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Research Article

PHYSICO-CHEMICAL PROPERTIES OF FIBERS FROM BANANA VARIETIES AFTER SCOURING

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ABSTRACT
Fibers extracted from Banana varieties scoured with 2% NaOH solution at 100^0C for 45min and analyzed for their physico-chemical and mechanical properties. The moisture regain, cellulose content, modulus and tenacity of the fibers of all varieties were increased after scouring process. The fiber from the variety rasthali had high moisture content (13.21%), cellulose content (83.02%), modulus (3293.16gf/den) and tenacity (48.66gf/den) when treated with 2% NaOH solution. Thus, the scouring can increase the fiber quality for their usage in industries like paper and textile.

Key Words: *Physico-Chemical, Mechanical properties, Rasthali, Scouring.*

INTRODUCTION

In recent years, the search for alternative sources of fibers has been increased due to the growing shortage of fibers from the wood of forest trees for paper making in many countries. There are many solutions like recycling of paper and paper products to overcome this shortage, among which the usage of fibers from fast growing and high biomass yields non woody plants, are to be considered as the best alternative source of raw materials (Atchison J.E. and Collins T.T., 1976). Certain agricultural plants which are producing high biomass after harvesting are found to be suitable substitute for certain fiber based industries (Saikia *et al*., 1997). Among them banana is one which yields high biomass that may serve as an alternative source in fiber based industries like paper, card board, tea bags, fiber lining for car interiors, high quality dress material, currency notes (Shivasankar *et al*., 2006). Fiber from banana is also useful to make grease proof paper when blended with 20%bamboo pulp due to its good physical strength, higher pentosan gums and mucilage contents (Goswami *et al*., 2008).

Banana is an important fruit crop belonging to the family Musaceae. It is a gigantic herb with pure adventitious root system. Instead of their fruit, the flower and psuedostem are used as cheap source of vegetable and also, the leaf sheath encircling the growth tip yields the fiber of commercial importance (Singh and uma, 1996) which is suitable for making ropes and twines earlier (Saikia *et al*., 1997).

The production of banana in India is about 27.01 million tons from an area of 0.765 million ha in 2011(Mustaffa, M.M., 2011). From the above views, the present study was undertaken to analyse the scouring effect on physic-chemical and mechanical properties of fiber from banana varieties like Mondhan, Kadhali, Rasthali and Poovan to improve their quality by removing the impurities.

MATERIALS AND METHODS

Fiber Extraction

The fibers form leaf sheaths of each variety were extracted using the decorticating machine. The fibers obtained were 60-110cm long.

Scouring

Fiber (2g) of each varieties was immersed in 2% solution of NaOH and heated at 100^0C for 45 min. Care was taken to ensure that the materials were not exposed to air to prevent oxidation.

Then, the materials were washed with over flowing tap water, followed by drying in oven at 50^0C for 20min (Modibbo *et al*., 2009).

Moisture Regain (Astm 1997)

Oven drying procedure using ambient air heated to 105^0C was adopted to record the moisture regain percentage for the given samples according to the following formula.

$$\text{Moisture regain (\%)} = \frac{L-W}{L} \times 100$$

Where, L= weight of the specimen before drying
W= weight of the specimen after oven dried.

Fiber Density (Tappi 1980)

The determination of the density of all the fiber samples was carried out using standard method as described in a standard hand book of TAPPI (1980). The specimens were conditioned for 24h at 65% relative humidity and 25^0C before carrying the density test.

2g of samples were accurately weighed out for each fibre type. Each weight was immersed in toluene in a calibrated glass tube, and the value of toluene displaced was determined. It was equal to the volume of fiber immersed. The density of the filber was calculated from the formula.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Note: Toluene was used because it was not absorbed into fibre structure.

Linear Density

Linear density of the material was measured using the ASTM test method D 1577. The standard length (L) template the fiber samples were cut and weighed (W). The denier of the fiber sample is calculated using the formula.

$$D = \frac{9000XW}{L \times N}$$

Where, N is the number of fibers in the specimen.

Chemical Analysis

Direct method of cellulose, hemicelluloses and Lignin (Moubasher *et al.*, 1982).

2g of fiber was boiled in ethanol (4 times) for 15min, washed thoroughly with distilled water and kept in oven for dry weight at 40^0C over night, then divided into two parts in which one part is considered as A fraction. Second part of residue was treated with 24% KOH for 4hrs at 25^0C, washed thoroughly with distilled water dried at 80^0C over night and the dry weight taken as B fraction. The same samples again treated with 72% H_2SO_4 for 3hrs to hydrolyse the cellulose and the refluxed with 5% H_2SO_4 for 2hrs. H_2SO_4 was removed completely by washing it with distilled water, dried at 80^0C in oven for over night and dry weight taken as C fraction.

Cellulose = B-C
Hemicellulose = A-B
Lignin = C itself.

