Technology Section

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Improvement of Low Grade Jute Fibre by Enzymatic Pretreatment with Higher Pin Density in the Finisher Card

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Low grade jute fibres are mainly used for sacking weft batches. In processing technology these fibres draw least attention of the millers. In the present work enzymes were used to improve the softening of hard fibres for further processing. The enzymes were extracted by fermenting indigenous wheat bran as substrate with the fungi, *Aspergillus spp*. The carding effect was improved by introducing higher pin density at the sacking finisher card. By pretreatment with *A terreus* enzyme, 36.37% jute cutting was used in hessian weft batch which reduced the batch cost without impairing yarn quality and production efficiency. Moreover, the use of modified finisher card improved the yarn quality of both, the enzyme treated and untreated batches.

Key words: Jute, Xylanase, Carding.

Introduction

Jute is a natural cellulosic bast fibre. Annual production of jute is around 3 million metric tonnes of which 30-35 % fibres are of low grade. As these low grade fibres are not suitable for mechanical processing, so an additional treatment is required for their improvement in making yarn. The yarn is produced from the raw jute through different stages of mill processing. Carding is an important factor of the processing line. This stage of processing enables the fibres to achieve an average length and the stage is virtually the heart of the entire processing line. It breaks up the hard meshy structure and gives a cleaning action to the fibre. In jute processing there are two types of carding machines, *viz* breaker card and finisher card. The finisher card has the higher pin density than the first card i.e. breaker card. Upto a certain limit, higher the pin density better is the carding. The two carding points are cylinder to worker and cylinder to doffer. So, to enhance the carding effect, the pin density of the three rollers were increased. During softening, enzymes were used to improve the quality of the low grade jute and higher pin densities were introduced in the sacking finisher card for better splitting action into the processing fibre.

Materials and Methods

Production of Enzymes

a. Organisms: Microorganisms were isolated from natural habitats and the purified strains were maintained on PDA and nutrient agar slants. A potential fungal strain, *Aspergillus terreus*, was used in this study for the production of jute softening enzymes.

b. Solid State Fermentation and Extraction of Enzymes. Wheat bran (mesh size 6) with 50% (w/v) added moisture was autoclaved in flat aluminium trays for 15 min at 121°C. The natural pH of the moistened wheat bran was around 6.5. Sterilized wheat bran was inoculated with 1% inoculum which was prepared in yeast-malt extract medium (0.3% yeast extract, 0.3% malt extract, 0.5% peptone and 1% dextrose with pH 5.5) incubated at 35°C for 48 h at 100 rpm.

Enzymes were extracted from fermented bran by adding 5 volumes (w/v) of 1% (w/v) NaCl solution and leaving it for 2 h with occasional stirring. The slurry was filtered through a nylon cloth, centrifuged at 7000 rpm for 10 min. The clear supernatant containing the enzymes was stored with preservative for mill trials.

c. Enzyme Assay. The assay method was based upon the increase of reducing sugars during incubation of substrate with enzyme solution. Reducing sugars were determined spectrophotometrically at 575 nm according to DNS method of Miller (1959). Carboxymethyl cellulase (CMCase), xylanase and polygalacturonase (PGase) activities were measured with Na-CMC (Sigma), Xylan (larch wood, Sigma) and Polygalacturonic acid-Na (Sigma) as substrates. The hydrolysis of these substrates were carried out by incubating with enzyme solution in acetate buffer pH 4.8 at 40°C for 20 min. Enzyme units were expressed as International Units (IU).

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One IU of enzyme is the amount of enzyme which liberates one micro mole of reducing sugars per minute under assay conditions.

Processing of Jute

a. Batch Composition. The batches were made from raw jute of different qualities, such as Bangla White D, tossa cross bottom, white cross bottom, white and tossa rejections (SMR), habijabi, hard cuttings (the barky, hard lower portion of the fibre) and thread wastes. At the M/S Karim Jute Mills Ltd.(KJML) Dhaka, one running hessian weft batch was considered as control whereas another hessian weft batch utilizing 36.37% low grade fibre (cuttings) replacing some higher grade fibres was taken as the experimental batch (Table 1). The batches were matured after treatment with enzymes into oil-in-water (Enzyme Extract:Jute batching oil- 1:5) emulsion and through piling.

b. Carding. Pin density of a sacking finisher card (Fraser; James & sons) in the Experimental Mill of Bangladesh Jute Research Institute (BJRI) was increased by setting new pins on the cylinder, worker rollers and doffers (Table 2). Rolls from breaker card of both control and experimental batches of KJML were then divided into two parts. One part of each of the two batches was packed in polythene bag and transferred to the experimental mill where it was passed through the modified finisher card. The other two parts were processed conventionally in the KJML. Performances of the rolls of the modified finisher card in comparison with those of conventional finisher card are shown in Table 3.

c. Spinning. The rolls of both the finisher cards were passed through the three drawing passages and finally to slip draft spinning frames, the flyer speed of which was 3600 rpm. The ends down rate was recorded. The tests were carried out simultaneously in both the testing laboratories of KJML and BJRI (Technology).

