Pakistan J. Sci. Ind. Res., **12**, 303–306 (1969)

A STUDY OF ELEPHANT GRASS (TYPHA ELEPHANTINA ROXB) FOR TEXTILE PURPOSES

Part I.—Physical and Chemical Examination of the Fibres

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(Received June 13, 1968; revised October 2, 1968)

Typha elephantina Roxb (elephant grass) is a leaf fibre cheaply and abundantly available in Pakistan. In order to assess its suitability for textile manufacture, some of the important fibre characteristics were studied. A detailed study of fibre diameter was undertaken. The rheological properties such as breaking strength, elongation, stress, tenacity and tensile strength were also studied. Relationships of diameter to strength stress, and tensile strength were investigated. Further chemical analysis of the fibre for its major components was carried out. Keeping in view its properties, the suitability of the fibre for various textile purposes was discussed.

Vegetable fibres can be classified into various groups; among them long vegetable fibres are divided into two categories,[1] bast and leaf fibres. Leaf fibres are often termed "hard" fibres because they are generally harder, stiffer and coarser in texture than those in the best fibre group. In bast fibres the most important are jute, flax and ramie, while in leaf fibres, abaca, sisal and henequen account for more than 80% of the commercial leaf fibre production. The principal use is for various types of cordage and twine, though the fibres are also used in the manufacture of woven fabrics.

On the botanical[2] side *Typha elephantina* is a perennial, marshy herb, 6–12 ft high, leaves erect, spongy, 3-cornered margins, wavy about the middle. This grass-like shrub is planted as a soil binder. The long strong roots bind the soil of the river banks and prevent them from falling in. The plant is used for making ropes, mats and baskets by the local people.

In Pakistan considerable work has been done on such vegetable fibres as those from jute and banana, but little attention seems to have been given to the use of other vegetable fibres. *Typha elephantina* is a leaf fibre abundantly and cheaply available in marshy places, such as the Indus Delta, Jhelum and the Gujrat Districts.[3] In this paper, important fibre characteristics such as the diameter and the mechanical properties as well as the composition of the fibre have been studied in some detail to assess its suitability for textile purposes.

Materials and Methods

The plant was obtained from marshy places near Peshawar in dry form. It was soaked in water for about a week, the water being replaced from time to time. When the plant became soft, the fibre could be removed easily. The fibre was taken at random from all parts of the plant. The following tests were made on 10 samples used in the present study. Each sample represents one complete plant.

Diameter.—About 200 readings were taken from each sample by the Lanameter method[4] ($\times 500$). The coefficient of variation (C.V.) was determined by using the rapid method.[5]

Mechanical Properties.—The strength characteristics of the fibres were measured employing a Schopper dynamometer[6] (constant rate of loading). About 20 fibres were measured from each sample for breaking strength and percent elongation and the corresponding stress, tenacity and tensile strength calculated. The tests were carried out on fibres conditioned at 65% R. H. and 20°C as well as on wet fibres (soaked in water for 24 hr). Fibres were withdrawn easily from the tip and root ends of the plant and their breaking strength measured.

Fibre Analysis.—In order to elucidate the composition of the fibre percentage cellulose, hemicellulose, lignin, wax and moisture were determined. Briefly, loss in weight resulting from treating with sulphuric acid as described by Howlett,[7] was the cellulose content. The hemicellulose content was the loss in weight resulting from treatment with sodium hydroxide by Jengton's method.[8] For lignin, the sulphate process[9] was adopted wherein the material dissolved in alkaline solution, keeping pH above 9, determined the lignin content. Wax, aqueous extract and moisture were determined by the usual procedures.

Results and Discussion

The mean values of the diameter of the samples tested are given in Table 1. In estimating the value and suitability of textile fibres, several characteristics need to be examined for determining the quality. First of these is the fibre diameter or fineness; the strength and length are also significant. There are variations in diameter within as well as between the samples. In some samples the coefficient of variation is of distinctly higher order than that in other samples (range 6–24%). The mean diameter came out to be 40.1μ. On overall basis, the diameter of the fibres ranged between 20–68μ for the 10 samples tested. As compared to other vegetable fibres, its diameter falls in the same range as that of ramie fibre in bast fibre group, but is of a higher order than that of leaf fibres.[10] Microscopic examination (×500) showed that the fibre is associated with numerous striations which run parallel to the fibre axis in a fashion, similar to that of viscose rayon fibres.[11]

A certain amount of strength is a necessity in any fibre that is to be used to make a textile fabric. Because of this fact considerable attention has been paid to measurement of the strength of individual fibres. With other properties remaining constant, the stronger the fibre, the stronger will be the yarn or the fabric. Moreover, fibres are subjected to tensile strain more frequently than to shear or torsional strain.[12]

The results of testing for breaking strength have been given in Table 1 in respect of all the samples tested. It is evident that large variations exist within as well as between the samples (range 31–45%). The mean breaking strength is 83.4 g wt. In order to give an idea of single fibre rheological properties, 17 fibres have been selected from the 10 samples, for example, covering a wide range of fineness and their characteristics given in Table 2. The tensile strength and tenacity have larger values than those of other vegetable fibres and are more variable.[3] The stress and tensile strength

TABLE 1.—MEAN VALUES OF DIAMETER AND BREAKING STRENGTH OF ELEPHANTINA FIBRES.

Sample	Diameter (μ)	Breaking strength (g wt).
1	36.2	70.3
2	48.4	96.1
3	38.5	87.3
4	25.2	85.9
5	35.8	83.2
6	33.1	76.3
7	44.8	72.4
8	44.8	82.4
9	43.5	106.8
10	29.0	48.7
For all fibres	40.1	83.4

TABLE 2.—FINENESS AND RHEOLOGICAL PROPERTIES OF ELEPHANTINA FIBRES.

