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Extraction, Grading and Utilization of Fibre from Banana (*Musa sapientum*) Pseudo-stem

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Natural fibres, often referred to as vegetable fibres, are extracted from plants and are classified into three categories, depending on the part of the plant they are extracted from. Fruit fibres are extracted from the fruits of the plant, they are light and hairy, and allow the wind to carry the seeds. Bast fibres are found in the stems of the plant providing the plant its strength. Usually they run across the entire length of the stem and are therefore very long. Fibres extracted from the leaves are rough and sturdy and form part of the plant's transportation system, they are called leaf fibres. Banana (*Musa sapientum*) is a popular fruit crop and grown extensively in India. In fact, India is the leading producer of banana. After harvest of banana fruits, huge quantity of biomass residues (60 t ha^{-1} - 80 t ha^{-1}) is left over as waste that constitutes pseudo stem, leaves, sucker etc. Among these waste components, there exists a vast potential of extracting fibres from the banana pseudo stem.

(***Key words**: Banana fibre, Pseudo-stem, Extraction*)

Banana (*Musa sapienta L.*) is cultivated in a wet tropical climate, but unable to withstand water logging. There are different varieties of banana with different type of fibre, since the varieties differ with different soil and climatic conditions. For banana crop, soil should be loose, rich in humus, and properly drained. The banana plant does not grow well under swampy conditions. The stem of the banana plant is usually thrown away once the plantain is harvested (Ray *et al.,* 2011).

The stem forms a major waste material in large scale banana plantations. For the large farmers, the disposal of these stems is a real problem. Fibre can be extracted from banana stem both manually and by mechanical extractor. Low cost, user-friendly device for extracting fibres from the banana pseudo stem can extract 15-20 kg fibres from the banana wastes in a day compared to 0.5 kg a day through the laborious manual process (Ray *et al.,* 2012). The machine extraction process reduces the drudgery, and provides a clean working environment for labours. It increases the fibre production by fifty times and the extracted fibre is of superior quality in terms of length, softness, strength and colour. India is the biggest producer of banana across the globe. Almost all the states of India are familiar with banana cultivation. Banana fibre with its inherent characteristics can be used as a raw material for development of various diversified products as mentioned below.

Banana fibre as a natural sorbent

Banana fibres in their natural state produce a highly sorbent material. The key factor is the high porosity and natural capillary action of the fibre, allowing it to absorb oil. Banana fibre is a super-sorbent, in that less fibre product is needed to remediate any spillage. Banana fibres can be used in sorbent socks, pillows and booms, or as loose fibre to clean up land-based spills.

Banana fibre as a base material for bioremediation and recycling

Organic contamination is frequently treated through 'bioremediation', a method that employs bacteria to 'eat' the contamination. In order for these bacteria to survive within the contaminated environment, they must be provided with a natural substrate material on which they will thrive. Banana fibre provides this medium and could be used in the remediation industry as a natural bioremediation agent.

Banana fibre as a natural water purifier

Banana fibres have already been tested for use as a filtration agent in the treatment of wastewater, which is often contaminated with oils and other organic materials. The natural affinity of banana fibre to oils and organics, and its tendency to repel water, makes it a good natural alternative filtration agent for industrial and municipal waste treatment.

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Banana fibre as a base material for the paper and pulp industry

The use of banana pseudo stem has been investigated for the production of craft cellulose, to be whitened for use in the manufacture of special paper used in the restoration of documents. The raw material used, at nearly 94% humidity, is obtained from commercial banana plantations. Wild varieties, which are grown in abundance in the north-eastern Indian forests, can be efficiently used in the pulp industry. After harvesting the bunches, all the spent plants of commercial cultivars can also be used. Paper made out of banana fibre is reported to be of high strength and is used to make tea bags and currency notes.

