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STUDY ON THE TENSILE BEHAVIOR OF JUTE-COTTON BLENDED YARN USING RING AND ROTOR SPINNING SYSTEM

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ABSTRACT

Shahid MA, Mahabubuzzaman AKM, Ahmed F (2011) Study on the tensile behavior of jute-cotton blended yarn using ring and rotor spinning system. *J. Innov. Dev. Strategy* 5(2), 34-40.

The present study investigated the spinning performance by rotating the ratio of modified jute and cotton fibers blending to improve the tensile behavior for new diverse uses of jute fibers using ring and rotor spinning systems. For the successful completion of the research work, jute (variety-0-9897) and American cotton (Pima) fibers were selected. Bottom, middle and top portion of the jute fibers were processed separately with cotton fibers to spin the 18^S yarn count at 20:80 and 50:50 ratio. It was observed that yarn properties produced from the middle portion of jute and cotton fiber blending at 20:80 showed the better results in rotor spinning system and compared to rotor spun yarn, ring spun yarn showed better results at same yarn count in the terms of tensile and unevenness properties.

Key words: *modified jute, cotton, blending, spinning, tensile and unevenness properties*

INTRODUCTION

Jute is one of the world's most important fibrous crops, being exceeded in quantity only by cotton. It has long been known to people and known as golden fiber. But now days, it is facing tough competition with synthetic fibers (Shahid and Siddique, 2007). For the survival of jute, it is necessary to diversify the uses of jute and developed new products by blending jute with cotton and cotton waste. It is now common practice to blend two or more fibers together in order to produce yarns or fabrics with required properties and end uses. Blending of jute with other fibres may be considered as an alternative and possible diversified uses of jute yarns and fabrics (Mazumdar *et al.* 1975). Jute fibre can be blended with cotton, cotton waste and blended fabrics could be used as shirting, suiting, curtains, bed cover, sofa cover, fine quality shopping bag, furnishing fabrics and for other upholstery purposes. Because of its great abundance and shortage of cotton, jute is blended with cotton and jute cotton-blended yarns are manufactured mainly to take advantages of the lower price of jute fiber. Jute is blended with cotton or any other synthetic and natural fiber and the blended yarns are used for production of blended fabrics. For this reason quality jute-cotton blended yarn is required. Jute is a vegetable fiber derived from the barks of an annual plant grown mainly in the sub-tropical area of Asia (Gordon 2005). Important characteristics of jute fiber are its silky, luster, high tensile strength, low extensibility, and considerable heat and fire resistance. The cotton spinning system generally known as short staple spinning system (ring) is abundant in Bangladesh (Chowdhuryb 2002). Presently 357 spinning mills are running in Bangladesh. Recently rotor spinning has been introduced in the short staple cotton fiber processing in textile industry. Generally low grade and waste cotton are used in Rotor spinning machine for producing yarns. No other natural or man-made fibers are being used in this system in the country.

The objective of this experiment was to produce the quality jute-cotton blended yarn that can be used for weaving and knitting fabrics by using rotor spinning system. Blending ratio parameter was subjected to examine the impact on the blended yarn quality. Yarn quality was treated as tensile and evenness properties. Among desirable yarn characteristics, tensile properties are very important for post-spinning operations as well as for determining some final fabric characteristics. The object of this research is also to create an opportunity in the country to use the jute fibers as a raw material along with cotton fibers in short staple spinning industries.

MATERIALS AND METHODS

The variety O-9897 of jute and American pima cotton fibers were selected to carry out this experiment. The following fibers properties were measured:

Fiber Strength: Bundle strength (Pressley index) of fibers was determined by Pressley fiber strength tester (using zero gauge length). The flat bundle of approx. 6.35mm (1/4 inch.) width was held by a pair of clamps. All protruding ends were then sheared off evenly and tension was applied to separate the clamps and to break the fiber thereby. The broken bundle was then weighed in a precision balance. The resulting strength was computed as

$$pressley\ index = \frac{Breakingload(lbs)}{Bundleweight(mg)}$$

Fiber Fineness (Diameter): WIRA fiber fineness meter was used to determine the diameter of the fiber in micron. In this apparatus air was sucked in through a cylindrical bundle of fibers of 7.62 cm long and 3.25 cm diameter. The resistance to airflow was indicated in a flow meter, which was calibrated in terms of fiber

diameter in micron. On switching the machine the position of the float was read, which indicated diameter of the fiber in micron.

