Development of Eco-Friendly 3D Printing Filament Using Banana Peduncle

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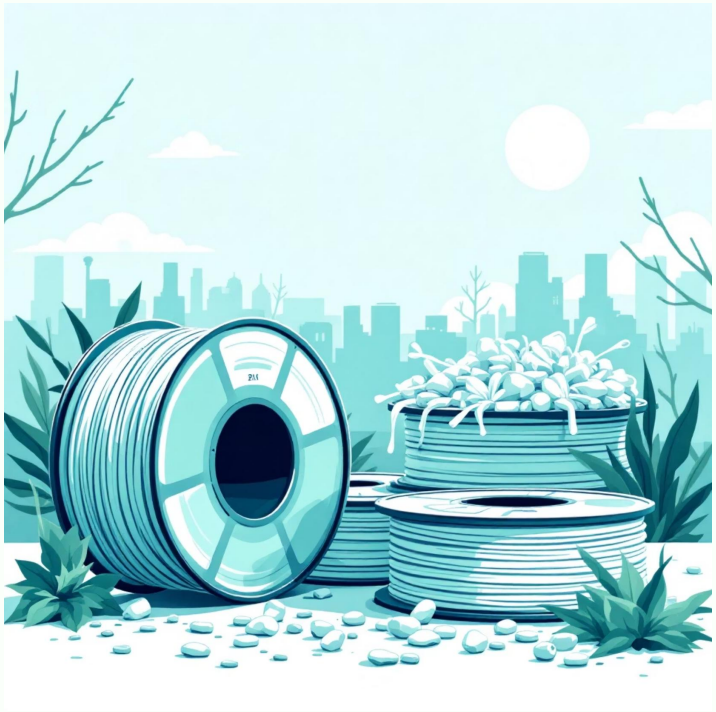
The Urgent Need for Sustainable 3D Printing



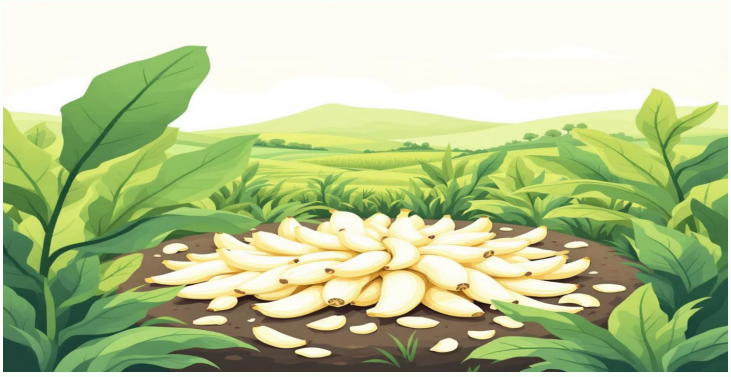
The Challenge of Traditional Filaments

The exponential growth of 3D printing across diverse industries has increased the demand for synthetic filaments such as PLA and ABS. While these materials offer high performance, their partial reliance on fossil fuels and contribution to plastic pollution present a significant environmental concern.

A Global Environmental Crisis

Our planet faces an urgent environmental crisis due to excessive plastic waste. This necessitates an immediate shift towards eco-friendly and biodegradable alternatives in manufacturing, especially in rapidly expanding sectors like 3D printing.

Transforming Waste: The Potential of Banana Peduncles



An Underutilized Resource

Agricultural waste, particularly banana peduncles, represents a vast and often underutilized resource. These by-products are typically left to decay or discarded, contributing to environmental pollution. Our project harnesses this waste as a valuable resource.

Aligning with Sustainable Development Goals

Transforming banana peduncles into 3D printing filament directly supports global sustainable development goals. This innovation addresses SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

Our Innovative Approach: Banana Peduncle Filament

Reducing Environmental Waste

By utilizing banana peduncles, we significantly reduce agricultural waste and its associated environmental impact, fostering a more sustainable ecosystem.

Cost-Effective Biodegradable Filaments

Our filament offers a low-cost, biodegradable alternative to conventional synthetic materials, making sustainable 3D printing more accessible.

Enhanced Polymer Composites

The natural fibers from banana peduncles can enhance the mechanical strength and properties of polymer composites, opening new possibilities for material science.

Challenges and Solutions

We acknowledge challenges such as efficient lignin removal, ensuring processing consistency, and optimizing printability. Our research directly addresses these obstacles to create a viable product.

Key Insights from Literature Review

Development of Banana Fiber Reinforced Bioplastic Filament for 3D Printing	A. Kumar et al. (2021)	Produced bioplastic filaments reinforced with banana fiber for FDM 3D printing.	Good biodegradability and mechanical properties; successfully printed.
Green Composite from Banana Peduncle Fiber for Sustainable Product Design	R. Sharma et al. (2020)	Developed eco-friendly green composites using banana peduncle fiber in epoxy.	Lightweight composite; not 3D printed; used for molding.
Characterization of Natural Fibers from Banana Waste for Composite Applications	M. Singh et al. (2022)	Characterized raw and alkali-treated banana fibers for composite use.	Fibers were suitable for composites; not tested for 3D printing.
Extraction and Treatment of Banana Fiber for Polymer Matrix Composites	T. Devi et al. (2019)	Studied extraction and NaOH treatment effects on banana fiber for composites.	Improved fiber adhesion; no filament developed yet.

