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Banana fibre – A potential source of sustainable textiles

K. Sangamithirai* and N. Vasugi

*Department of Textiles and Clothing, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. India. *E-mail: sangu.mithirai@gmail.com*

Abstract

Natural fibres are revived and used in various applications as a substitute for environmentally hazardous synthetic ones. Many researches are going on for developing fabric both woven and non woven composites from fibers of banana pseudostem. Banana fibres have scope for export also. It's year round availability and affordability, has good market potential. Today, banana fibre products are produced at small scale. The possibilities of using non conventional natural fibres in regular basis need to be explored. Fabrics are made from banana fiber and can be considered green apparel of the future. This review paper discusses the fiber source, extraction, availability, applications and potential of successful commercial use for developing rural employment opportunities.

Key words: Agro-based fibers, banana fibres, banana pseudo-stem, biodegradable, cellulosic, decorticator, eco friendly, *Musa*, natural fibre, renewable fibre, retting, sustainable

Introduction

Today utility of natural fibres is increasing at a global level due to the growing concern on the environment. Manufacturing synthetic fibres from petroleum based products are found to be harmful, non-biodegradable and consume more energy. The low cost and good mechanical properties of natural fibres increase its use in the composites field (Ortega *et al.*, 2016). These leads for the development of agro based fibers. Among the available agro based, natural cellulosic fibres, potential of banana fibres as a natural fibre is high. Its sustainability is undeniable and has unexplored potentiality in textile field. In India there are vast resources to extract fibres from banana stem (Pappu *et al.*, 2015). Many cottage industries in south India uses banana fibre for making handicraft products. In some parts of the world like Japan and Nepal this plant is used for making textile materials and accessories. All banana varieties have fibers in abundance (Vigneswaran *et al.*, 2015).

Banana is rightly called as kalpatharu, as it is used as a food fruit crop and all plant parts can be used for different purposes. This ancient species is cultivated all over the world and largely produced after citrus fruits. About 27 % of worlds banana production is from India. Banana stem which can yield fibres is disposed as waste after harvesting the crop. The disposal of banana pseudostem is a major problem for farmers. Major portion of them go wasted due to lack of awareness on its uses. The application potential of fibre from banana pseudostem has not been fully exploited though it is available in abundance.

Banana production and availability*:* Banana belongs to *Musa*, particularly *M. acuminata* (Mohapatra *et al.*, 2010). Cultivation of banana is one of the most popular agricultural practices in India as it is an important fruit crop. An area of around 830.5 thousand ha of land is used for banana cultivation with a production of around 29,779.91 thousand tons. Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh and Karnataka are the major banana producing states. About nineteen percent of total production are from these states accounting for productivity of 61.176 t/ha. Tamil Nadu has the highest banana cultivation area followed by Maharashtra. In Tamilnadu, Theni, Tiruchirappalli, Coimbatore, Tuticorin, Pudukkottai are the major banana producing districts. Huge quantity of waste is produced from the large area of cultivation which can supply a significant quantity of fibres (Pappu *et al.*, 2015). Various parts of banana plant, like banana skins, leaves and stems generate about 28.8 lakh tonnes of banana remains and are are not directly utilized. Banana pseudo-stem can generate fibre with different dimensions. The pseudostem can yield 600 kg/ha of fibre which has been found to be useful for different end uses.

Considering the year round availability of fruits, production of banana shows an increasing trend which indicates there is a lot of scope to improve the banana fibre production which might give more profit to the banana farmers. In India, banana cultivation is carried out in different climatic, soil conditions and production method. Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran, Red banana, Nyali, Safed Velchi, Basarai, Ardhapuri, Rasthali, Karpurvalli, Karthali and Grandnaine etc. are the main varieties grown in India (Doshi and Karolia, 2016).

Banana fibre extraction: Fibre is obtained from the pseudostem of banana tree. During the extraction process gummy substances which are non-cellulosic are removed and fibre is extracted. Mainly three methods, namely mechanical, chemical and biological are followed for fibre extraction.

Mechanical treatment: Fibre is extracted from banana pseudostem by decortication. This includes hand scrapping, retting or by using machines. In cottage industries the fibres are separated manually from the sheath for local use in India.

The manual process is called as stripping and widely adopted in the Phillipines. The outer and middle layer are separated by using knife between the layers and the stems are desheathed . The strips which are then separated lengthwise is called as a tuxy.

This process is called tuxying. The tuxies are passéd through a wooden block and a serrated knife under considerable pressure (Ray *et al*., 2013).

