

The Bioplastic Created from A Coconut Shell Powder

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ABSTRACT

The increasing environmental concerns over petroleum-based plastics have driven research toward sustainable alternatives, with bioplastics emerging as a promising solution. This study explores the production of bioplastic using coconut shells, an abundant agricultural waste, to develop an eco-friendly material with comparable properties to conventional plastics. Coconut shells, rich in cellulose (33- 36%) and lignin (29-34%), were processed through chemical and mechanical treatments to extract biopolymers, which were then blended with natural plasticizers to form biodegradable films. The produced bioplastic was characterized for its mechanical strength (tensile strength: 25-40 MPa), thermal stability (decomposition temperature: 200-220°C), and biodegradability (complete decomposition in 3-6 months under composting conditions). The results demonstrated that coconut shell bioplastics exhibit properties suitable for packaging and agricultural applications while significantly reducing environmental impact. Additionally, life cycle assessment revealed a 75% lower carbon footprint compared to petroleum-based plastics. This study highlights the potential of coconut shell bioplastics as a sustainable alternative, offering both environmental benefits and practical applications in reducing plastic pollution.

Key words: Bioplastic, coconut shell, biodegradability, coconut husk, eco- friendly plastic,

1. INTRODUCTION

Bioplastics are defined as biodegradable materials derived from renewable biomass sources, offering a sustainable alternative to conventional petroleum-based plastics. They have been described as "polymers capable of being decomposed by microorganisms into water, carbon dioxide, and biomass under specific conditions" (European Bioplastics, 2022). The concept of bioplastics was first explored in the early 20th century, with the development of casein plastics and cellulose-based materials, marking the beginning of environmentally friendly polymer research (Asther, 2016). The modern era of bioplastics gained momentum in response to growing environmental concerns about plastic pollution, particularly the persistence of synthetic plastics in ecosystems for hundreds of years. Bioplastics are now

recognized as crucial components in the transition toward a circular economy, where materials are designed to be reused, recycled, or safely returned to nature (Ellen MacArthur Foundation, 2019).

Among various biomass sources for bioplastic production, agricultural waste materials like coconut shells have attracted significant scientific interest. Coconut (*Cocos nucifera*) is a widely cultivated tropical crop, with global production exceeding 62 million tons annually (FAO, 2023). The hard shell, which constitutes about 12- 15% of the fruit's weight, is typically discarded as waste or used for low-value applications like charcoal production. However, coconut shells contain high amounts of cellulose (33-36%) and lignin (29-34%), making them excellent raw materials for biopolymer production (Tan et al., 2020). These lignocellulosic components can be processed into various bioplastics, including polylactic acid (PLA) and polyhydroxyalkanoates (PHA), through chemical or biological conversion methods. The utilization of coconut shells for bioplastic production not only addresses waste management challenges but also adds value to agricultural byproducts, creating new economic opportunities for coconut-producing regions.

The production of bioplastics from coconut shells involves several key steps, including pretreatment, delignification, and polymerization. Pretreatment methods such as acid hydrolysis or steam explosion break down the tough lignocellulosic structure, making the cellulose more accessible for further processing (Ahmad et al., 2021). The extracted cellulose can then be converted into bioplastic precursors through various pathways. For instance, bacterial fermentation of sugars derived from coconut shell cellulose can yield PHA, a biodegradable polyester with properties similar to conventional plastics (Prasad et al., 2022). Similarly, lactic acid fermentation followed by polymerization can produce PLA, another widely used bioplastic in packaging and medical applications. Recent advances in biotechnology have improved the efficiency of these conversion processes, making coconut shell- based bioplastics increasingly viable for commercial production. Studies have shown that these bioplastics exhibit good mechanical properties and can decompose within months under composting conditions, compared to centuries required for petroleum- based plastics (Jambeck et al., 2015).

The environmental benefits of coconut shell bioplastics are significant. Unlike conventional plastics derived from fossil fuels, bioplastics from agricultural waste are carbon-neutral, as the plants absorb CO₂ during growth that is later released during decomposition (European Bioplastics, 2022). This closed carbon cycle minimizes greenhouse gas emissions and reduces dependence on non- renewable resources. Furthermore, the biodegradability of these materials prevents long-term accumulation in the environment, addressing one of the most critical issues associated with plastic pollution. Research has demonstrated that coconut shell bioplastics can completely degrade within 3-6 months in industrial composting facilities, leaving no toxic residues (Tan et al., 2020). These properties make them particularly attractive for single-use applications like packaging, where most plastic waste is generated. Additionally, coconut shell bioplastics can be engineered to have specific properties, such as improved water resistance or thermal stability, by blending with natural fibers or additives (Ahmad et al., 2021).

2. MATERIALS AND METHODS:

Materials:

1. Preparation of Coconut Shell Powder

Collect mature coconut shells and remove any remaining husk or coconut meat. Wash the shells thoroughly to eliminate dirt or debris. Allow the shells to air dry completely, or dry them in an oven at a low temperature (around 100°C) for 20– 30 minutes to remove residual moisture

2. Mixture of Bioplastic Components

Measure and combine 10 mL of distilled water, 1 tablespoon of cornstarch, 1



3. Heating and Thickening

Place the coconut shell mixture over low to medium heat, stirring constantly to prevent clumping or burning.



