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Banana Fiber Waste: Potential and Utilization

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Abstract

Banana cultivation is a significant agricultural activity in many tropical and subtropical countries, leading to substantial agricultural waste in the form of banana stems and pseudo-stems. These by-products are often discarded, contributing to environmental pollution. However, recent advancements have shown that banana fiber, derived from these wastes, has immense potential in various industries such as textiles, paper, composites, and bioenergy. This review explores the potential of banana fiber waste, its properties, extraction methods, and diverse applications. It also highlights the economic and environmental benefits of utilizing banana fiber waste, thus promoting sustainable agricultural practices.

Keywords: Banana Fiber, Sustainability, Biodegradable

Introduction

Banana cultivation is a significant agricultural activity in many tropical and subtropical countries, leading to substantial agricultural waste in the form of banana stems and pseudo-stems. These by-products are often discarded, contributing to environmental pollution. Anita Roy (2022) Bananas are the most common fruit consumed worldwide. The banana plant has a life span of 9 months. Once the fruit is harvested, the stem of the plant is treated as waste. Similar to rice straw, the fields are burnt to clear the land for next year's crops. Banana fiber, derived from the pseudostem, exhibits superior fineness and spin ability compared to alternative fibers.

Banana trunks (pseudo-stems) are usually burnt or discarded as waste. Banana fibre comprises cellulose, hemicellulose, and lignin. There are various methods for producing banana fibre. It depends on the final product required. Whatever the production method, the final product is fully biodegradable. Furthermore, banana fibre is a highly absorbent material that is also environmentally sustainable.

Despite of its huge area under cultivation and production banana generate huge volume of the biomass. According to Dr. S. Uma (2021), Director, ICAR-NRCB after harvesting the fruit bunch, huge plant bio-waste is generated, out of which pseudostem (30-34%), flower & bracts (5%) and rhizome (12-14%) together contribute 50 per cent of the banana plant biomass. Disposing off this huge waste, roughly 60 tons per hectare is the biggest problem for farmers. Roughly, for every ton of banana fruit harvested, about 4 tons of biomass wastes (e.g., leaf, pseudo-stems, rotten fruit, peel, fruit-bunch-stem, rhizome, etc.) are produced. In India, we guesstimate that with the extractable pseudostem fiber yield of 400-600 kg fibers per hectare, 1.8 million tons of fiber could be produced which is otherwise dumped as a waste after harvesting the bunches. Dr. P. Suresh Kumar (2021), Principal Scientist and inventor of the technology briefed that with and increasing demand on eco-friendly materials, banana fibers are now used to make garments, ropes, mats, carpets, cushions, cushion covers, bags, baskets, table cloths etc, Rugs made from banana silk yarn fibers are also very popular world over. More than 10000 crores worth of business could be generated with the banana fibre and allied products. Banana fibres could also be used as a raw material for the extraction of cellulose, synthesis of composite materials etc.

Properties of Banana Fiber

Banana fiber is a bast fiber obtained from the pseudo-stem of the banana plant. It is known for its good mechanical properties and biodegradability. The following are key properties that make banana fiber a promising material:

Mechanical Properties

Strength and Durability: Banana fiber exhibits high tensile strength, making it suitable for applications requiring durability and resilience.

Flexibility: The fiber is flexible and can be spun into fine threads, making it ideal for textile applications.

Lightweight: It is a lightweight fiber, offering advantages in applications where weight is a crucial factor.

Chemical Properties

Cellulose Content: Banana fiber contains high levels of cellulose (50-60%), which contributes to its strength and durability.

Lignin and Hemicellulose: The presence of lignin and hemicellulose provides rigidity and resistance to microbial degradation.

Environmental Properties

Biodegradability: Banana fiber is biodegradable, reducing the environmental impact when disposed of or composted.

Renewable: As a by-product of banana cultivation, it is a renewable resource that can be replenished with each crop cycle.

Extraction Methods

The extraction of banana fiber involves separating the fiber from the pseudo-stem. Various methods can be employed to extract banana fiber, each with its own advantages and limitations.

- **Manual Extraction**

Manual extraction involves peeling the pseudo-stem and scraping the fibers manually. This method is labor-intensive but results in high-quality fiber with minimal damage.

- **Mechanical Extraction**

Mechanical extraction uses machines to crush and strip the fibers from the pseudo-stem. This method is more efficient than manual extraction and suitable for large-scale operations. However, it may lead to some degradation in fiber quality due to mechanical stress.

- **Chemical Extraction**

Chemical extraction involves treating the pseudo-stem with chemicals to separate the fibers. This method can produce high-quality fibers but may not be environmentally friendly due to the use of chemicals Arbaoui, T. *et al* (2020).

- **Biological Extraction**

Biological extraction employs microorganisms or enzymes to break down the non-fibrous material, leaving behind the fibers. This method is environmentally friendly but can be time-consuming and requires precise control of biological agents.