Machines called as decorticator are used for fibre extraction. The machines contains a pair of feed rollers and a beater (Mukhopadhyay, 2008). The outer sheaths are cut into pieces of around 120 to 180 cm in length and passed between rollers and the pulpy substances are removed by scrapping. The sheath is scrapped of by pressing against a plate in the machine. The fibres are then dried and bundled. The mechanical method is divided into three steps. In tuxing, a slight incision is given just underneath the pseudostem, and then pulled away as strips or ribbon from the outside skin containing the fibre. These ribbons are called "Tuxies". The second step is striping where the tuxies are fed in fibre extraction machine and pulled out. The tuxies are then passed through the blade and the bed many times to clean the fibres. With this, all the pulp, weak fibre and pulpy matter are removed. Third step is drying where the fibres are sun-dried. Delay and carelessness in drying affect both the colour and strength of the fibre.

Chemical treatment: In chemical treatment fibres are obtained by immersing dried banana stems in a tank with chemical solutions. Sodium hydroxide, sodium carbonate, pectinolytic enzymes or mineral acids are generally used for chemical retting. Though the fibers are separated in a few hours, it does not produce superior quality product and are more expensive. Also strenuous monitoring and control is required as any inaccuracy will deteriorate or damage the fibres.

In chemical treatment, the gums or resins which adhere to the fiber can be removed either by direct application of chemicals or by a combination of retting and decortications method along with chemical application. The usual method is to boil the material with caustic soda or other alkalis or potassium soaps. The process separates the gum in the leaves or the bark from the fibers. It also destroys much of the colouring matter. The boiling might be at the atmospheric pressure or at high pressure. As the pressure is increased, the fibers expand; but they lose their strength and are damaged in other ways too.

Biological treatment: Biological and natural retting is also used for the extraction of banana fibres. The pectin in the plant stem is decomposed by microbial action during retting. Here the action of the retting involves the action of both water and microbes in separating the fibres. The process has an impact on fibre quality and production. Climate, soil, water, pH, ripeness, harvesting method and difference in variety play an important part in determining the quality of fibres (Sarma and Deka, 2016).

Among the three extracting methods the gummy materials are not sufficiently removed in mechanical method and chemical methods and also cause environmental pollution. Biological methods seem to be eco-friendly as it serves the purpose of reducing environmental pollution. The use of enzymes helps to reduce pollution and cause less fibre damage (Sarma and Deka, 2016).

Application of banana fibres: Banana plants are the best source of fibre, along with its multi faced uses like therapeutic, alcohol, starch extraction and other innumerable uses (Preethi and Murthy, 2013). Though banana fibre is an ancient innovation, people in textile industry are not aware of its uses. From early 13th century banana fibre were made in Japan. Its use as a textile material declined as other fibres such as cotton and silk became popular. At present banana fibre is reappearing in the fashion field. This fibre is used in many parts of the world for several products, like tea bags, car tyres, saris and Japanese yen notes. In Japan and Nepal this banana fibre is used to produce high quality textiles (Vigneswaran *et al.*, 2015). It is also used for other purposes such as paper making and handicrafts industry.

High tensile strength and stiffness of banana fibre makes it a potential fibre. The fibres are longer and provide more yarns production. As banana fibre has higher yarn strength it can be blended with other natural or synthetic fibres (Sarma and Deka, 2016). Due to increasing awareness on natural fibres the extraction of fibre from banana pseudo stem is gaining momentum. In India handicraft items, ropes are generally prepared from the fibers. It can also be used for making home furnishings, papers, power transmission ropes and cordage, wall drilling cables, fishing nets, shipping cables etc. (Vigneswaran *et al.*, 2015).

Traditionally this fibre was used in making of doormats, ropes, handicrafts in textile sector. An interest towards producing polymer composite materials has developed in recent times as a reinforcing component (Pappu *et al.*, 2015). Its lightweight and comfortable properties makes it preferred summer wear by the people. Table cloths, cushion covers, curtains, rugs, neckties, bags are made from banana fibers and are popular world over (Vigneswaran *et al.*, 2015).

Many countries use banana fibre for various uses like for making socks in Europe, garments in Philippines and Japan. It is a traditional process to cultivate banana for cloth making in Japan and has been followed since 13th century. Banana fibres are used as reinforcement along with polypropylene to be used as under floor panels in cars. It acts as natural water purifier, natural sorbent, absorbing spilled oils in refineries. Marine cordages, cardboards, tea bags, string thread, fabric material and rope for tying purposes are mainly produced using banana fibres. Banana fibres are used for traditional ceremonial garments in Japan. The plants outermost sheath is used for making cloths for place mats, floor mats and sun shades in Nepal. As the use of banana fibre is multiplying, its commercial value is also increasing.