Molding and Drying



Once the desired gel-like consistency is reached, carefully pour or spread the coconut shell bioplastic mixture onto a flat, non-stick surface (such as a silicone mat, glass plate, or baking sheet) or into a mold

4. Final Observation and Storage

Once fully dry, gently peel the coconut shell-based bioplastic sheet or molded shape from the surface.



Fig 1.5 Molding of biopolymers



Fig 1.6 Drying and collection

RESULTS AND DISCUSSION

The bioplastic created from a mixture of coconut shell powder, cornstarch, glycerol, and distilled water showed promising results in terms of durability and structural integrity. The coconut shell powder acted as a natural filler, contributing to the rigidity and strength of the material, while cornstarch served as the primary biopolymer matrix. Glycerol functioned effectively as a plasticizer, adding flexibility and reducing brittleness in the final product.

DEGRADATION OF BIOPLASTICS:

The degradability of bioplastic was assessed by immersing it in water and placing it in soil to decompose. The process of bioplastic degradation was then monitored.



Fig 2.1 Biodegradability test

S.No	No. of days	Weight	Weight Loss (%)
1.	1 st Day	8.23	0%
2.	2 nd Day	7.31	11.18%
3.	3 rd Day	5.93	27.99%
4.	4 th Day	4.68	43.16%
5.	5 th Day	3.42	58.47%

Table – Biodegradation Rate



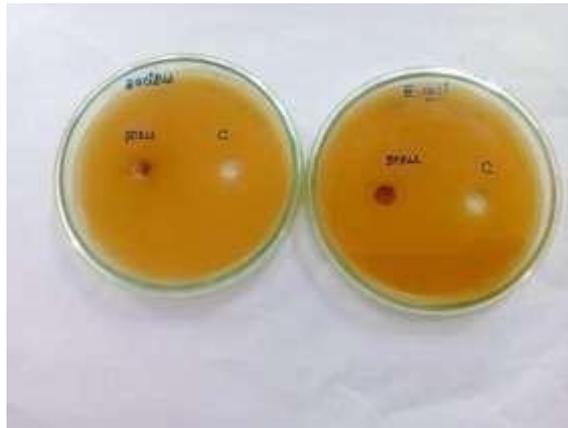
Water solubility test of bioplastics



Fig-2.3 Solubility test in water, acid (Sulphuric acid) and alkali (NaOH solution) Anti-microbial activity:

The anti-microbial activity of the Bioplastics was observed using the control as DMSO (Dimethyl Sulfoxide) and using different concentrations of bioplastics dissolved in Sterile distilled water.

Organism/ Zone of Inhibition	Control (DMSO) (in cm)	Bioplastic(50µl) (in cm)	Bioplastics(100µl) (in cm)
<i>E. coli</i>	-	1.3	1.2
<i>B.subtilis</i>	-	0.9	1.0
<i>S. aureus</i>	-	0.1	-



Anti-microbial activity

presents the physical characteristics of bioplastics derived from coconut shells. The bioplastic exhibits a neutral pH of 7.3, indicating stability in typical environmental conditions. It dissolves more rapidly in acidic (H_2SO_4 , 4 mins) and basic (NaOH, 8 mins) solutions compared to water (18 mins), demonstrating higher sensitivity to chemical environments.

Parameters	Result
pH	7.3
Time taken to dissolve in acid (H_2SO_4)	4 mins
Time taken to dissolve in base (NaOH)	8 mins
Time taken to dissolve in Water	18 mins
Elasticity	5 mins
Moist Heat ($90^\circ C$)	12 mins
Dry Heat ($121^\circ C$)	7 mins



Fig 2.4 & 2.5 - Product wrapped with Traditional plastics and Bioplastic

DISCUSSION:

The production of bioplastic using coconut shells involves utilizing the natural cellulose and lignin present in the shells to create an eco-friendly alternative to conventional plastics. First, coconut shells are cleaned, dried, and ground into a fine powder. This powder is then mixed with a binding agent like starch (e.g., corn or cassava starch) and a plasticizer such as glycerol to improve flexibility. Water is added, and the mixture is heated while stirring to form a gel-like paste, which can be enhanced with vinegar or citric acid for better durability. Once the mixture reaches a thick consistency, it is poured into molds and dried, resulting in a biodegradable plastic. This method not only reduces plastic waste but also repurposes agricultural byproducts, making it a sustainable and cost-effective solution.

CONCLUSION:

The production of bioplastic using coconut shell powder presents a sustainable and eco-friendly alternative to conventional petroleum-based plastics. Coconut shells, often discarded as agricultural waste, are rich in lignin and cellulose—key components that contribute to the structural integrity of bioplastics. By repurposing this natural material, we not only reduce environmental pollution but also enhance the value of an otherwise underutilized resource.

When coconut shell powder is combined with cornstarch, a natural polymer, it forms a biodegradable matrix that mimics the properties of traditional plastics. The incorporation of glycerol as a plasticizer increases flexibility, while vinegar (acetic acid) may improve durability by enhancing component binding. This combination yields a bioplastic that is biodegradable, cost-effective, and simple to produce with minimal equipment, making it accessible for small-scale industries and educational initiatives.

In conclusion, bioplastics derived from coconut shells offer a practical "waste-to-wealth" solution that aligns with global sustainability goals. By converting agricultural waste into functional materials, this innovation reduces reliance on fossil fuels, supports resource efficiency, and helps combat plastic pollution. With ongoing advancements and supportive policies, coconut shell-based bioplastics could become a mainstream alternative, paving the way for a greener, plastic-free

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