheet degrades in 3 months and hence will not pollute the environment when discarded.*
Conclusion: *This simple ecofriendly packaging sheet is safe for food packaging as its process does not involve use of any harmful chemicals. The bioplastic coating provides waterproof barrier avoiding spillages during transportation.*
Key Word*:Banana leaves; Biodegradable packaging;Biopulping; Xylanase; Bioplastic; food packaging.*

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I. Introduction

In India's economy, Packaging Industry is the fifth largest sector and is one of the highest growth sectors in the country averaging 24% to 27% growth per annum[1]. Food processing sector is one of the biggest users of flexible packaging, accounting for more than 50% of the total demand. Indian Food Packaging Marketis projected to reach a CAGR of 10.3% to US$ 108.2 Billion by 2027.Plastics are predominantly used in food industry to improve the hygiene quotient and shelf life of products[2]. Plastics are widely preferred and used for their characteristics and versatility in applications. They are light weight, corrosion resistance, moisture proof, highly versatile and can be moulded into attractive shapes[3]. Disposable packaging is often preferred owing to their low-cost and short-term convenience. Usage of plastic food packing boxes has reached alarming proportions that it is harming our environment in a big way.Popularity of online retail and food delivery apps is contributing to the rise in plastic waste, say waste management experts, adding upto 22,000 tonnes of plastic waste every month in India[4].

Disposable plastic packages littered from takeaway orders take more than 500 years to decompose and till then, they remain in landfills, choke our drainage systems, or seep into waterways and oceans harming marine life and contribute to environmental pollution[5]. To solve this problem, packaging industries are now turning their interests towards developing biodegradable packaging materials which are intended to reduce waste. Biodegradable is a type of material that can easily decompose into natural polymers under the action of microorganisms within a short period of time after disposal[6]. It is believed that these biodegradable packaging materials can replace the synthetic ones at a low cost, thereby producing a positive effect both environmentally and ecologically. Many types of alternative packaging materials using plant-based resources such as bioplastics, recycled leaves are being tried which are safe for environment[7].Many biodegradable and recyclable packaging material alternatives are being tried. Edible and biodegradable films are some such, which can serve as excellent packaging options. Their main advantage over synthetic packaging polymers is that they do not cause long-term environmental pollution[8]. Further, these biodegradable materials extend the shelf life by providing physical shield as well as a semi-permeable barrier from gases and water vapor. These biodegradable packaging

materials provide protection to products against physical factors and biological contaminations, thereby reducing food wastage[9].By 2050, if one in two food packs are made of such a "bio-benign" material, then 50% of packaging waste reduction, that is about 46 million tons of plastic waste reduction could be achieved[10]. Plant products such as leaves, barks and agro-based waste materials are now catching attention of many in creating sustainable and ecofriendly packing materials.

Banana (*Musa spp.)*, belonging to the family Musaceae, is a major tropical and subtropical fruit crop cultivated in nearly 9 million hectares across the world[11].The leaves of this plant have wide application ranging from cooking, wrapping and food serving in wide cuisines in tropical and subtropical regions. The current study explores the use of banana leaves in making biodegradable food packing material by biopulping and biobleaching methods. Conventional pulping and bleaching involves chemical processes which result in effluents with high BOD, COD and suspended solids. The resultant effluents in addition contain strong toxic and mutagenic substances that get to waterbodies and nearby land and cause serious environmental pollution. Treatment of hemicellulose and lignin in plant based raw materials with enzymes such as Xylanase results in biopulping and biobleaching. These methods can be considered as efficient alternative technology that allow low energy consumption and less effluent load for making paper[12].

II. Material and Methods

Procurement of raw materials

Banana leaves along with midribs were sourced from college garden, Women's Christian College, Chennai. Older torn leaves and leaf sheaths were chosen for the study with the intention of utilizing purposefully parts of less utility value. Xylanase enzyme, calcium chloride and sodium alginate were purchased from Hi-Media Laboratories Ltd, Mumbai, India. Starch used as binder was prepared using Jackfruit wastes as described in Krishnamurthy and Amritkumar[13]. Mould and deckle for casting the pulp into sheet was locally fabricated (**Figure 1**).

