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(Research Article)

Escalating the use of jute (Robi-1)-cotton blended yarn rather than entirely made of cotton yarn

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Abstract

The process of blending involves the mixing of two different fibers to achieve the desired percentage. Various compositions, lengths, diameters, or colors may be intermingling to produce a blended yarn in a ring spinning system. This system entails the combination of different fibers lots into a homogeneous mass before spinning the mass into a staple fiber yarn. Typically, BJRI Tossa Pat-8 (Robi-1) and cotton fibers are combined to create jute-cotton blended yarn. Jute can be utilized in various ways, which is one approach to blending yarn. The jute-cotton blended yarn was produced in a ratio of 30% and 70%. Both jute-cotton blended yarn and totally cotton yarn were produced on a cotton spinning line using a ring frame. The physical characteristics of both yarns, such as count, yarn Lea strength, and CSP were measured. The average count of fully cotton yarn and jute-cotton blended yarn was found to be roughly equal at 12.16 and 11.82, respectively. However, the yarn lea strength and CSP of both samples, which are significantly different from one another, were 232 lb, 140 lb, and 2835, 1670, respectively. Along with entirely made of yarn, blended yarn also exhibits consistency in terms of CV%, SD, and PMD. This study compared the physical characteristics of both yarns after Robi-1 was first introduced for the blending process with cotton to produce a jute-cotton blended yarn.

Keywords: Robi-1; Cotton; Modification; Blending; Ring-Yarn

1. Introduction

Jute soft, golden, and silky-shiny vegetable fiber, is commonly known as the "Golden Fiber" and is cultivated primarily in Bangladesh and India. The South Asian region, particularly Bangladesh and India, is the primary producer of jute, accounting for approximately 95% of global jute production [1-3]. Nepal and Myanmar also produce small quantities of jute. Jute is available in two varieties: Tossa jute (*Corchorus olitorius*) and white jute (*Corchorus capsularis*) It is derived from a plant belonging to the Malvaceae family, specifically the genus Corchorus [4]. The primary constituents of jute fibers are cellulose, hemicellulose, and lignin. Jute is classified as a ligno-cellulosic fiber and is a member of the same class of fibers as kenaf, industrial hemp, flax (linen), ramie, and other bast fibers. It is commonly used as a textile fiber [5, 6]. Bangladesh is recognized as one of the leading producers and exporters of jute, and is also known for its production of various useful jute products. Jute fiber is considered an industrial raw material in Bangladesh and around the world. There are 272 different varieties of jute products that are exported from Bangladesh to 135 countries [7]. Jute has been utilized as a natural fiber for centuries to create items such as rugs, hessian bags, ropes, and other products. In terms of production availability and use, jute is the second-most significant vegetable fiber after cotton [8,9]. Despite its extensive use worldwide, jute's popularity is not as widespread as it has the potential to be. Additionally, jute sticks, which are readily available, are commonly used for the production of charcoal and activated carbon for various purposes. This practice occurs on a large scale, with estimates suggesting that it is carried out between five to seven times [10-12]. There have been optimistic expectations that this groundbreaking achievement

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will contribute to the advancement of the more modern jute variety known as Robi-1. This optimism stems from the successful study of the jute genome conducted by Bangladeshi researchers. The development of the jute Robi-1 is undoubtedly a commendable accomplishment in this regard. The Robi-1 yarn is expected to fulfill the public's expectations in this field, as it holds a prominent position as one of the main drivers of the economy. In the context of jute production, the term "blending" refers to the process of combining different fiber lots to create a uniform mass [13].

