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Mechanical Properties of Kenaf Fibres (*Hibiscus cannabinus*) and their Spinning Quality

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Abstract: The physico-mechanical properties and stress-strain behaviour of three varieties of Kenaf fibres (*Hibiscus cannabinus*) have been studied and compared. It was found that the visco-elastic behaviour of kenaf was almost nil and the physico-mechanical properties of kenaf HC-2 and kenaf HC-95 fibres were similar to those of white jute fibre (*Corchorus capsularis*) but kenaf HC-4 showed very poor performance. Kenaf fibre contained relatively greater diameter (less fine) compared with that for white jute fibre and consequently, the quality ratio value of yarn for each of the kenaf varieties was much smaller than that of white jute fibre.

Key words: Tex, lbs/spy, tenacity, quality ratio

Introduction

Kenaf is a kind of vegetable fibre that grows abundantly in Thailand, China and some parts of East Africa. But in Bangladesh only a small quantity of this fibre is produced. Here its production was banned from 1948 to 1960, giving much more emphasis on the yield of jute fibres. But it has been observed that kenaf cultivation has got some advantages over jute cultivation because, kenaf can grow in the marginal land while jute can not. Moreover, it needs less weeding and less care compared with jute and its production cost is low. It is thus a cheaper fibre but brighter in colour than jute.

Various studies have been made on the morphological and agronomic characters (Sobhan and Hussain, 1977) and on the yield of kenaf fibre (Sobhan and Khatun, 1982). But information on the fibre quality is meagre.

In estimating the price and suitability of fibre for quality yarn manufacturing purposes mechanical properties and fineness of fibre are the most important characteristics to be considered. It has been found necessary that a fibre which could offer high tenacity, and a small and even diameter (Welford, 1966) would be welcome in the textile field. It will yield yarns/fabrics of high strength. The presentation of the mechanical behaviour of fibres will consider both practical and basic approaches viz (a) the correlation of fibre properties with yarn/fabrics properties and (b) the correlation of molecular and intermolecular structure with fibre properties (Arjamand, 1965). So far, no previous work appears to have been done on the physico-mechanical characteristics of kenaf fibres. So, for determining the mechanical properties as well as spinning quality of kenaf fibre (*Hibiscus cannabinus*), this project was conducted.

Materials and Methods

The experiment was carried out at Testing and Standardization Laboratory, Bangladesh Jute Research Institute (BJRI), Dhaka. Three varieties of kenaf namely Kenaf HC-2, Kenaf HC-4 and Kenaf HC-95 were collected from the experimental station of Bangladesh Jute Research Institute at Manikganj. For sampling each variety weighing about 30kg was spread out on the floor. Then from each variety 10 kgs of fibre was randomly separated for studying fibre properties, the remaining portion being used to spin into 8 lbs/spy (Count in tex system = lbs/spy x 34.45) (=275.67 tex) and 10 lbs/spy (=344.5 tex) counts of yarns.

Following test methods were then undertaken to measure the various fibre characteristics and the yarn properties in standard atmosphere (Temp. 20±2°C and R.H. 65±2%).

Wira fibre fineness meter (Anderson, 1954) was used to determine the fineness (diameter) of the fibre in micron. In this apparatus air was sucked in through a cylindrical bundle of fibres 7.62 cm long and 8.38 cm diameter. The resistance to airflow was indicated in a flowmeter which was calibrated in terms of fibre diameter in micron. On switching the machine the position of the float was read which indicated the diameter of the fibre in microns.

Linear density in tex was determined by Cut-middles method. For this measurement 50 to 60 reeds were randomly taken from the fibre samples. Then 36 cm lengths were cut from the middle portion of the reeds from which one hundred filaments/fibre were taken out. These filaments were cut at 12 cm lengths and weighed in a microbalance to determine their linear density in tex and then tested on a testing instrument INSTRON Mode1 TM-M employing tension load cell B, with gauge length fixed at 5 cm and the rate of transverse of actuated jaw 0.5 cm per minute. Load and elongation at break of the filaments were automatically recorded on the chart of the instrument. During test the time required to break the filaments was from 2.4 to 14.8 seconds.

Tenacity was then calculated as follows:

$$\text{Tenacity} = \frac{\text{Breaking load (gm)}}{\text{Linear density (tex)}}$$

Where, linear density (Lyons, 1963) is the weight of 1 km length of materials in grams which is called tex.