Xylanase enzyme immobilization in calcium alginate beads

25 ml of 3% sodium alginate solution was prepared and mixed with equal volume of 3% xylanase enzyme solution to get the final concentration of sodium alginate-enzyme mix of 1.5%. Entrapment of enzyme in calcium alginate gel was done by method described by Mahajan et al., (2010) . Sodium alginate-enzyme mixture solution was dropped from a height of nearly 20 cm, into excess of 0.5M $CaCl_2$ solution using a syringe. For 50 ml sodium alginate-enzyme mixture, 500 ml of 0.5M $CaCl_2$ solution was used. Calcium alginate beads of diameter 2mm with entrapped xylanase enzyme were prepared in this manner (**Figure 2**). All the immobilized beads were stored at 4°C in sterile distilled water after proper washings till further use.

Biopulping process

One kg of Banana leaves and sheaths were processed by cutting them into small pieces, along with their mid rib (**Figure 3**), followed by autoclaving at 121°C, 15lbs for 45mins and soaking in sterile distilled water for 3 days. Post soaking period, 250g of enzyme immobilized beads were added to the soaked samples and left for 7 days for biopulping.

Biobleaching process

500 g of pulped samples were strained to separate out the beads and autoclaved again at 121°C, 15lbs pressure for 1 hour. The banana leaves pulp was allowed to cool and mechanically beaten into uniform pulp using an electric blender. The smooth pulp was poured onto a tray and resuspended with distilled water. 125g of Immobilized enzyme beads were added to the tray and left for bleaching for a period of 2 days.

Layering

The strained pulp was mixed with jackfruit waste starch (25:1 ratio) for proper binding. For 500g of pulp, 20g of jackfruit waste starch was mixed in 100ml of warm water (thin boiled starch) and mixed with pulp. This mixture was poured over the mould and deckle (**Figure 4**), pressed and dried.

III. Result and Discussion

Banana leaves and sheaths on biopulping and biobleaching for two weeks gave coarse thick board like sheet on layering and drying (**Figure 5**). To improve the pliability of the sheet, the banana leaf sheet was coated with bioplastic (**Figure 6**) developed in our laboratory (Krishnamurthy and Amritkumar, 2019) and then cut into template of a box (**Figure 7)**. The coating improved the pliability of these paper sheets. The bioplastic coating used in this sheet degrades in 3 months and hence will not pollute the environment when discarded. This simple ecofriendly packaging sheet is safe for food packaging as its process does not involve use of any harmful chemicals. The bioplastic coating also provides water proof barrier avoiding spillages during transportation.

IV. Conclusion

With increased use of packaged foods and advent of online delivery systems, it is also important to safeguard our environment and address the issues related to disposable, single use plastics. In this present study, biodegradable packaging material was tried using banana leaves and sheath through biopulping and biobleaching methods using immobilized Xylanase enzyme beads. The sheets developed were coated with bioplastic developed in our laboratory and it enhanced the pliability of the sheets. Packaging boxes were made out of them successfully.

This is only a preliminary study, hence with improvement in biopulping methods and with better sheet casting methods, we can improve these packaging materials. Through this study, biodegradable alternate food packing material was developed which has good potential for commercial production on a large scale, providing a safe and ecofriendly solution for plastic pollution.

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Conflict of Interest

The authors report no financial or commercial conflicts of interest.

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FIGURES

Figure 1: Mould and Deckle fabricated for this study

Figure 2: Xylanase enzyme immobilized in calcium alginate beads

Figure 3: Banana leaves along with midribs cut into pieces

Figure 4: Processed Banana leaf pulp layered on mould and deckle

Figure 5: Coarse banana leaf sheet

Figure 6: Banana leaf sheet after bioplastic coating

Figure 7: Banana leaf sheet made into packaging box

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