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Extraction and characterization of fibre from musa plant bract

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An attempt has been made to extract the fibres from banana bracts which have several advantages in terms of environmental friendliness, sustainability and converting the waste into wealth. The banana bract fibres are extracted through mechanical and chemical treatments. The fibre characteristics, such as length, fibre strength, fibre elongation, and moisture regain, has been tested and analyzed. The bract fibre yield percentage varies from 1.02 to 1.84. Most of the bract fibres possess 14 - 24 cm length, which is sufficient to produce textile staple spun yarn. The banana bract fibre has the moisture regain of 8.51-11.63%. The fibre length, tensile strength, fibre elongation and moisture properties of the banana bract fibre show that the bract fibre can be used as raw materials for the production of biodegradable yarn. The 6^s Ne rotor staple spun yarns has been successfully produced from bract fibre using miniature lab model rotor spinning machine.

Keywords: Banana bract fibre, Biodegradable yarn, Fibre length, Fibre yield, Rotor yarn

Natural fibres are generally obtained from agricultural byproducts and renewable resources. Natural fibres, like cotton, jute, coir, sisal and banana, have attracted the attention for application in consumer goods with wide ranging applications from environment-friendly biodegradable composites to biomedical. The advantages of using natural fibres are renewable, biodegradable, low cost, give lower pollution level during production, and energy required for fibre production is lower than that of synthetic fibres production. The bio-degradable materials from nature are found to be a better solution as they are eco-friendly and have diversified applications. With the rising population and environment aspects, it is essential to use naturally degradable materials so that we can achieve sustainability. Bio-fibres are purely derived from vegetative sources which are fully biodegradable in nature. The main components of bio-fibres are cellulose, lignin, hemicelluloses and wax[1].

Savitha *et al*[2]. mentioned that *Sesbania grandiflora* fibres have comparable fibre strength, elongation and cellulose content to jute, hemp, ramie, phoenicx sp, okra and *Prosopis juliflora* fibres. Sundaram and Jayapal[3] extracted dharbai fibre by a simple and economical water retting process. Sunnhemp fibre from stalks of its plants is extracted by water retting method[4]. *Caryota urens spadix* fibres was extracted by traditional manual scrabbing process[5]. Banana fibre is one of the bio-fibres, derived from the banana plants and used for various textile applications. Practically, all the parts of this banana plant, like fruit, leaf, pseudo-stem, and bract, can be used. Banana fibres can be used in various industries, such as textile, paper or handicrafts. Fibres obtained from banana pseudo stem and sheath can be utilized as biodegradable binding ropes[6]. The benefits of bio-fibre as low cost and renewable biodegradable raw material can be utilized in some technical textile products[7].

The banana (*Musa paradisiac*) fibre is a potential raw material for making grease proof paper[8]. Banana and plantain fibres are used throughout the world to weave ropes, mats and other textiles products[9]. Many attempts and studies have been made for the effective utilization of fibre extracted from banana pseudo stem. In this research work, an attempt has been made to extract the fibres from the bract of banana flower and its properties are analyzed to explore the potential uses of fibres for textile production.

Experimental

Fibre Extraction

The waste bracts of the banana flower were collected for the study. The mechanical and chemical treatments were used for the extraction of fibre from the bract. In mechanical method three different tools (glass bar, metal comb and sheet of card clothing wire) were used. The glass bar, metal comb and wire sheet were used to strip on the banana bracts to remove gummy substances. The bracts were then washed to extract fibres and opened for fibre extraction. In mechanical methods, the fibre segregation is difficult since scrapping and stripping over the banana bracts require much time. Also, some

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gummy substances remain attached to the fibre. Further intense scrapping to remove those resulted in fibre rupture and damages. Eventually, the extracted bract fibre quality is low. This mechanical method damages the fibre during extraction, because the process is carried out in dry condition. Thus, chemical retting is preferred.

Retting of banana fibre is defined as the separation of the fibre bundles from the stem or bract, which causes partial digestion of the cementing material (such as lignin and hemicellulose) between the fibres in the bundles[10]. The trials were carried out to optimize the processing conditions for chemical retting. Table 1 shows the processing conditions of chemical retting process and their influence on fibre extraction and quality. The optimized processing conditions for chemical retting of banana bract are found to be 1% NaOH concentrations at 60°C temperature for 30 – 40 min. With these processing conditions, it is observed that most of the fibre can be extracted from bract without fibre loss or damages. Then the extracted bract fibres were segregated by washing and opened for further processes.