Fiber Whiteness and Luster: Photo Volt Meter-577 was used to determine the whiteness of the fiber in percentage.

Breaking Twist: Twist tester Trumeter was used to determine breaking twist.

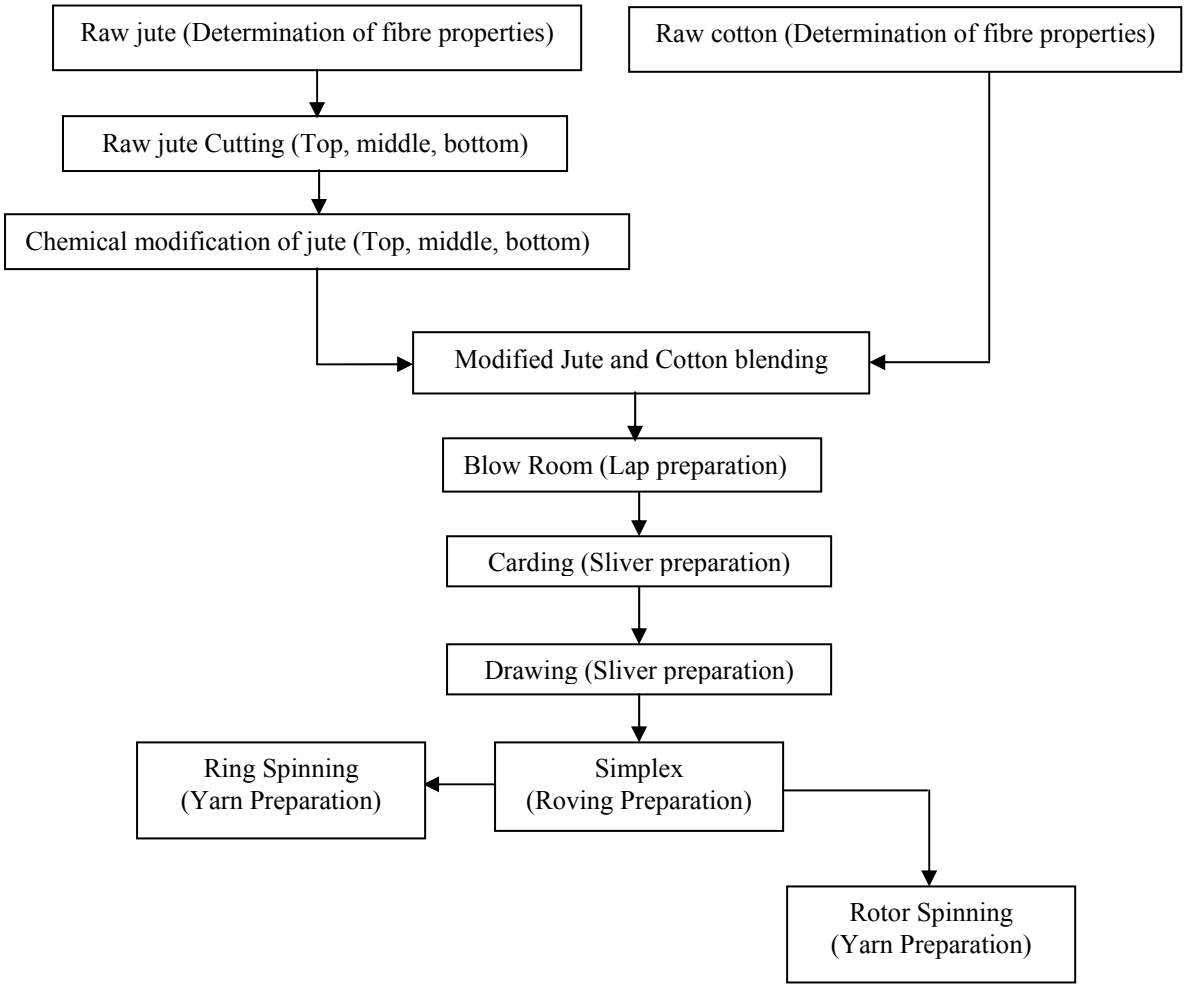
The given flow chart was used for final jute cotton blended yarn production.

