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The Promise of Banana Fiber as a Sustainable Textile Source

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Abstract: *The revival and utilization of natural fibers in many applications serve as a viable alternative to environmentally detrimental synthetic fibers. Several ongoing studies are focused on the development of fabric composites, both woven and non-woven, using fibers derived from banana pseudostem. Banana fibers possess potential for exportation as well. The product is available year-round and is affordable, making it highly marketable. Currently, banana fiber products are manufactured on a limited scale. It is imperative to investigate the potential applications of non-conventional natural fibers on a regular basis. Fabrics are derived from banana fiber and can be regarded as environmentally sustainable garments for the future. This review study examines the origin, extraction, accessibility, uses, and possibilities for profitable commercial utilization of fiberin order to create employment prospects in rural areas.*

Keywords: Agro-based fibers, banana fibers, banana pseudo-stem, biodegradable, cellulosic, decorticator, eco-friendly, Musa, natural fiber, renewable fiber, retting, sustainable.

I. INTRODUCTION

Currently, there is a global increase in the utilization of natural fibers, driven by the escalating environmental concerns. The production of synthetic fibers derived from petroleum-based materials has been identified as having detrimental effects, lacking biodegradability, and requiring higher energy use. The affordability and favorable mechanical characteristics of natural fibers contribute to their widespread utilization in the field of composites (Ortega *et al*., 2016). These factors contribute to the advancement of agricultural fibers. Banana fibers have a great potential as a natural cellulosic fiber among the existing agro-based options. The unquestionable sustainability of this material presents untapped potential within the textile industry. According to Pappu *et al.* (2015), India possesses abundant resources for the extraction of fibers from banana stems. Banana fiber is commonly utilized by numerous cottage enterprises in southern India for the production of handmade products. This plant is utilized in certain regions such as Japan and Nepal for the production of textile products and accessories. According to Vigneswaran *et al*. (2015), there is a significant presence of fibers in all types of bananas.

The banana is commonly referred to as kalpatharu due to its utilization as a food fruit crop and the versatility of its various plant parts for several applications.

The cultivation of this ancient species is widespread globally, with a significant emphasis on its production following citrus fruits. India accounts for around 27% of global banana production. The banana stem, which has the potential to produce fibers, is typically disposed of as waste once the crop is harvested. The management of banana pseudostem is a significant challenge for agricultural practitioners. A significant proportion of them are wasted due to a lack of information regarding their appropriate usage. The untapped potential of fiber derived from banana pseudostem remains untapped, despite its abundant availability.

Production and accessibility of bananas: The banana plant is classified within the genus Musa, specifically Musa acuminata (Mohapatra *et al*., 2010). The cultivation of bananas is widely recognized as a prominent agricultural technique in India due to its significant role as a fruit crop. Approximately 830.5 thousand hectares of land are dedicated to the cultivation of bananas, resulting in a production of approximately 29,779.91 thousand tons. The largest banana-producing states in India include Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh, and Karnataka. These

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states provide around 19% of the overall production, resulting in a productivity of 61.176 t/ha. Tamil Nadu has the largest banana cultivation area, with Maharashtra following closely behind.

The major banana producing districts in Tamilnadu include Theni, Tiruchirappalli, Coimbatore, Tuticorin, and Pudukkottai. A substantial amount of trash is generated from the extensive cultivation area, which has the potential to provide a big quantity of fibers (Pappu *et al*., 2015). Different components of the banana plant, such as banana skins, leaves, and stems, produce around 28.8 lakh tons of banana residue that are not directly used. The pseudo-stem of bananas has the ability to produce fibers of varying dimensions. The pseudostem has the capacity to produce 600 kg/ha of fiber, which has been identified as valuable for many applications.

Given the consistent availability of fruits throughout the year, there is a noticeable upward trajectory in banana production. This pattern suggests significant potential for enhancing banana fiber production, hence potentially increasing profitability for banana growers. Banana farming in India is conducted under varying climatic conditions, soil conditions, and production methods. The principal cultivars planted in India include Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran, Red banana, Nyali, Safed Velchi, Basarai, Ardhapuri, Rasthali, Karpurvalli, Karthali, and Grandnaine (Doshi and Karolia, 2016).