Fibre Yield

The amount of fibre extracted from the banana bract after the mechanical and chemical treatments can be calculated as fibre yield percentage, using the following relationship:

$$FY\ \% = (Fw \times 100) / Bw$$

where FY is the fibre yield percentage; Fw, the weight of dried fibres; and Bw, the weight of dried bracts in gram.

Fibre Characterisation

Fibres are broadly used in apparel or domestic textile and in industrial textile. For use in these categories, the fibre has to meet some specific requirements. The basic fibre properties, such as length, strength, extensibility and moisture regain, has been tested. The fibre samples were selected at random and prepared to measure length. The bract fibres need to be hand doubled and drawn to give a fairly well straightened tuft. Then they are laid on flat black background and each fibre is measured individually using ruler. About 100 samples were taken for measurements. The percentages of fibres are calculated based on the length ranges.

The mechanical properties of the fibres are much important for their use in high end applications, including load bearing applications, geo textiles, agro textiles and hybrid composites. The parameters tested to evaluate these properties are fibre strength and extensibility. Tensile properties of single fibre are tested with Zwick Roell tensile tester according to ASTM D3822. The bundle fibre strength is tested using stelometer fibre strength tester. The bundle fibre strength is calculated in g/tex. The evaporation weight loss method (heat drying and weight loss) is used in UniBloc moisture analyzer with heater temperature range 50°- 200°C at standard atmospheric conditions for the measurement of moisture content of fibres. The measurable quantity is moisture content (c) in grams. The moisture regain is calculated using moisture content with formula 100c/100-c.

Table 1 — Processing conditions of chemical retting process and their influence on fibre extraction and quality

NaOH concentration %	Temperature °C	Time min	Interpretation
Nil (Water retting)	80	120 – 180	Some non-cellulosic substances and foreign matters other than fibres remain unremoved
5.0, 10, 15	80	60	Degradation of cellulose, Short fibres and unfit for usage
1.0, 1.5, 2.0	60	50 – 60	Easy segregation of fibres and there is slight damage of cellulose
1.0	60	30 – 40	Degradation is very less

Results and Discussion

Fibre Yield

Figure 1 shows the effect of bract weight on the fibre weight. It is observed that the amount of fibre collected from the bract increases with bract weight. Further, the bract weight depends on the growth of banana plant. The 623.6 g of banana bract gives the fibre weight 8.6 g, whereas the 312 g of banana bract gives the fibre weight 3.2 g only. The different

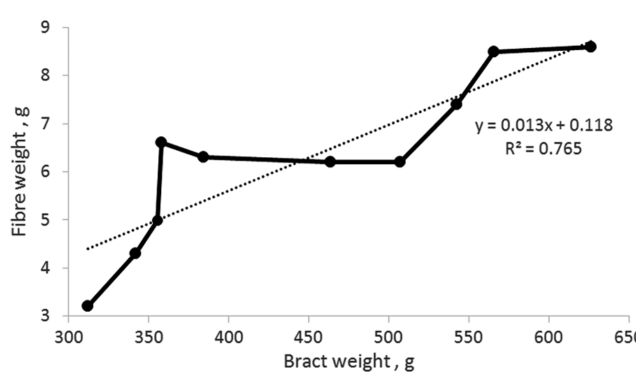

Fig. 1 — Effect of banana bract weight on fibre weight

varieties of banana plant give different bracts sizes and subsequently fibre yield.

Table 2 indicates the fibre yield percentage. It is noted that the fibre yield percentage varies from 1.02 to 1.84. The table shows that for some bracts, the fibre yield is more and vice-versa. Thus, it is found that the fibre yield depends on the variety of banana bracts. Therefore, on an average 1-2 g of fibres can be extracted from 100 g of raw bracts. Generally, the fibre yield increases with the increase in quantity of bracts.

The ginning percentage or fibre yield in cotton is 38.1- 40.3%[11]. In the jute fibre, green plant weight yield is 45-50 tonnes per hectare and fibre yield is 2.0-2.5 tonnes per hectare, it gives fibre yield 4.44-5%[12]. The banana fibre yield from pseudo stem is 0.283-2.71%[13] . The raw fibre extracted from the natural vegetable plant will be useful for textile production, and the availability of raw material is one of the key factors in textile production. From the research work, it shows that the bract fibre yield percentage is 1.02-1.84. So, it is possible to extract the fibre from bract waste. Hence, the fibre extracted from bract will create new textile product development and leads to effective utilization of waste to extract fibres for textile production.