The breaking elongation percentage of the fibre was calculated as the ratio of elongation of fibre at break to original length expressed in percentages.

Bundle strength (Pressley Index) of fibres was determined by Pressley fibre bundle strength tester using zero gauge length. The flat bundle approximately 6.35 mm width was held by a pair of clumps. All protruding ends were then sheared off even and tension applied to separate the clumps and thereby to break the fibres. The broken bundle was then weighed in a precision balance. The resulting strength was then computed as,

$$\text{Pressley Index} = \frac{\text{Breaking load (lbs)}}{\text{Bundle weight (mg)}}$$

For bursting energy measurement 60 cm lengths of reeds were cut from the middle of each 250 reeds taken at random from the fibre samples. The reeds were broken through bursting energy tester designed and developed by British Jute Trade Research Association (BJTRA). The broken parts of the reeds were weighed in a balance. The bursting energy was then calculated using the following relation:

$$\text{Bursting energy} = 0.021 \frac{B}{W}$$

Where, B = total work absorbed in breaking 250 specimens,
W = total weight of 250 specimens in ounces.

The yarns of 8 lbs/spy and 10 lbs/spy were spun through Apron draft sliver spinning frames where Flyer speed was 4000 r.p.m. The twist of the yarns were determined through Goodbrand Single yarn Twist tester. The gauge length was 50 cm and the rate of traverse of the actuated jaw was 30 cm per minute.

Results and Discussion

The stress-strain curve for each of the variety of kenaf *(H. cannabinus)* was almost straight up to the breaking point (Fig. 1). Thus, visco-elastic behaviour in kenaf fibre was almost nil.
The physico- mechanical properties of Kenaf HC-2 and Kenaf HC-95 fibres were found similar, but kenaf HC-4 fibre showed very poor performance (Table 1).
Kenaf fibres contain very big diameter compared with other textile fibres like Tossa and White Jute fibre (Ali *et al.*, 1996) and mainly due to this bigger diameter kenaf fibre produces very low percent quality ratio's (Table 2).

Table 1: Physico-mechanical characteristics of Kenaf fibres at Temp. 20± 2°C and R.H. 65 ± 2%

Parameters	Varieties		
	Kenaf HC-2	Kenaf HC-4	Kenaf HC-95
Bundle strength (Pressley index, kg/mg)			
Mean	5.02	3.21	5.02
Range	3.10-6.34	1.37-5.78	2.86-6.44
CV%	19.16	36.75	22.67
Fineness			
Diameter (width)	41.7	42.4	41.9
Linear density (tex)			
Mean	3.00	3.59	3.20
Range	1.25-5.33	1.17-5.66	1.24-5.16
CV%	29.75	23.69	25.33
Breaking tenacity			
Mean (gf/tex)	29.50	25.60	28.40
Range (gf/tex)	8.50-61.60	4.95-46.68	8.20-73.77
CV%	39.33	48.90	44.08
Breaking elongation			
Mean	1.17	0.93	1.18
Range	0.40-2.20	0.40-2.48	0.40-2.44
CV%	33.15	47.04	39.22
Bursting energy (gm.cm/tex)	4.67	4.67	4.45

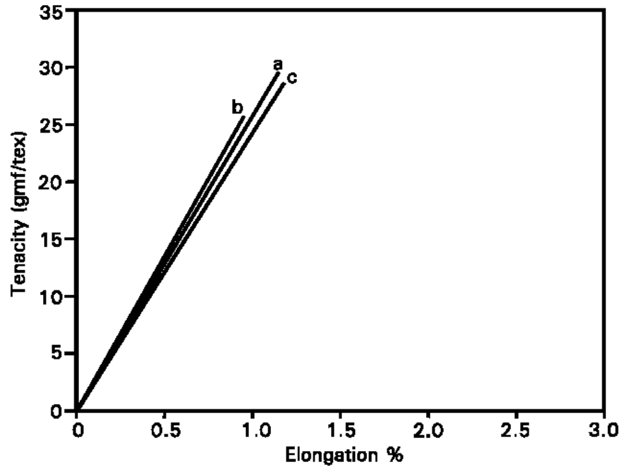

Fig. 1: Typical stress-strain curves of Kenaf fibres:
a. Kenaf HC-2. b. Kenaf HC-4. c. Kenaf HC-95