(**A) Cutting/ stapling of raw jute:** At first raw jute was cut into three main portions like top, middle and bottom manually and then these three portions were cut into 40 mm staple length by a cutting machine.

(**B) Chemical modification:** Stapled jute fibers were first treated with 20% NaOH solution at room temperature for 20 minutes. The fibers were hydro extracted to recover NaOH solution (Sinha *et al.* 1988). They were then washed several times with water, neutralized with dilute sulhpuric acid and finally rinsed. The fibers were then bleached with Hydrogen peroxide (H_2O_2) (10% o.w.m) at a temperature of 85^0 C for 1 hr. at pH of 10-10.5 (Hongqin *et al.* 2003; Wang *et al.* 2008). These were then washed and dried.

(C) Opening & cleaning: Jute and cotton fibers contain various kinds of dirt, dust, leaf, foreign matters etc. On the other hand, both the fibers remain compact at initial stage. So it is necessary to open the fiber by breaking their net structure. Waste opener machine was used for well opening and cleaning the jute fibers.

Flow chart of jute-cotton blended yarn production process



(D) Blending: For improvement of functional properties, process performance and to reduce the mixing cost and get fancy effect, it is necessary to blend jute cotton (Shahid 1998). After opening and cleaning, jute fibres were blended with cotton manually in the ratio of jute: cotton = 20: 80 and 50:50.

(E) Sliver & Yarn preparation: The blended material was then fed in Blow Room machine for the preparation of lap. This lap was then fed in a carding machine for the preparation of sliver. This sliver was feed into a drawing frame. This drawing frame was having 4 over 4 drafting system. In the drawing frame doubling and drafting operations were applied on the sliver. This sliver was fed in the Rotor spinning machine to produce rotor yarn (Cierpucha *et al.* 2006). The sliver is opened in the opener roller and after opening fibers is allowed to pass through the fiber tube. Fibres are collected in the Rotor and the twist is inserted by the rotation of the Rotor. Finally, yarn is wound into a package. On the other hand, for ring yarn production drawing frame sliver was feed in the roving frame. Then roving was feed in the ring frame. Finally, yarn is wound into a bobbin.

The following yarn parameters were tested:

Yarn Tenacity: Strength is a measure of the steady force required to break yarn for an individual yarn, it is given by breaking load in gm-weight. To compare different yarns specific stress at break is used and is called Tenacity.

Elongation at break: The elongation at break may be expressed by the actual fractional or percentage increase in length and is called breaking extension.

Unevenness of yarn: Uster Tester 3 was used to determine the unevenness and imperfections of the yarn at a speed of 400 m/min. for a period of one minute. The observed parameters were Um%, thin (-50%), thick (+50%) & neps (+200%). Average of ten tests was taken for final result at each trial.

RESULTS AND DISCUSSION

***Determination of Fiber Properties*:** Physical properties such as strength, breaking twist fineness and elongation of top, middle and bottom portions of bachh pat (jute fibers) of four varieties like O-9897, OM-1, CVE-3 and BJC-7370 have been determined. Important physical properties of cotton fibers have also been determined.