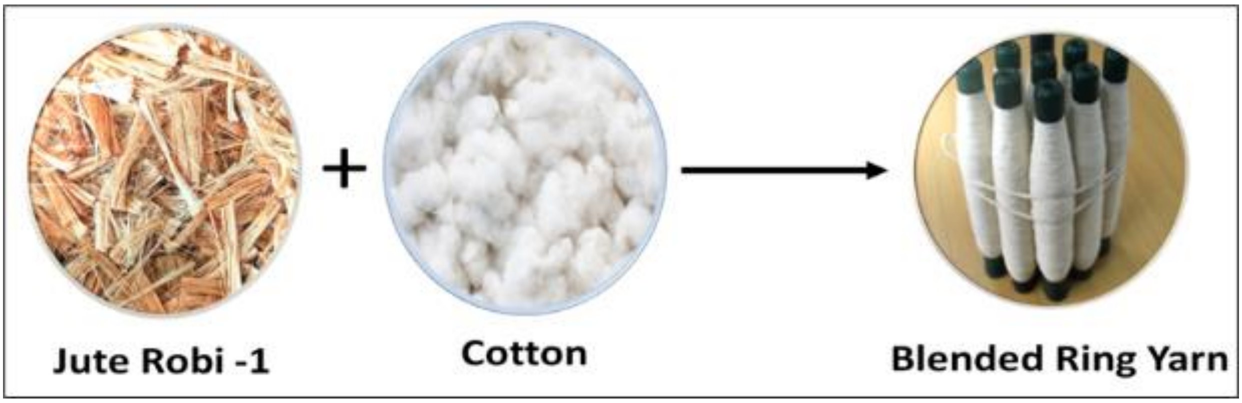

Figure 1 Preparation of jute-cotton blended ring yarn

Usually, blending happens before a staple fiber yarn is spun or before a nonwoven process forms a staple fiber web. It is possible to blend fibers together without creating a homogeneous mixture. As an illustration, a fabric can be created by weaving together two or more different yarn types, each of which is made from a unique kind of fiber or combination of fibers. Utilizing each fiber's unique benefits is the goal of mixing or blending two or more types of fibers into a single product [14, 15]. If only one type of fiber is used, these benefits may be either unachievable, too expensive, or causing undesirable side effects. From a business standpoint, fiber blends and mixtures are created by combining the unique properties of various fibers to enhance product performance, open up new markets, lower production costs, or raise sales prices. Wool, for instance, has a number of qualities for which it is highly regarded. To increase the processing efficiency and the durability of the finished goods, polyester or nylon may be added to wool. Recent years have seen the development of numerous new fibers with high functionality, including high stretch, wicking, water repellency, flame retardancy, and electrical conductivity. The possibilities for product development are endless when these functional fibers are combined with conventional fibers. The woollen industry has a history of using mixtures of fibers from various sources, including virgin wool of various qualities, noils, recycled and reprocessed wools, other animal fibers, cotton, silk noils, and synthetic fibers [16]. The advantages of combining these fibers include the ability to mix colors and effects, reduce costs (and maximize profit), enhance processing efficiency, and produce goods with novel properties. It is common practice to combine fibers of the same type coming from various sources to ensure the quality and consistency of natural fibers. By combining fibers from various sources, a blend can be created whose characteristics can be more precisely duplicated by swapping out some or all of the blend's component fibers. This enables the maintenance and replication of a uniform and consistent product over time and within a predetermined budget. We will concentrate on fiber mixtures and blends in this paper that improve performance rather than just achieving cost savings. Figure 1 demonstrates the scheme for producing a blended ring yarn consisting of jute (Robi-1) and cotton. The aim of this study was to obtain a blended yarn by employing Robi-1 jute fiber and cotton through a ring frame cotton spinning line. The blending technique entailed the incorporation of 30% jute and 70% cotton in the yarn composition.

2. Material and methods

2.1. Materials

Cotton was procured from a local source in Bangladesh, and jute fiber (Robi-1) was obtained from the Bangladesh Jute Research Institute (BJRI). The fiber-cutting machine was used to cut the jute fibers. All of the chemicals, including caustic soda, detergent, sodium silicate, hydrogen peroxide, acetic acid, and softener, are of commercial grade and were bought at the local market. The study was carried out at the Jute Textilein Bangladesh Jute Research Institute, Dhaka, Bangladesh.

2.2. Methods

The jute fibers were cut into small pieces measuring 40 mm using a fiber cutting machine. The chemicals used for the treatment of the jute fibers followed standard procedures and included caustic soda, sodium silicate, hydrogen peroxide, acetic acid, and others. After the chemical treatment, the jute fibers were dried and processed using a fiber opener machine four times. Then, a specific ratio of 30% jute fibers and 70% cotton fibers were blended together in a blow room. The blended fibers were spun on a ring frame to produce jute-cotton blended yarns. The same spinning system was used to manufacture 100% cotton yarn. The strength of the yarn's lea was determined by the Good Brand & Co. Ltd. Machine.