The study of the mechanical properties of fibres owes its importance to two considerations, one is practical and the other is basic. The practical consideration arises to govern the utility, and the sale of the yarn/fibres. The basic consideration of fibre characteristics is concerned with the mechanical properties and structural features of the fibre.
The elongation of the fibre is proportional to stress up to the breaking point. This obeys Hook's law and this region is called Hookean region (Fig. 1).
Hooke's law may feasibly depend on intermolecular attraction and on stretching the potential energy increases. The rate of breaking of hydrogen bonds may depend on the diffusion of hydrogen ions into the fibre and therefore follow the osmotic dehydration which may be relatively rapid (Arjamand, 1965). In the normal unstretched fibre, the folds in the molecular chains are probably held together by hydrogen bonds (Brady and Humiston, 1982). The load-elongation curve or stress-strain curve may be due to the gradual deformation of these hydrogen bonds which normally prevent unfolding of the intermolecular chains. But at the end of Hookean region, where the stress on the hydrogen bonds is too great to be borne, the strength of the intermolecular forces fails due to the failure of hydrogen bonds. Thus the fibre breaks straight showing almost no visco-elastic effect. The higher

Table 2 : Test results of yarns spun from the kenaf fibers at 20 ± 2°C and R.H. 65 ± 2%

Varieties	Nominal count (lbs/spy)	Actual count (lbs/spy)	TPI(Twist/inch)	Tensile strength, lbs		*Quality ratio (%)
				Mean	CV%	
Kenaf HC-2	8	7.28	4.17	5.75	37.82	78.98
	10	9.78	3.89	8.68	20.04	88.75
Kenaf HC-4	10	9.83	3.62	4.10	31.21	41.70
Kenaf HC-95	8	8.06	4.08	5.96	31.30	73.94
	10	9.71	3.84	8.18	25.18	84.24

$$\text{Quality ratio\%} = \frac{\text{Tensile strength (lbs)}}{\text{Actual count (lbs/spy)}} \times 100$$

** lbs/spy indicates the fineness or coarseness of yarn and it is determined by the weight of 14400 yards (= 1spyndle) length of yarn in pounds (lb).

breaking load or tenacity or tensile strength may be due to the tight packing of the crystalline and amorphous regions and higher intermolecular forces in the fibre (Brady and Humiston, 1982).

The mean tenacity values obtained for kenaf HC-2, kenaf HC-4 and kenaf HC-95 were 29.5, 25.6 and 28.4 gf/tex respectively (Table 1). This value as obtained earlier for white jute fibre (*C. capsularis*) is 31.4, gf/tex (Ali, 1994). So except kenaf HC-4, kenaf HC-2 and kenaf HC-95 are comparable to white jute fibre in respect of tenacity value. Again, as determined earlier, the mean values of bundle strength, bursting energy, breaking elongation percentage for white jute fibre are 5.03 kg/mg, 4.94 gm.cm/tex and 1% respectively. Referring to the Table 1, it is observed that kenaf HC-2 and kenaf HC-95 are comparable to white jute fibre with respect to these properties, too. But kenaf HC-4 shows very poor performance.

The linear density for white and Tossa jute fibres are 2.4 and 2.5 tex respectively. But the linear density for each of the varieties of kenaf is much higher than that of the jute varieties (Table 1). Thus, kenaf fibre contained relatively greater diameter (less fine) compared with jute.

The average quality ratio values of Tossa jute fibre for 8 lbs/spy and 10 lbs/spy count of yarns are 110.5 and 117.3% respectively (Ali, 1990). This value for white jute fibre at 8 lbs/spy is 108.8% (Ali, 1994). But compared to these values of jute the quality ratio value is mainly due to the bigger diameter contained by the kenaf fibre. Thus kenaf fibre cannot be spun alone for quality yarn manufacturing purposes, but diameter being greater and fibre being cheaper compared to jute, this fibre could have better application in jute industries for producing thicker weft filling yarn and economic yarns for Geo-textiles. In conclusion, a fibre having a good strength can not produce a good quality yarn unless its diameter is small i.e. a small and even diameter is necessary for producing good quality yarn.

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