Fig. 1. Middle portion of jute fibers cutting

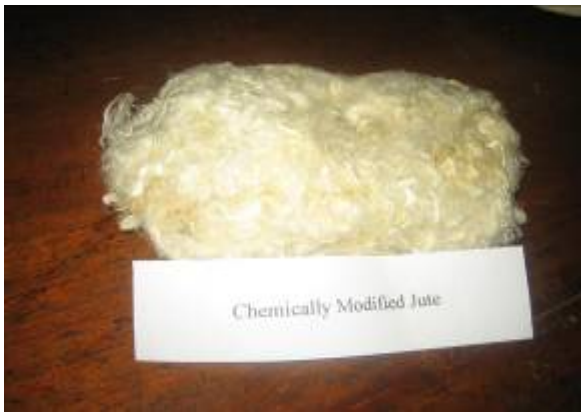


Fig. 2. Chemically modified jute fibers

Fig. 3. Carded sample of modified jute fibers

Fig. 4. Jute-cotton blended rotor yarn

Measured physical properties of jute fibers are furnished below:

Table 1. Fiber strength and fineness of different portions of jute fibers before treatment

Varieties	Fiber strength: pressly index(lb/mg)				Fineness/Diameter (μ)		
	Statistics	Top	Middle	Bottom	Top	Middle	Bottom
O-9897	Avg	10.27	10.91	11.21	22.2	24.3	21.4
	SD	0.46	0.42	1.36			
	CV%	4.5	3.89	12.14			
OM-1	Avg	9.75	11.26	10.72	22.5	23.6	22.7
	SD	0.95	0.93	1.26			
	CV%	9.81	9.12	11.75			
CVE-3	Avg	10.60	10.63	11.50	23.4	24.3	24.4
	SD	0.75	0.97	0.99			
	CV%	7.07	8.22	8.59			
7370	Avg	11.94	11.67	10.50	26.2	24.0	27.7
	SD	0.87	0.92	1.10			
	CV%	7.35	7.95	10.49			

Table 2. Fiber strength and fineness of different portions of jute fibers after treatment

Varieties	Fiber strength: pressly index(lb/mg)				Fineness/Diameter (μ)		
	Statistics	Top	Middle	Bottom	Top	Middle	Bottom
O-9897	Avg	9.50	10.15	11.00	21.5	24.00	21.00
	SD	0.75	0.45	1.36			
	CV%	7.89	4.43	12.36			
OM-1	Avg	8.25	10.75	10.00	20.25	22.00	22.15
	SD	1.00	0.95	1.25			
	CV%	12.12	8.83	12.50			
CVE-3	Avg	9.00	10.25	11.00	21.15	23.00	23.75
	SD	0.65	0.85	1.15			
	CV%	7.22	8.29	10.45			
7370	Avg	10.25	10.85	10.15	24.25	22.50	26.15
	SD	0.87	0.75	1.25			
	CV%	8.45	6.91	12.32			

Table 3. Whiteness (%) and the Breaking Twist of different portions of jute fiber before chemical treatment

Varieties	Whiteness (%)				Breaking Twist/inch		
	Statistics	Top	Middle	Bottom	Top	Middle	Bottom
O-9897	Avg	42.50	42.00	35.25	45.12	50.25	38.16
	CV%	10.50	11.25	12.00	25.25	20.10	15.00
OM-1	Avg	50.35	48.12	25.00	28.25	15.26	27.12
	CV%	07.45	07.50	08.00	18.35	15.27	12.32
CVE-3	Avg	55.70	47.15	52.05	15.12	13.02	26.25
	CV%	09.85	12.35	17.50	11.75	09.75	13.25
BJC-7370	Avg	54.20	55.35	42.15	35.65	33.00	27.25
	CV%	11.25	12.00	09.15	10.52	07.81	09.45

Table 4. Whiteness (%) and the Breaking Twist of different portions of jute fibers after chemical treatment

Varieties	Whiteness (%)				Breaking Twist/inch		
	Statistics	Top	Middle	Bottom	Top	Middle	Bottom
O-9897	Avg	55.00	52.00	47.00	30.00	38.00	35.00
	CV%	15.25	25.45	21.24	25.65	17.45	28.23
OM-1	Avg	52.00	46.00	44.45	25.36	30.16	27.00
	CV%	32.15	19.25	24.00	19.17	15.54	20.25
CVE-3	Avg	45.25	47.12	28.35	35.00	30..00	31.50
	CV%	18.00	25.24	26.25	22.60	18.56	23.75
BJC-7370	Avg	55.50	44.00	42.00	22.00	25.00	23.00
	CV%	22.85	32.00	24.00	26.33	21.25	19.17