Tensile Properties

The tensile properties of the fibers in terms of the breaking tenacity, stress, percentage of breaking elongation and Young's modulus were determined using tensile testing machine (Instron Model 3343).

Fiber samples of equal length 20cm were prepared for tensile testing. A gauge length of 50mm and a cross head speed of 5mm/min were used for the testing. 10 fibers of each sample were tested for their tensile properties.

RESULTS AND DISCUSSION

Physical, chemical and mechanical properties of fiber from kadhali, pooven, mondhan and rasthali of untreated and scoured fiber were shown in Table 1 and Table 2 respectively.

Physical Properties

Moisture regain and density of the fiber of each variety were increased after scouring. Moisture regain of poovan (9.59%) and mondhan (9.89%) is less, followed by kadhali(10.15%) and rasthali (11.25%). The moisture regain of the fiber (poovan) is slightly lower than reported earlier (Kulkarni *et al*., 1983). The moisture regain is increased at 10-14% after scouring due to the removal of impurities like waxes, pectin and hemicelluloses. The density of the fiber variety kadhali (1.04 gml^{-1}) is higher than other three varieties.

Table 1: Physico-Chemical and Mechanical Properties of four varieties Banana Fiber

S.No.	Properties	Poovan	Kadhali	Mondhan	Rasthali
1	Physical:				
	a) Moisture regain (%)	9.59	10.15	9.89	11.25
	b) Density (gml^{-1})	0.67	0.39	0.5	0.44
	c) Linear Density(den)	10.15	11.61	11.61	7.39
2	Chemical (%):				
	a) Cellulose	59.55	63.9	62.4	55.31
	b) Hemi Cellulose	28.09	22.6	26.4	34.04
	c) Lignin	12.36	13.4	11.2	10.63
3	Mechanical:				
	a) Modulus (gf/den)	1554.56	1917.46	1918.13	1903.46
	b) Stress (MPa)	0.21	0.3	0.2	0.3
	c) Strain (%)	2.32	1.84	1.51	2.2
	d) Tenacity (gf/den)	20.46	26.77	21.19	41.89

Table 2: Physico-chemical and Mechanical properties of four Banana varieties after scouring

S.No.	Properties	Poovan	Kadhali	Mondhan	Rasthali
1	Physical:				
	a) Moisture regain (%)	11.11	11.54	11.11	13.21
	b) Density (gml^{-1})	0.83	1.04	1.00	0.69
	c) Linear Density(den)	9.4	6.7	9.54	5.4
2	Chemical (%):				
	a) Cellulose	80	72.92	75.51	83.02
	b) Hemi Cellulose	10	14.58	14.28	7.54
	c) Lignin	10	12.5	10.2	9.43
3	Mechanical:				
	a) Modulus (gf/den)	2484.49	2405.51	2129.06	3293.16
	b) Stress (MPa)	0.31	0.39	0.38	0.26
	c) Strain (%)	2.88	2.22	1.78	2.62
	d) Tenacity (gf/den)	31.38	28.23	33.16	48.66

Linear density of the fiber variety rasthali is lower followed by kadhali, poovan and mondhan. Among the banana varieties, linear density of the fibers Rasthali (5.4den) and Kadhali (6.7den) are similar to that of cotton, while the other two varieties are slightly higher than cotton (Batra, 1998). Linear density of the fiber of all varieties were decreased after scouring due to the large loss of hemicelluloses which made the

fiber to lose their cementing capacity and separate out from each other that making them finer (Dipa Ray and Sarkar, 2000).

Chemical Properties

The cellulose content of the fiber samples of each variety were increased after scouring, while hemicelluloses and lignin content are decreased due to their removal from the fiber (Table 1 and table 2).
The cellulose content of poovan (80%) and Rasthali (83.02) is close to cotton (85-90%) whereas the cellulose content of kadhali and mondhan is close to hemp (55-72%) (Batra, 1998).

Mechanical Properties

The mechanical properties such as modulus, stress, strain and tenacity of the fiber of banana varieties were increased after scouring due to the increase in cellulose content.Among the four varieties, rasthali showed higher modulus and tenacity than other varieties (table 2).
The modulus of all fiber samples is higher than that of cotton (55-90) and hemp (203-345) (Batra, 1998).
The high modulus makes the fiber stiff and suitable for use in applications such as composites and carpets (Reddy and Yang, 2009).

CONCLUSION

The scouring with 2% NaOH of fibers of banana varieties increases the quality of fiber in terms of their physico-chemical and mechanical properties. Among the four varieties, fiber extracted from rasthlai has high modulus, tenacity and cellulose and low lignin, hemicelluloses and linear density. Eventhough the modulus of poovan and rasthali varieties are greatly higher than cotton and hemp, the cellulose content of both is close to cotton. From the above results, the fiber obtained from rasthali followed by poovan after scouring could be suitable for use in textile, composite and other fibrous applications.

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