Extraction of banana fiber: The pseudostem of the banana tree serves as a source of fiber. During the extraction process, non-cellulosic sticky components are eliminated and fiber is extracted. The process of fiber extraction primarily involves three methods: mechanical, chemical, and biological.

Mechanical therapy: The process of decortication is employed to extract fiber from the pseudostem of bananas. This encompasses manual scraping, retting, or the utilization of machinery. Cottage businesses in India painstakingly extract the fibers from the sheath for local usage.

The manual procedure, commonly referred to as stripping, is extensively utilized in the Philippines. The separation of the outer and middle layers is achieved by employing a knife, while the stems are then desheathed.

The strips that are then divided along their length are referred to as a tuxy.The name given to this technique is tuxying. According to Ray *et al*. (2013), the tuxies are passed through a wooden block and a serrated knife while being subjected to significant pressure.

Decorticators, which are machines, are utilized for the extraction of fibers. According to Mukhopadhyay (2008), the machine is equipped with a set of feed rollers and a beater. The outer sheaths are fragmented into segments measuring around 120 to 180 cm in length, which are then subjected to a rolling process to eliminate the pulpy contents through scraping. The removal of the sheath is achieved by applying pressure against a plate within the machine. The fibers are subsequently dehydrated and consolidated. The mechanical approach is comprised of three distinct stages. Tuxing involves making a small cut immediately below the pseudostem, which is then removed in strips or ribbons from the outer skin that contains the fiber. The term used to refer to these ribbons is "Tuxies". The second stage involves striping, during which the tuxies are introduced into a fiber extraction machine and subsequently extracted. The tuxies are subsequently subjected to multiple passes through the blade and the bed in order to effectively cleanse the fibers. This process eliminates all the pulp, weak fiber, and pulpy stuff. The third stage involves the process of sun-drying the fibers. Both the color and strength of the fiber are impacted by delays and negligence in the drying process. Chemical treatment is the extraction of fibers from dried banana stems by submerging them in a tank containing chemical solutions. Chemical retting is commonly achieved through the utilization of sodium hydroxide, sodium carbonate, pectinolytic enzymes, or mineral acids. While the fibers can be separated within a few hours, this process does not yield a product of superior quality and is also more costly. Continuous monitoring and control are necessary to prevent any inaccuracies from causing deterioration or damage to the fibers. The gums or resins that stick to the fiber can be eliminated through chemical treatment, either by directly applying chemicals or by employing a mix of retting and decortication methods in conjunction with chemical application. The conventional approach is subjecting the substance to boiling using caustic soda, alkalis, or potassium soaps. The method involves the extraction of gum from the leaves or bark, separating it from the fibers. Additionally, it eliminates a significant amount of the pigmentation. The process of boiling can occur either at atmospheric pressure or under high pressure conditions. As the pressure is heightened, the fibers undergo expansion; nevertheless, they also experience a decrease in strength and incur more damage.

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Biological therapy: The extraction of banana fibers also involves the utilization of biological and natural retting techniques. Microbial activity facilitates the decomposition of pectin within the plant stem during the process of retting. The retting process utilizes the combined action of water and bacteria to separate the fibers. The method significantly affects both the quality and production of fiber. The quality of fibers is influenced by various factors like as climate, soil, water, pH, maturity, harvesting method, and variation in variety (Sarma and Deka, 2016).
Among the three extraction methods, mechanical and chemical approaches fail to adequately eliminate sticky materials, resulting in environmental degradation. Biological approaches are considered to be environmentally benign due to their ability to mitigate environmental pollution. Enzymes are employed to mitigate pollutants and minimize fiber damage (Sarma and Deka, 2016).