Banana fibre in handicrafts and textiles

A variety of products have been made from banana fibres in the Philippines. The banana fibres were reported to be elegant and highly versatile. As they do not crumple easily, these fibres have been used in the manufacture of dress materials. The fineness of texture depends on the quality of the fibre used. The material has a beautiful sheen and is used for making wedding gowns and barongs. Hand-extracted fibres have been used to produce handbags, wall hangings, table mats and other fancy articles. The fibre can be powdered and different colours of fibre obtained using natural dyes, which can be made into beautiful pictures. Portraits drawn and filled with colourful banana fibre chips have become popular in the handicraft industry in Mizoram, India, and have good potential in the export market.

Banana fibre: a license to print money

Few paper products undergo more continuous handling and folding than currency notes and it is a significant expense for national banks to replace worn banknotes. New Agriculturist (99/4), the online journal also reports that Japanese yen notes printed on paper based on the banana fibre, abaca (*Musa textilis*), exhibited superior tear resistance and tensile strength.

Other uses

A wide range of goods are available, including rope cordage, yarns, abrasive backing paper, tea bags, attractively patterned cloth, handbags/purses and shoes. Exports of abaca products are an important earner of foreign exchange, with the USA taking around two-thirds of exports. Singapore, Australia, Malaysia, Thailand and Europe are also important markets. The inherent drawback of banana fibre is its poor quality and higher irregularity, owing to the multi-cellular nature of the fibres. The individual cells are cemented with lignin and hemi-cellulose and thus form a composite fibre. Banana fibre is classified as medium quality fibre and performs very well in combination with other fibres for making fine articles like handicrafts, currency, etc.

MATERIALS AND METHODS

Study was conducted at ICAR-National Institute of Research on Jute and Allied Fibre Technology (NIRJAFT), Kolkata for extraction, grading and utilization of banana fibre. Banana pseudo-stems were collected and cut into proper sizes for extraction of fibre. Chemical retting (Anonymous, 2011) of the banana pseudo-stem was carried out by the application of Sonali Sathi (7g litre^{-1} of water). The retting of pseudo-stem was completed within 10 days. The whole process is depicted in Fig. 1 to Fig. 4. For machine extraction, ICAR-NIRJAFT developed extractor was used. This up-graded extractor was designed and fabricated with the provisions of feeding mechanism and scratched roller-guide plate clearance adjustments. The machine consists of a rigid frame with a rotating roller. The roller is made of horizontal bars with blunt edges, and it is driven by a one hp single-phase electric motor. For feeding the banana pseudo-stems, adjustable guiding rollers are provided (Fig. 5).

Fig. 1. *Shredded pseudo-stem for retting*

Fig. 2. *Retted pseudo-stem*

Fig. 3. *Removal of debris*

Fig. 4. *Fibre obtained through retting*

Fig. 5. *Extraction in the up-graded extractor*

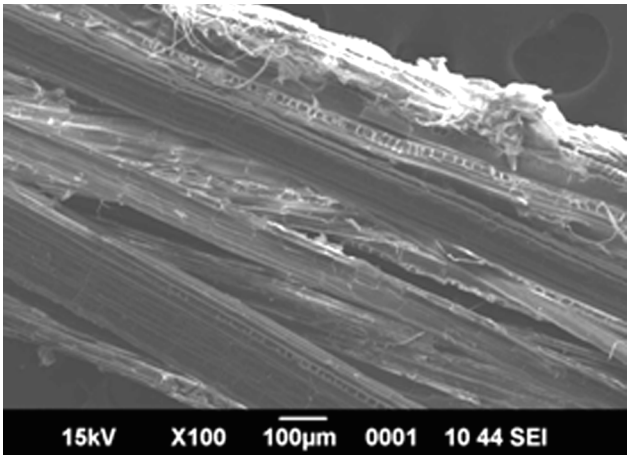

Fig. 6. *SEM Photograph of machine extracted banana fibre*

RESULTS AND DISCUSSIONS

The variation of yield of fibre from green and white sheath of pseudo-stem was studied. The fibre yields from green and white sheath were found to be 0.70% and 0.96% respectively. The overall yield of dry fibre from pseudo-stem was found to be 0.80%. The basic characteristics of the pseudo-stem processed were given in Table 1. It shows that the average length of whole stem: 267 cm, average weight of whole stem: 37.5 kg, average diameter of whole stem (*Basal End*): 21.3 cm, average diameter of whole stem (*Top End*): 15.3 cm, average number of sheath on whole stem: 22, average weight of sheath on whole stem: 90%, average number of green sheath: 4, average weight of green sheath: 15%, average number of white sheath: 18 and average weight of white sheath: 75%.