Table 5. Physical Properties of Cotton fiber

	Staple Length	Strength (gm/tex)	Linear Density (m tex)	5% Span length (mm)	2.5% Span length (mm)	% of elongation	Fineness (mic.gm/inch)
	25.45	22.00	135	36.00	38.00	8.50	3.50
C.V%	5.50	2.50	3.00	2.00	2.50	3.50	2.50

Yarn production &Test Results of Yarn Samples: Two types of single yarns were produced in ring and rotor spinning system and yarn properties in terms of count, CSP, tenacity, breaking elongation, Um%, thich, thin and neps were measured. The test results are given in Table-6.

Table 6. Physical Properties of O-9897 Jute (bottom)-cotton blended rotor yarns

Blend Ratio Jute : Cotton	Count	Lea CSP	Tenacity (cN/tex)	Breaking Elong. (%)	Unevenness (Um %)	Thick/km (+50%)	Thin/km (-50%)	Neps/km (+200%)
20 : 80	18^S	1500	10.4	5.5	16.00	250	150	400
CV%		15.00	15.00	15.00	12.85	25.60	35.12	28.45
50 : 50	18^S	1250	8.50	3.5	17.00	350.00	350	200
CV%		22.5	17.5	20.00	16.90	25.45	17.25	24.14
100% Cotton	18^S	2000	11.00	7.6	12.00	150	50	250
C.V%	6.5	7.5	8.5	5.5	8.5	10.5	15.5	20.5

Table 7. Physical Properties of O-9897 Jute (middle)-cotton blended rotor yarns

Blend Ratio Jute : Cotton	Count	Lea CSP	Tenacity (cN/tex)	Breaking Elong. (%)	Unevenness (Um %)	Thick/km (+50%)	Thin/km (-50%)	Neps/km (+200%)
20 : 80	18^S	1700	9.40	6.20	14.25	200	70	296
CV%	5.2	12.36	9.10	6.93	12.22	12.58	25.54	23.56
50 : 50	18^S	1500	8.15	4.8	15.85	230	100	382
CV%	7.5	15.87	11.58	15.47	14.45	15.25	22.32	31.19
100% Cotton	18^S	2000	11.00	7.6	12.00	150	50	250
C.V%	6.5	7.5	8.5	5.5	8.5	10.5	15.5	20.5

Table 8. Physical Properties of O-9897Jute (top)-cotton blended rotor yarns

Blend Ratio Jute : Cotton	Count	Lea CSP	Tenacity (cN/tex)	Breaking Elong. (%)	Unevenness (Um %)	Thick/km (+50%)	Thin/km (-50%)	Neps/km (+200%)
20 : 80	18^S	1600	8.00	6.00	15.15	200	100	300
CV%	3.5	12..45	21.25	8.5	12.5	20.25	25.75	35.25
50 : 50	18^S	1300	6.5	4.00	16.75	300	150	412
CV%	20.5	15.75	25.45	9.5	17.5	25.75	35.12	40.45
100% Cotton	18^S	2000	11.00	7.6	12.00	150	50	250
C.V%	1.5	7.5	8.5	5.5	8.5	10.5	15.5	20.5

Table 9. Comparison between ring and rotor spun jute- cotton blended yarn

Spinning system	Blend Ratio Jute : Cotton	Jute-type	Tenacity (cN/tex)	Breaking Elong. (%)	Unevenness (Um %)	Thick/km (+50%)	Thin/km (-50%)	Neps/km (+200%)
Ring	20 :80	Top	9.45	6.45	13.45	245	190	450
		Middle	11.25	7.5	14.00	225	114	410
		Bottom	9.15	6.5	16.00	350	190	500
	50 : 50	Top	8.50	4.5	18.00	390	400	525
		Middle	10.15	5.0	17.25	315	335	495
		Bottom	11..00	4.5	19.00	400	450	250
Rotor	20 : 80	Top	10.40	6.00	15.15	200	100	300
		Middle	9.40	6.20	14.25	200	70	296
		Bottom	8.4	5.5	16.00	250	150	400
	50 : 50	Top	6.5	4.00	16.75	300	150	412
		Middle	8.15	4.8	15.85	230	100	382
		Bottom	8.50	3.5	17.00	350.00	350	200