Applications of Banana Fiber

Banana fiber has diverse applications across various industries due to its favorable properties. Here are some key areas where banana fiber is being utilized:

Fabrics and Garments: Banana fiber can be spun into yarn and woven into fabrics. It is used in the production of eco-friendly textiles and garments, providing a sustainable alternative to synthetic fibers. Sato, Y., & Tanaka, M. (2018) stated that banana silk is also known as *Basho-fu,* banana silk has been used for centuries in Okinawan kimonos. Modern Revival: Efforts are underway to revive and modernize the use of banana fiber in Japanese textiles, blending traditional techniques with contemporary designs.

Home Textiles: It is also used in home textiles such as curtains, upholstery, and carpets due to its durability and aesthetic appeal.

Paper and Pulp Industry

- **Specialty Papers**: Banana fiber is used to produce specialty papers, including currency notes, tea bags, and filter papers, due to its strength and long fiber length.
- **Handmade Papers:** It is also popular in the production of handmade papers, which are valued for their texture and natural appeal.

Composite Materials

Reinforcement in Composites: Banana fiber is used as a reinforcement material in composite production, providing strength and stiffness to the final product. It is used in automotive parts, building materials, and packaging Thiruchitrambalam, M., & Alavudeen, A. (2017).

Biodegradable Plastics: Banana fiber can be combined with biodegradable polymers to produce eco-friendly plastics for various applications.

Bioenergy and Biomass

Industrial utilization of a bio-waste obtained from plant kingdom, adopting an appropriate technology without affecting ecological balance is a global phenomenon today.

Biogas Production: Banana pseudo-stems can be used in anaerobic digestion to produce biogas, a renewable energy source.

Biochar: The residues from banana fiber extraction can be converted into biochar, which can be used as a soil amendment to improve soil fertility stated by Reddy, N., & Yang, Y. (2005).

Handicrafts and Artisanal Products

Rope and Cordage: Due to its strength and durability, banana fiber is used to make ropes and cordage for various uses, including agricultural and marine applications.

Craft Products: Artisans use banana fiber to create a range of handcrafted items such as bags, mats, and decorative pieces, Mishra, R., & Goel, S. (2020) revealed that Indian artisans and designers are reviving banana fiber crafts, integrating them into contemporary fashion and decor products particularly in Kerla and Tamil Nadu region. Sone, V., & Patel, S. (2021) analysed that women can engage in the production of artisanal crafts, such as bags, mats, and decorative items, using banana fiber, providing them with a source of income as well as promoting sustainable livelihoods Gupta, P., & Jaiswal, S. (2019).

Economic and Environmental Benefits

Economic Benefits

Value Addition: Sharma, A., & Kumar, R. (2020) found that utilizing banana fiber waste adds value to the banana crop, providing additional income streams for farmers.

Job Creation: The banana fiber industry can create jobs in rural areas, from fibre extraction to product manufacturing. Gupta, P., & Jaiswal, S. (2019) stated that training in banana fibre extraction and product creation enables women to start their microenterprises, promoting entrepreneurship. Forming cooperatives allows women to pool resources, share knowledge, and access markets more effectively, fostering collective economic empowerment reported by D'Souza, L., & Fernandes, J. (2020).

Export Opportunities: Banana fiber products have a growing demand in international markets, offering export opportunities for developing countries.

Environmental Benefits

Waste Reduction: Kalyani, B. S., & Prasad, R. V. (2016) reported that using banana pseudo-stems for fiber production reduces agricultural waste and the environmental impact of waste disposal .

Sustainable Resource: Banana fiber is a renewable and biodegradable material, contributing to sustainable production and consumption. Banana fiber is blended with piña (pineapple) fiber to create the luxurious piña cloth, traditionally used in Filipino formal wear. The Philippines is leveraging banana fiber in sustainable fashion initiatives, promoting eco-friendly textiles globally (Villanueva, E., & Dizon, N. (2019).

Reduced Dependency on Synthetics: Utilizing natural fibers like banana reduces the reliance on synthetic fibers, which are often non-biodegradable and environmentally harmful.

Challenges and Future Prospects

Challenges

Quality Consistency: Maintaining consistent quality in banana fiber can be challenging due to variations in extraction methods and raw material quality.

Processing Technology: Advanced and cost-effective technologies for efficient fiber extraction and processing need further development.

Market Awareness: Increasing awareness and acceptance of banana fiber products among consumers and industries are necessary for market growth.

Future Prospects

Research and Development: Continued research into improved extraction methods and innovative applications can enhance the commercial viability of banana fiber.

Policy Support: Government policies supporting sustainable agricultural practices and natural fiber industries can boost the growth of the banana fiber sector.

Global Market Expansion: Expanding the market for banana fiber products through international trade and promoting eco-friendly products can drive future growth.

7. Conclusion

Banana fiber waste represents a significant untapped resource with immense potential across various industries Vijayakumar, G., & Elanchezhiyan, S. (2015). Its utilization not only provides economic benefits to farmers and manufacturers but also contributes to environmental sustainability. Gupta, V., & Sharma, S. (2020) suggested that Advancements in extraction technologies and increasing market awareness are key to realizing the full potential of banana fiber. Embrcing this renewable resource can lead to innovative solutions and sustainable practices in both agriculture and industry .

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