Utilization of banana fibers: According to Preethi and Murthy (2013), banana plants are considered to be a highly valuable source of fiber because to their diverse range of applications, including medicinal, alcohol, starch extraction, and numerous other purposes. Despite being an old innovation, the textile industry lacks awareness of the various applications of banana fiber. Banana fiber production in Japan commenced in the early 13th century. The utilization of this textile material experienced a drop due to the increasing popularity of alternative fibers like cotton and silk. Currently, banana fiber is making a comeback in the fashion industry. Fiber is widely utilized in various regions across the globe for a multitude of applications, including but not limited to tea bags, automobile tires, saris, and Japanese yen notes. The banana fiber is utilized in Japan and Nepal for the production of superior fabrics (Vigneswaran *et al.,* 2015). Additionally, it finds application in other sectors like as paper production and the handicrafts industry. The promise of banana fiber lies in its high tensile strength and stiffness. The fibers exhibit greater length and yield a higher quantity of yarns. According to Sarma and Deka (2016), banana fiber possesses greater yarn strength, making it suitable for incorporation into blends with various natural or synthetic fibers. The extraction of fiber from banana pseudo stem is gaining speed due to the growing awareness of natural fibers. In India, the production of handmade objects sometimes involves the utilization of fibers to create ropes. According to Vigneswaran *et al*. (2015), this material has several applications such as the production of household furniture, paper materials, power transmission ropes and cordage, wall drilling cables, fishing nets, and shipping cables. Historically, this particular fiber has been utilized in the production of doormats, ropes, and handicrafts within the textile industry. In recent years, there has been a growing interest in the production of polymer composite materials as a means of reinforcement (Pappu *et al*., 2015). The lightweight and comfy characteristics of this garment make it a popular choice for summer wear among individuals. The utilization of banana fibers in the production of table cloths, cushion covers, curtains, carpets, neckties, and bags has gained significant popularity on a global scale (Vigneswaran *et al*., 2015). Banana fiber is utilized in numerous nations for diverse purposes, such as the production of socks in Europe, clothes in the Philippines, and Japan. The cultivation of bananas for fabric production in Japan has been a historic practice since the 13th century. Banana fibers are employed as a reinforcing material in conjunction with polypropylene for the purpose of constructing underfloor panels in automobiles. In refineries, it serves as a natural water purifier and sorbent, effectively absorbing spilled oils. Banana fibers are mostly utilized in the production of marine cordages, cardboards, tea bags, string thread, fabric material, and rope for the purpose of tying. Banana fibers are utilized in Japan for the production of traditional ceremonial clothing. In Nepal, the outermost sheath of plants is utilized in the production of textiles for place mats, floor mats, and sun screens. The increased utilization of banana fiber has led to a corresponding rise in its commercial worth.

The Role of Banana Fiber in the Textile Industry: The unique attributes of natural fibers, such as their affordability, lightweight nature, and biodegradability, render them a viable solution for addressing the issue of pollution. The natural fiber sector has the potential to generate job possibilities for a significant number of individuals, particularly small-scale farmers and cottage industries. The banana business in India holds great relevance to the national economy and has the potential to generate substantial additional money for farmers. The agricultural waste that is readily accessible has the potential to yield renewable fiber derived from banana plants, so presenting a lucrative opportunity for farmers. It has extensive use in reinforcing thermosets and thermoplastics. According to Kiruthika and Veluraja (2009), the fibers are derived from renewable sources and possess biodegradability, making them an environmentally benign product due to

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their inherent degradability. Researchers in the field of textiles utilized fiber derived from banana pseudostem to create both woven and non-woven materials. Economic factors: When evaluating the economic dimensions of bananas,

Economic considerations: When calculating the economic elements, it is found that a single acre of banana pseudostem may produce approximately 120 kg of fibers. Approximately 900 to 1000 stems are cultivated per acre, with 10-13 stems capable of producing one to two kg of fiber, contingent upon factors like as soil composition, water availability, plant health, and variety. The average weight of a pseudostem ranges from 10 to 25 kg, resulting in a fiber production of 75 to 150 g, equivalent to approximately one percent, depending on the specific plant variety. The extractor machine specifically designed for this purpose has the capability to extract around 30 kilograms of banana fiber within a single day. Currently, the price range for one kilogram of banana fibers is between Rs.200/- and Rs.500/-. The labor charges for fiber extraction in the machine amount to Rs 500/- per day per person, with a total of two individuals being hired. This can generate an additional income of approximately Rs.2,500/- per acre for farmers, in addition to the payments paid to landlords.