The variation of mechanical characteristics of the machine extracted, chemically retted and bleached fibres are given in Table 2. It shows that the machine extracted fibre is of highest strength (18.3 g tex^{-1}) in comparison to the bleached (10.7 g tex^{-1}) and chemically retted fibre (16.4 g tex^{-1}). Bleached fibre is the finest among the three categories of fibre obtained.

To know the chemical behaviour of banana fibre SEM and PXRD studies were made for the machine extracted fibre only. The SEM photograph (Fig. 6) shows

Table 1*. Basic Characteristics of pseudo-stem processed*

Parameter	Value
Average Length of whole stem	267cm
Average Weight of whole stem	37.5 kg
Average Diameter of whole stem (*Basal End*)	21.3cm
Average Diameter of whole stem (*Top End*)	15.3cm
Average Number of sheath on whole stem	22
Average weight of sheath on whole stem	90%
Average Number of Green sheath	4
Average weight of Green sheath	15%
Average Number of White sheath	18
Average weight of White sheath	75%
Average weight of Edible Core	10%

Table 2*. Variations in the strength and fineness of fibre*

Category	Strength (g tex^{-1})	Fineness (tex)
Machine extracted	18.3	7.0
Machine extracted & bleached	10.7	4.0
Chemical retted Fibre	16.4	6.5

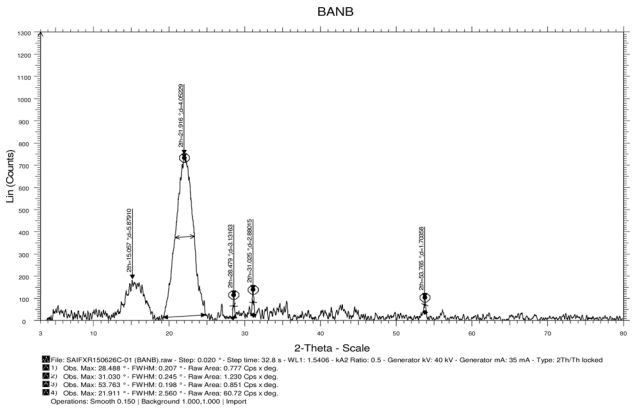

Fig. 7. *SEM Photograph of machine extracted banana fibre*

the individual fibres with little amount of gummy material present over it. Fig. 7 shows distribution of amorphous and crystalline constituents of the fibre revealing the typical characteristics of a natural fibre.

CONCLUSIONS

The fibre yield from green sheaths was found to be higher than that of the white sheaths. The average yield of dry fibre was found to be less than 1% of the total raw material processed in the developed extractor. The strength of fibre decreases with the bleaching action and the strength of retted fibre was less than that of machine extracted fibre. Machine extracted fibre followed by the bleaching action has produced the finest fibre. SEM and PXRD studies reveal the chemical behaviour of the machine extracted fibre resembling a typical natural fibre.

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REFERENCES

Anonymous (2011). *VISION 2030 Doccument*. National Institute of Research on Jute & Allied Fibre Technology, Kolkata. pp 1-18.

Ray, D. P., Ammayappan, L. and Nayak, L. K. (2011). Banana Fibre Extraction and Utilization-A Review. *Agricultural Reviews* **33**: 37-45.

Ray, D. P., Ammayappan, L., Nayak, L. K. (2012). Sustainable rural livelihood through utilization and value addition of Banana Fibre. *Journal of Inter-Academicia* **16**(3): 792-800.