3. Results and discussion

The fundamental characteristics of cotton, jute and other fibers make them complicated to spin simultaneously on a spinning machine. These fibers have significant differences in their properties, such as strength, length, and texture, which create challenges in achieving a uniform and consistent yarn [17, 18]. To overcome these challenges, a combination of mechanical and chemical processing techniques is required. Mechanical processing techniques involve various steps such as cleaning, carding, and combing the fibers to remove impurities and align them in a parallel manner. Chemical processing techniques, on the other hand, involve treatments such as bleaching to improve the quality and appearance of the fibers. In addition to these processing techniques, the adjustment of process parameters is crucial [19-21]. Factors such as temperature, humidity, and tension need to be carefully controlled to ensure the fibers are spun properly. Meticulous selection of raw materials is also important, as the quality and properties of the fibers used directly impact the final yarn. To create jute-cotton blended yarns, a specific blend ratio of 30% jute and 70% cotton was employed. This ratio was determined based on the desired characteristics of the final yarn, such as strength, texture, and appearance. The blending process involves thoroughly mixing the jute and cotton fibers to ensure a homogeneous blend. Once the blending is complete, the blended fibers are spun on a ring frame. This process helps to further align the fibers and create a strong and durable yarn. The comprehensive procedure for blending jute and cotton fibers to create yarn is illustrated in Figure 2. This diagram provides a visual representation of the various steps involved in the blending and spinning process, highlighting the importance of each step in achieving a high-quality jute-cotton blended yarn.