The banana as a renewable source of fiber: Sustainability in textiles entails the utilization and enhancement of eco-friendly techniques for fabric production. This involves implementing strategies that save energy and natural resources while minimizing adverse consequences on the environment, economy, and society (Mercer and Tyndall, 2014). Natural fibers possess sustainable qualities such as affordability, lightweight nature, and biodegradability, which make them a viable solution for addressing pollution issues.

According to Ramachandran *et al.* (2015), bamboo fiber, banana fiber, and linen fiber are examples of natural fibers that possess significant potential for profitability and are widely cultivated. The enormous cultivation of banana pseudo stem in India presents a significant opportunity for the extraction of around 17,000 tons of fibers yearly. The incorporation of banana yarns can introduce a novel dimension to handloom fabrics. Due to its consistent production and year-round availability, this textile fiber is considered sustainable and has potential applications in garments and home furnishings. Concurrently, the promotion of banana fibers would effectively enhance the supply of fibers necessary to achieve the growth objectives of the textiles and apparel industry. Banana fiberhas the ability to generate employment opportunities for a significant portion of the population, both in agricultural and non-agricultural sectors. Additionally, it can serve as an extra means of livelihood generating and contribute to the development of a sustainable economy.

Additionally, this initiative will benefit farmers by affording them the chance to produce supplementary revenue by means of extracting or selling the banana pseudostem (Doshi and Karolia, 2016). The utilization of banana fiber, a by-product derived from the growing of banana fruit, contributes to the creation of environmentally sustainable products that promote a harmonious interaction with the ecological system (Sucharitha, 2017).

Outlook for the Future: The international markets have a high demand for banana pseudostemfiber due to its biodegradability, natural origin, and renewable nature. The demand for it will rise due to its non-polluting nature. The banana fiber possesses high mechanical qualities, which facilitate its seamless integration with a wide range of other fibers or materials (Ramachandran *et al.,* 2016). Therefore, banana fibers can be combined to create different types of fabric that can be used for a range of purposes, such as home textiles and technical textiles. India possesses a substantial reservoir for extracting fibers from banana stems due to its status as the foremost producer of bananas (Vasug, 2018). Furthermore, it is currently employed in the fabrication of composites with various fiber materials for diverse applications. The utilization of banana pseudo-stem fiber in the production of polymer/fiber composites has been documented in research investigations (Pappu *et al.*, 2015). The utilization of natural fibers has experienced a substantial surge in recent years, primarily due to their advantageous environmental attributes. The utilization of natural cellulosic minor fibers as a reinforcing material has been widely employed. The combination of their abundant presence in nature and the simplicity with which they can be processed possesses an appealing characteristic. Numerous studies are currently being conducted to explore the potential applications of banana fiber. Producing of yarn from the fibre, household materials, agricultural inputs and handicrafts can be manufactured from the waste Currently, banana fabrics are being utilized in the production of garments and home furnishings. By adapting

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suitable technology it can be brought to commercial utilization and thus help to provide an alternate income for farmers. Banana fiber from its pseudostem is a waste product of banana cultivation and it is under utilized in the textile sector. Enormous amount of biomass pseudostem, leaves, suckers etc are generated during the fruit production (Vigneswaran *et al.,* 2015). Disposal of the biomass is a major problem for farmers. Adverse weather circumstances, such as floods or strong winds, as well as price variations for banana fruits, result in significant financial losses for growers. In this context extracting the fibres from banana pseudostem can be an income generating activity. This fibre can certainly be an eco-friendly substitute in textile industry replacing synthetic fibers which cause harm to environment. Also it will help the rural people to earn by creating employment in the fiber extraction. The fabrics made from banana fiber will be definitely and truly an ecofriendly apparel of the future. Researchers also say that it can be cheaper than cotton and linen if produced on a mass scale. Limitations in growing fibre yielding crops and the problems in meeting the demands of the increasing population make agro-based fibers especially banana fibre the most promising and sustainable alternative to natural fibers.

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