Closing the Research Gap: Our Unique Contribution

Previous studies have explored natural fibers in composites, but there's a significant gap in using banana peduncle specifically for 3D printing filament. Most research focuses on other banana plant parts like pseudostems or leaves, often stopping short of actual 3D printing validation.

Our project directly addresses this by covering the complete lifecycle: from fiber treatment and filament extrusion to comprehensive 3D printing trials. We also aim to standardize methods for lignin removal and blending techniques, which have been inconsistent in prior work.

This project aims to bridge existing gaps by taking banana peduncle through complete stages–fiber treatment, filament extrusion, and actual 3D printing trials.

Our Core Objectives

Sustainable Filament Development

Develop a sustainable and biodegradable 3D printing filament using banana peduncle waste.

Cellulose-Rich Powder Production

Convert banana peduncle into cellulose-rich powder through precise chemical and mechanical processing.

Enhanced Bonding Properties

Eliminate lignin and enhance fiber bonding capabilities through effective alkaline treatment.

Filament Extrusion & Blending

Blend the treated powder with a suitable polymer, such as PLA, for efficient filament extrusion.

Real-Time 3D Printing Validation

Produce and validate a printable filament through rigorous real-time 3D printing trials.

Promote Environmental Sustainability

Contribute to environmental sustainability by upcycling agricultural waste, supporting a circular economy.

Methodology: From Waste to Filament

Raw Material Collection

Collect fresh banana peduncles from farms, ensuring quality and minimal decay.

Drying and Powdering

Remove moisture using solar or oven drying, then grind into fine, uniform powder.

Lignin Removal

Treat the powder with NaOH to increase cellulose content and improve bonding.

Polymer Blending

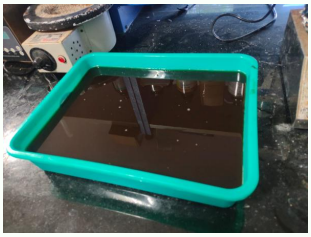
Mix the treated fiber with a polymer (e.g., PLA) for optimal consistency.

Filament Extrusion

Produce filament of desired diameter using an advanced extrusion machine.

Testing and Printing

Conduct 3D printing tests and mechanical validation for quality inspection.



Results & Discussion: A Viable Eco-Filament

Successful Lignin Removal & Cellulose Enrichment

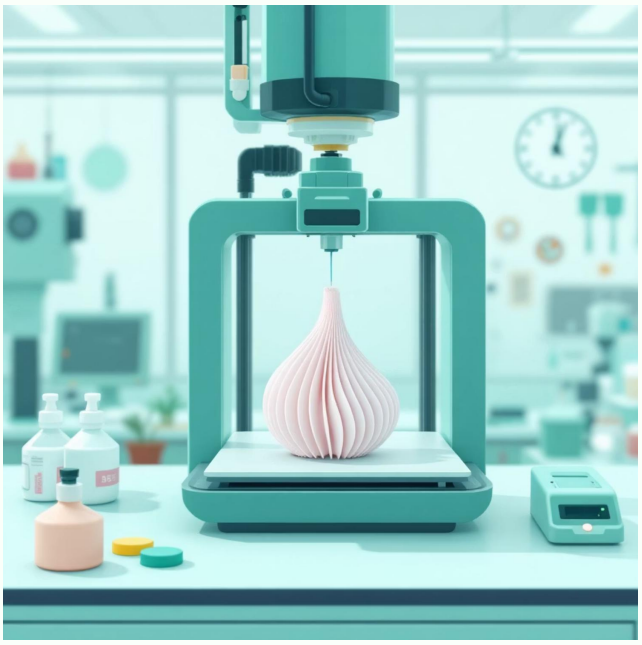
Our experiments demonstrated that NaOH treatment effectively removes lignin from banana peduncle powder, resulting in a cellulose-rich material with enhanced bonding properties for polymer integration.

Consistent Extrusion & Printability

The blended material smoothly extruded into consistent filaments, maintaining a diameter of approximately 1.75 mm. Initial 3D printing trials showed promising results with excellent layer adhesion and a smooth surface finish.

Sustainability vs. Mechanical Strength

While the mechanical strength was moderately comparable to commercial PLA, our banana peduncle filament exhibited superior sustainability and cost-efficiency. It demonstrated acceptable flexibility, printability, and biodegradability, validating its potential as an eco-friendly alternative.



Future Directions & Broader Impact

Optimize Processing Methods

Refine current techniques to further enhance filament quality, consistency, and printability.

Investigate Alternative Natural Fibers

Explore other natural fibers for developing hybrid biodegradable filaments with improved properties.

Conduct Large-Scale Production Trials

Assess commercial feasibility and scalability of the banana peduncle filament production.

Develop Protective Coatings & Additives

Introduce enhancements to improve moisture resistance and overall durability of the filament.

Expand Application Areas

Target diverse applications including biodegradable packaging, medical prosthetics, and automotive parts, promoting a greener future.