Fibre Length

Table 3 shows the fibre length variations and % of fibres. About 100 fibres are taken for measurements and it is found that the fibres have different sets of length. It is observed that, various sets of bract fibre length range from 9 cm to 35 cm. The percentage of longer fibres with a length of about 30 -35 cm is found less. However, majority of the fibres have a length of about 14 -24 cm which is sufficient to produce textile staple spun yarn. Further, it is also observed that about 78% of fibres are in the length range between 9cm and 24 cm. The higher fibre length variation may be due to the varieties of banana bracts and growth stages of banana fruit, i.e. beginning stage, middle and ending stage. It is also found that the fibres extracted from the inner bracts are of shorter length as compared to outer bracts which contain longer fibres. The length of the bracts is longer between middle and end stage of banana growth, and hence collecting bracts at this stage yields longer fibres.

Table 2 — Banana bract fibre yield percentage

Bract weight , g	Fibre yield , %
626.3	1.37
565.7	1.50
542.6	1.36
507.1	1.22
463.7	1.34
384.3	1.63
358.1	1.84
355.2	1.40
342	1.25
312.1	1.02

Table 3 — Banana bract fibre length and % of fibres

Fibre length, cm	% of fibres
9-14	24
14.1-19	29
19.1-24	25
24.1-29	13
29.1-34	6
34.1-35	3

Fibre Strength and Elongation

The fibre strength and elongation are the primary properties for textile fibres. The fibre should have minimum strength of 6 cN/tex and at least 1-2% elongation[14]. The tensile properties of the fibre depend on the structures of the fibres and have influence on the properties and applications of final end products. The maximum tensile force the bract fibres can withstand is found to be 1.73 N. It is observed that a large number of bract fibres is 0.5 -1 N. The elongation at break is about 15.3 %. The tenacity of the bract bundle fibre is in the range of 37.05 - 45.90 cN/tex. The cotton fibre strength is 15-40cN/tex[14]. The banana bract fibre have good fibre strength and elongation properties compared to that of cotton fibre. This indicates that the bract fibre is possible to convert as staple spun yarn.

Fibre Moisture

Moisture regain is one of the important properties of textile fibres. It is the desired property of fibre, where the moisture absorption is important, such as geo and agriculture textiles products. Bract fibres show good moisture absorption properties. The test results show that moisture regain of the bract fibre is about 8.51-11.63%. The moisture regain of cotton fibre is 8.50 %, jute fibre is 12.5%, and banana pseudo stem fibre is 9.8-12 % [10]. The moisture regain of bract fibre is found almost comparable to that of cotton, jute and banana pseudo stem fibres. This also suggests that the wearable apparels can be made out of them and can contribute better for fabric comfort. The textile product can be made, where the water retention properties are required.

Feasibility of Textile Yarn Production

The extracted bract fibres are used with cut length of 15-30 mm for yarn production. The bract fibre is opened and cleaned using miniature lab model carding machine. The card slivers are doubled and drafted using miniature lab model draw frame for improving uniformity of the sliver. The draw frame slivers are then fed into miniature rotor spinning machine for the production of rotor staple spun yarn. The linear density of the card sliver is 0.213 Ne. The rotor staple spun yarn count 6 Ne with 20 twist per inch is produced. It is found that the 100% bract yarn is possible to spin using bract fibre.

The study shows that it is possible to extract fibres from banana bract. This research work utilized the innovative approach to develop a new type of yarn product from the bract fibre. Bract fibres can be used as eco-friendly and biodegradable textile fibres. It is found that the effective method of chemical retting includes treatment of bracts with 1% NaOH concentrations at $60^{o}C$ for 30 min for fibre extraction. It is found that 1-2 g of bract fibres can be extracted from 100 g of raw bracts.

It is observed that nearly 78% of fibre have the fibre length range 9-24 cm, and it can be effectively used for textile yarn production. The moisture regain of bract fibre is comparable with cotton. The bract fibre shows higher strength and elongation values than the minimum required for textile fibres. The banana bract fibre have sufficient length, adequate strength and good moisture regain. The bract fibre is long enough to manufacture staple spun yarns. The rotor staple spun yarn development creates the way for producing novel textile products and applications.

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