Jute and cotton fibres are completely different in nature and in their physical properties. So jute fibres were chemically treated to make them soft and improve inter fibers cohesion so as to make them suitable and compatible for blending with opened cotton. From Table-2 it is seen that strength loss of the bottom portion of different varieties from 3.3% to 6.71% for middle portion 3.75% to 7.00% and for top portion 7.69% to 15.38%. From data it is clear that top portion strength loss of the different varieties is higher than other portions. From table-3 it is seen that whiteness (%) and breaking twist of middle portions of all varieties are better than other fibres. From Table-4 it is seen that whiteness (%) of top, middle and bottom portions of all varieties are increased and breaking twist is decreased due to bleaching and alkali treatment.

It was observed from the Table- 6 that tenacity of O-9897 of middle portion 20% jute- 80% cotton blended yarn is less than 100% cotton yarn but higher than 50% jute- 50%cotton blended yarn. Other properties like breaking elongation, Um%, thick & thin per km, neps/km, CSP (Count Strength Product) etc of 20% jute- 80%cotton blended yarn are inferior to 100% rotor spun cotton but better than those of 50% jute-50%cotton blended rotor spun yarn. Treatment with alkali has not only made the fibre suitable for blending but also has improved its physical properties. Due to the improvement of compatibility of blending with cotton the yarn quality has also improved. Rotor spinning technology is suitable for low- grade cotton processing. In this investigation it is observed that fine quality jute-cotton blended yarn is possible to be spun by using rotor technology. From the analysis of the results it is seen that some properties of jute-cotton blended yarn are closer to 100% cotton yarn.

It was observed from the Table-9 that tenacity of O-9897 of middle portion of 20% jute- 80% cotton blended yarn is less than 100% cotton yarn but higher than 50% jute- 50% cotton blended yarn. Other properties like breaking elongation, Um%, thick & thin per km, neps/km, CSP etc of 20% jute- 80% cotton blended yarn are inferior to 100% ring spun cotton but better than those of 50% jute-50% cotton blended rotor spun yarn. Ring spinning technology is suitable for higher grade cotton processing. In this investigation it is observed that fine quality jute-cotton blended yarn is possible to be spun by using ring spinning technology. From the analysis of the results it is seen that some properties of jute–cotton blended yarn are closer to 100% cotton yarn.

From Table 9 it is observed middle portion of jute by blending jute 20% + cotton 80% in rotor spinning yarn is better in all respect.

CONCLUSION

Jute fiber is woody, coarse, rigid, brittle and heterogeneous in nature. In contrast to cotton, silk and synthetic fiber, jute fiber is unyielding to external forces and lacks in “fiber to fiber cohesion. These properties of jute fibre are undesirable and unfavorable for it’s processing through series of mechanical system required for spinning to fine yarns. So fibre selection is very important for jute-cotton blended yarn production. Chemical modification of jute fibre reduces incrustation of lignin and hemi cellulose and modifies the constitutional and dimensional properties of the ultimate fibre cell of jute fibre. The following conclusion may be drawn based on the observation carried out during this study:

1. Jute fibers loss the strength after chemical treatment from 3.3% to 6.71% for bottom portion, 3.75% to 7.00% for middle portion and 7.69% to 15.38% for top portion. It is clear that the loss of strength in top portion of jute fibers in different varieties (0-9897, OM-1, CVE-3 and 7370) is higher than other portions.
2. The whiteness (%) of top, middle and bottom portions of the jute fibers in all varieties are increased and breaking twist is decreased after chemical treatment.
3. It is possible to spin the jute-cotton blended yarn through ring and rotor spinning system. In rotor spinning system jute-cotton blended ratio of 20 : 80 gives the better results in terms of tensile and unevenness properties of yarn.
4. Physical properties of jute-cotton blended yarn at 20 : 80 ratio are closer to 100% cotton yarn.

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