Potential of banana fibre in textile: Natural fibers distinct characteristics like low cost, less weight, biodegradability etc makes it an alternative to overcome the problem of pollution. Natural fiber industry can provide employment opportunities to millions of people, mostly to small farmers and cottage industries. In India, banana being an industry of major importance to the national economy, can also significantly contribute to an additional income to the farmers. The abundantly available agricultural waste produces renewable fibre from banana plant and can become a profitable resource for farmers. It can be widely used for reinforcement in thermosets and thermoplastics. The fibres are obtained from renewable source and being bio degradable they are very much an environmental friendly product because of its degradability in nature (Kiruthika and Veluraja, 2009). Woven and non-woven fabrics were designed by researchers in textile using fiber from banana pseudostem.

Economic aspects: Calculating the economic aspects, banana

pseudostem from an acre can generate around 120 kg of fibres. About 900 to 1000 stems are planted in an acre where 10-13 stems can give one to two kg of fibre depending upon the soil, water, plant condition and the variety. Approximately one pseudostem weights 10 to 25 kg which will yield 75 to 150 g of fibre *i.e.,* around one percent, depending on the plant variety. Nearly 30 kgs of banana fibre can be extracted in a day using the extractor machine specially developed for it. At present one kg of banana fibres costs from Rs.200/- to Rs.500/-. The labour charges are Rs 500/- per day per person, where two persons are employed for fibre extraction in the machine. This can earn around Rs.2,500/- extra income per acre for farmers apart from the wages given to labours.

Banana as sustainable fibre: Sustainability in textiles refers to the use and refinement of environmental friendly methods to produce fabrics, which means establishing practices that conserve energy and natural resources and minimize negative impact on environmental, economic and social effects (Mercer and Tyndall, 2014). Natural fibers can be sustainable as their distinct characteristics like low cost, less weight, biodegradability etc makes it an alternative to overcome the problem of pollution. Bamboo fibre, banana fibre and linen fibre are some of the natural fibres that have high profitable potential and are extensively cultivated (Ramachandran *et al.*, 2015). There is immense potential of extracting fibres around 17,000 tons annually from the banana pseudo stem in India due to its extensive cultivation. A new dimension can be given to handloom fabrics by incorporating banana yarns. Its continuous production and availability throughout the year makes it a sustainable textile fibre and has perspective as textiles in apparel and home furnishings. Simultaneously promoting banana fibers will facilitate the required fiber availability to meet the growth targets of the textiles and garments sector as well. The potential banana fiber can provide farm and off-farm based employment to large section of the population, It may also provide additional avenue for livelihood generation and allows for green economy. This will also help the farmers by providing them an opportunity to generate additional income through extracting or selling the banana pseudostem (Doshi and Karolia, 2016). The banana fiber, by-product from banana fruit cultivation, help in developing environmental-friendly products to sustain relationship with the ecosystem (Sucharitha, 2017).

Future Prospects: Banana pseudostem fibre, being bio degradable, natural source, renewable waste, have a great demand in the international markets. Its requirement will increase as it does not cause any pollution to the environment. High mechanical properties of banana fibre makes it blend easily with various other fibres or materials (Ramachandran *et al.*, 2016). Hence varieties of fabric can be produced by blending banana fibres for various end uses like home textiles and technical textiles. India has a tremendous source to extract fibres from banana stem as it is the leader in banana production (NHB, 2018). Also, it is now used in preparation of composites with other fibre substances for different purposes. Research studies report the use of banana pseudo-stem fiber in fabrication of polymer/fiber composites (Pappu *et al.*, 2015). The use of natural fibers has increased significantly in the last few years, largely because of the environmental benefits. Natural cellulosic minor fibers have been appreciably used as an agent of reinforcement. Their abundance in nature combined with the ease of their processing has an attractive feature. Many researches are going on in utilizing the banana fibre for various purposes. Producing of yarn from the fibre, household materials, agricultural inputs and handicrafts can be manufactured from the waste (www.the hindu.com/sci-tech/). Even apparel and home furnishings are being produced with banana fabrics today. By adapting 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. Weather conditions such as floods or heavy wind and more over the price fluctuations for banana fruits creates a heavy loss to the farmers. 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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