Density of the Fibres=1.40

Diameter (μ)	Breaking Strength (g wt)	Breaking stress mg/μ²	Elongation (%)	Tenacity/ g/ denier	Tensile strength kg/cm²
21.5	63	165	1.5	16	19008
23.7	57	124	1.0	15	17820
25.0	66	145	2.5	16	19008
27.5	69	112	0.5	11	13068
28.1	51	83	1.5	9	10692
29.1	42	59	0.5	5	5940
32.3	63	78	1.0	11	13068
33.4	102	112	2.0	11	13068
34.3	78	86	1.5	9	10692
37.6	51	45	2.5	5	5940
40.7	60	50	0.5	5	5940
44.1	39	20	2.5	3	3564
48.5	42	24	1.0	2	2376
49.3	57	29	2.0	3	3564
53.5	114	50	1.5	5	5940
54.0	84	45	1.0	4	4752
58.5	54	19	1.0	2	2376

are inversely related to diameter (Table 2). This is in general agreement with Stout and Jenkins[14] who showed that breaking stress of bast fibres increases as the area of cross section decreases. However, there appears to be no relationship between fineness and breaking strength. It may be mentioned that in view of the available reports, the fibres appear to have the highest breaking strength among vegetable fibres.[15] It was also found that the strength of root end is greater than tip end, thus confirming Berkley *et al*'s[16] results for abaca leaf fibres.

It is of interest to note that the strength of wet fibres is greater than that of fibres at 65% R.H. and 20°C (Table 3). In some fibres the increase in strength is more than 50% but a few fibres behaved exceptionally as there was a decrease in strength on wetting. The general behaviour is unlike leaf fibre where strength decreases on wetting; only ramie in bast fibre group shows increase in strength.[17] However, there is very little increase in elongation on wetting.

All vegetable fibre show low elongation and high breaking strength. It is clear[18] that the fibres which possess a well oriented structure are generally less extensible than those which are oriented at random or possess folded chains which can uncoil. It should be pointed out that elongation is an important characteristic for textile process. But low elongation has also its own merits: loaded jute bags have less tendency to shift about when stacked than bags made of fibres with greater percentage of elongation.[19] *Typha elephantina* fibres have a mean elongation of 1.5% (range 0.5–2.5%). As compared to other vegetable fibres, it seems to be like jute fibres associated with the lowest[20] elongation (1–2%).

Table 3.—Percentage Increase or Decrease in Strength on Wetting in Elephantina Fibres.

Fibre	Strength of fibres at standard conditions* (g wt)	Strength of wet fibres (g wt)	Increase or decrease in strength (%)
1	33	42	27.2
2	40	62	32.5
3	48	69	43.7
4	55	82	49.0
5	69	102	47.8
6	75	90	20.0
7	78	93	19.2
8	81	96	18.5
9	87	147	68.9
10	87	132	51.7
11	96	96	0
12	105	123	17.1
13	108	132	22.2
14	108	138	27.7
15	111	117	5.4
16	117	114	−2.5
17	123	147	19.5
18	132	144	9.1
19	147	144	−2.0
Mean	89	109	25.0

*At 65% R.H. and 20°C.

The fibres are white or light brown in colour and the fibre yield from the plant is about 40%. The fibres are readily dyed with direct cotton dyes. The handle of the fibres, however, appears to be harsh.

The results of the chemical analysis are given in Table 4 which illustrates the lignocellulose nature of the fibres. The fibres have approximately[21] the same proportion of cellulose and lignin as compared to leaf fibres; the ash percentage is, however, high. The percentage of hemicellulose is less than that in other leaf fibres. The hemicellulose comprises the substances in the cell wall that are less resistant to acids and alkalies than cellulose. Should such action as bleaching be too severe, considerable loss in fibre weight occurs due to dissolution of these substances. Moisture content is considered to be useful in spinning and dyeing.

The coarse nature of the fibre limits the fineness of the count to which yarn can be spun. A wide range of length can, however, be achieved as desired. Moreover, due to its high strength it can be used in making coarse textiles and also may be used as a carpet warp. The increase in strength on wetting makes it suitable for marine ropes and fishing nets. The presence of 1.4% wax is helpful in giving the fibres some lustre as well as imparting suppleness. Too little wax makes the fibre harsh and brittle, too much leaves them difficult to process. It may be mentioned that elephantina fibre is used by the poor people for making ropes, baskets and mats. They make yarn, taking the plant as a whole (without extracting the fibre), producing twist by head and using it for the above purposes.

Table 4.—Chemical Analysis of Elephantina Fibre.

Component	%
Cellulose	63.0
Hemicellulose	8.7
Lignin	9.6
Wax	1.4
Moisture	8.9
Ash	2.0
Aqueous Extract	6.4
Total	100.0

In view of its above properties, the fibre could become an important textile raw material, when utilized for the above mentioned purposes.

Conclusions

The following points emerge from the above discussion: Elephantina fibres are associated with the highest breaking strength among the vegetable fibres, but the elongation (1.5%) is the lowest, equal to that of jute fibres. The diameter is negatively correlated with the stress and tensile strength, but has no relation with the breaking strength. The mean diameter is 40μ. The strength of the fibre increases on wetting. It has got roughly the same chemical components as other leaf fibres. It may be used for making coarse textiles, marine ropes, fishing nets and carpet warp.

Acknowledgement.—The authors wish to express their thanks to Dr. S.A. Warsi for providing facilities to carry out this work and also to Dr. S.M.A. Shah for his help in preparing the manuscript. Thanks are also due to Mr. Abdul Rashid and Mian Taj Younis of the Wool Research Division for their help in some of the experimental work and calculations.

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