Physico-Mechanical Properties

a. Bundle Strength. Bundle strength expressed as Pressley Index (PI) of fibre was determined by Pressley Fibre Bundle Strength Tester using zero gauge length as per standard method. Pressley Index is computed as,

$$PI = \frac{\text{Breaking load (lb)}}{\text{Bundle weight (mg)}}$$

b. Fibre Fineness. Wira Fibre Fineness Meter (Booth 1969) was used to determine the diameter (width) of the fibre in micron.

c. Tensile Strength of Yarn. The tensile strengths were determined by a Goodbrand Single Yarn Tester using a gauge length of 50 cm. The CV% of the tensile strengths were also calculated.

d. Twist. A Goodbrand Twist Tester was used for measuring the number of twists per metre or twists per inch in the yarn. All the parameters and properties alongwith grist, moisture regain, quality ratio, production efficiency etc. were obtained by following standard methods at standard atmospheric condition.

Table 1

Batch composition

Quality of fibres	Control batch (%)	Experimental batch (%)
Bangla White D	18.18	---
Tossa Cross Bottom	---	27.27
White Cross Bottom	37.19	27.27
Rejections (SMR)	37.19	---
Cuttings	---	36.37
Threads	7.44	9.09

Table 2

Pin density of the rollers of sacking finisher card

Name of rollers		Conventional finisher card (pins sq.inch^{-1})	Modified finisher card (pins sq. inch^{-1})
Cylinder		9.86	12.50
Worker rollers	I	8.90	9.54
	II	9.64	9.84
	III	12.51	12.78
	IV	14.83	15.10
Doffer	I	14.33	14.58
	II	16.75	17.10

Table 3

Performance test results of the finisher card (F/C) rolls

Parameters/ properties	Modified F/C in BJRI	Conventional F/C in KJML
Sliver wt. in ktex	71.53	68.30
in lbs per 100 yds	14.42	13.77
CV% of Bundle strength (PI)	3.16	2.42
Moisture regain (%)	31.83	32.00
Average no. of undesired foreign matters (barks, specks, roots, etc.)	217.00	291.00

Results and Discussion

The activities of enzymes obtained from three different sources and used for improving the low grade jute fibre, are shown in Table 4. The enzyme preparation of *A terreus* contained higher amount of CMCase and xylanase activity compared with those of *A niger* and Flaxzyme. Table 5 shows that *A terreus* enzyme had the highest effective role relating to period of maturity (the time required for softening of the jute fibres) as well as the fibre fineness. The maturity period was reduced to more than 50%. Thus only enzyme extract of *A terreus* was selected for pretreatment of low grade jute fibre for processing purposes.

Table 4

CMCase, xylanase and polygalacturonase activity in different enzyme preparations used for softening of low grade jute

Source of enzyme	CMCase IU ml^{-1}	Xylanase IU ml^{-1}	PGase IUml^{-1}
Aspergillus terreus	0.36	1.10	0.23
Aspergillus niger	0.17	0.48	1.50
Flaxzyme (Novo)	0.20	0.30	1.10

Due to improvement in the low grade jute fibre it was possible to replace higher grade (Bangla White D) and other fibres of a batch (Control) by 36.37% jute cuttings in a running hessian weft batch (Experimental batch).

The overall improvement in low grade jute resulting from the application of enzymes was due to their action in the fibre matrix which they split into finer filaments and loosening the specks on the fibre. This enzyme action reduced the coarseness of individual fibre filaments and helped the removal of the barks, consequently the behaviour of fibre in processing was improved without impairing the production efficiency and quality of yarns.

It is shown in Table 6 that the spinning performance of hessian weft yarn from the experimental batches was slightly better than the yarns from control batches. The tensile strength and the QR% of yarns (C) was slightly lower and that might be due to the presence of some roots specks in yarns. The ends down rate was lowest in the yarns from the experimental batches using both enzyme and modified finisher card.

Table 5

Physico-mechanical properties of the fibre after piling

Treatment	Time required for maturation	pH of water extract	Pressley Index	Fibre fineness(μ)
Control	168 h	6.00	1.79	50.30
Nutrients	86 h	5.90	1.87	50.50
Flaxzyme (Novo)	72 h	5.90	1.91	43.50
Enzyme of *A terreus*	72 h	5.85	2.20	42.50
Enzyme of *A niger*	72 h	5.80	2.17	50.68

Table 6

Spinning performance and physico-mechanical properties of hessian weft batches

Parameters/properties	Control batch		Experimental batch	
	Conventional F/C (A)	Modified F/C (B)	Conventional F/C (C)	Modified F/C (D)
Average grist (tex)	364.48	355.52	364.48	361.73
" " (lbs spy^{-1})	10.58	10.32	10.58	10.50
Average tensile strength (kg)	3.44	3.47	3.36	3.54
" " " (lb)	7.57	7.63	7.39	7.79
CV% of tensile strength	20.81	21.69	16.30	17.00
Quality ratio (%)	71.55	73.93	69.84	74.19
Production efficiency (%)	65.72	71.32	69.14	70.00
Ends down 100 spindle^{-1} hr^{-1}	168.00	156.00	152.00	150.00
Twist metre^{-1} (tpm)	159.45	157.48	157.48	160.63
" " (tpi)	4.05	4.00	4.00	4.08

CV% in both the cases in (B) and (D) were higher than the yarns spun from conventional finisher card. It might be due to the dried and uncontrolled floating of short fibres in the drafting zone of the screw gill first drawing frame.

Different workers (Ghosh and Dutta 1983; Mohiuddin *et al* 1978, 1992a and 1992b) reported that enzymes hydrolyse the pectin and other gummy materials in the jute fibres. As a result fibres become softened and easily processable. In addition to the introduction of higher pin density, spinning performance also improved and better quality yarn was produced. The experiment also proved that enzymatic action and increased pin density in the finisher card had direct impact on softening and cleaning of fibres thereby resulting better quality yarn from low grade jute.

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