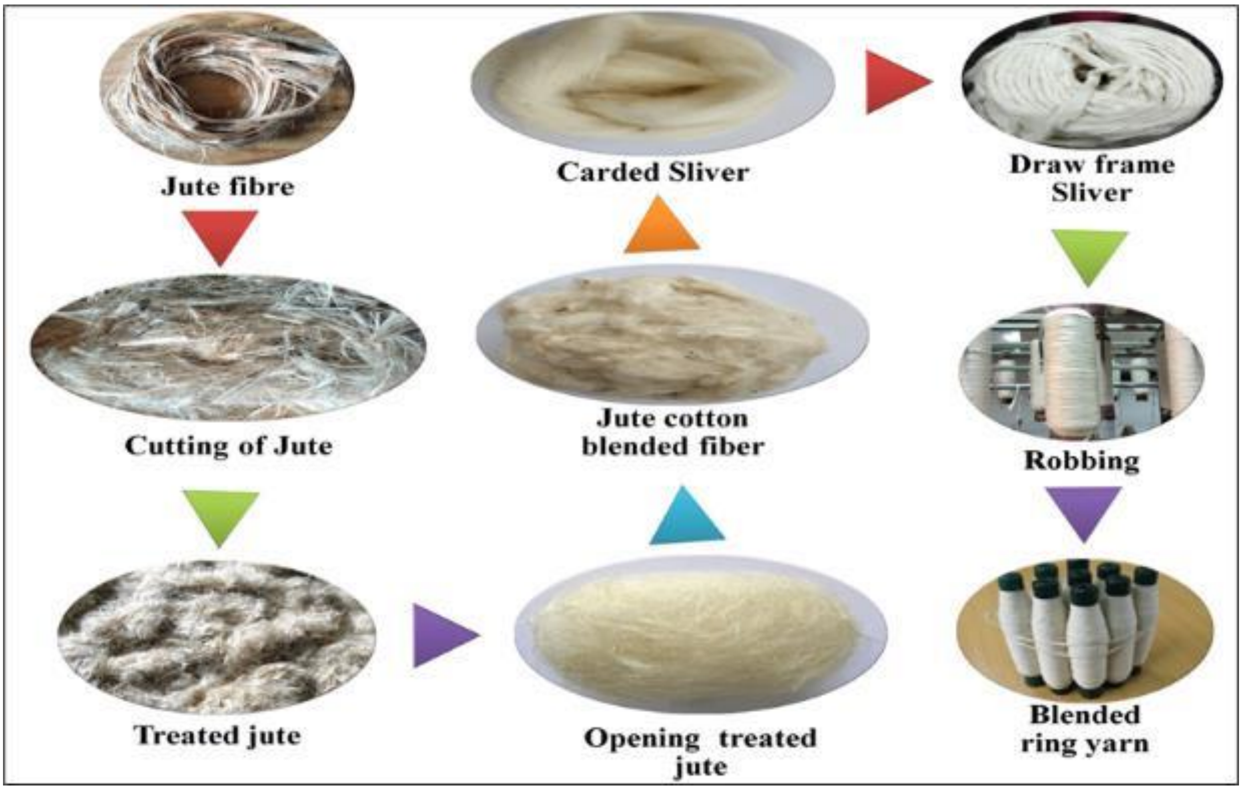

Figure 2 Flow chart diagram of blending process

The chemical and physical properties of the resulting substances from Robi-1 and O-9897 were compared and summarized in Table 1 [22]. The brightness index percentages for Robi-1 and O-9897 were found to be 22.0 and 21.5, respectively. The bundle strength of Robi-1 and O-9897 were measured to be 5.0 Kg/mg and 4.95 Kg/mg, respectively. The Whiteness index percentages for Robi-1 and O-9897 were determined to be 18.26 and 17.35, respectively. The cellulose percentages for Robi-1 and O-9897 were calculated to be 65.80 and 63.24, respectively. In terms of overall quality, Robi-1 exhibited superior characteristics compared to O-9897, not only in terms of brightness and whiteness, but also in terms of oil content. The results presented in Table 1 clearly indicate that the physical parameters of Robi-1 fiber are of higher quality in terms of strength, brightness, and whiteness.

Table 1 Chemical and physical properties of Robi-1 and O-9897

Chemical and physical properties	Jute variety	
	Robi-1	**O-9897**
Cellulose%	65.80	63.24
Hemicellulose%	18.12	18.47
Lignin%	14.67	14.04
Pectin%	0.23	0.21
Fat/Oil%	0.53	0.46
Ash%	0.65	0.79
Brightness index (%)	22.00	21.50
Whiteness index (%)	18.26	17.31
Bundle strength (Kg/mg)	5.00	4.95

The yarn count measurement for both 100% cotton yarn and jute-cotton blended yarn was conducted using the Lea (120yds) strength in an indirect system using the reap-reel and balance method. The results of the tests for Standard Deviation (SD) and Percentage of Mean Deviation (PMD) are shown in Table 2. The average count for jute-cotton blended yarn and 100% cotton yarn is 11.82 and 12.16, respectively, indicating a close similarity between the two. The SD values for jute-cotton blended yarn and 100% cotton yarn count are 0.31 and 0.17, while the PMD values for both yarns are 2.09 and 1.10. It is important to note that the SD and PMD values for jute-cotton blended yarn count are twice as high as those for 100% cotton yarn count. However, it is worth mentioning that these values still fall within the standard range and are relatively close to each other. The Lea strength and Count Strength Product (CSP) of jute-cotton blended ring yarn exhibit SD and PMD values of 6.19, 3.53 and 96.73, 4.59, respectively. Conversely, the Lea strength and CSP of 100% cotton ring yarns display SD and PMD values of 5.70, 1.96 and 98.71, 78.97, respectively.

Table 2 Comparison of Robi-1-cotton blended yarn and 100% cotton yarn

Sample Name	SD	PMD (U%)
Count of Robi-1-Cotton blended ring yarn (11.73)	0.31	2.09
Count of 100% Cotton ring yarn (12.00)	0.17	1.10
Lea strength of Robi-1-Cotton blended ring yarn	6.19	3.53
Lea strength of 100% Cotton ring yarn	5.70	1.96
CSP of Robi-1-Cotton blended ring yarn	96.73	4.59
CSP of 100% Cotton ring yarn	98.71	78.97

Based on empirical research, it has been determined that yarn possessing a CSP (Count Strength Product) value of 1400 or below is estimated to be of inferior quality and lacking in strength. Conversely, yarn exhibiting a CSP value ranging from 1400 to 1800 is considered to be of average strength, while yarn with a CSP value surpassing 2200 is regarded as strong.

In Table 3, a comparative analysis is presented, contrasting 100% cotton yarn and Robi-1-Cotton blended yarn in terms of Lea strength CV (Coefficient of Variation) percentage and CSP. Our experimental findings indicate that 100% cotton yarn possesses an average CSP value of 2835, which surpasses the average CSP value of 1670 observed in Robi-1-Cotton blended ring yarn. The statistical analysis of yarn samples involves the calculation of the coefficient of variation (CV%), which is determined by dividing the standard deviation by the average and multiplying the result by 100. This measure is commonly used to assess the degree of variation within the yarn structure. As presented in Table 3, the CV% values for 100% cotton and Robi-1-Cotton blended yarn are 3.50 and 5.74, respectively. These findings suggest that the Robi-1-Cotton blended ring yarn is comparable to the 100% cotton ring yarn.

Table 3 Lea strength and CSP comparison of 100% cotton yarn and Robi-1-cotton blended yarn

Robi 1-cotton blended ring yarn	S.N	Lea weight (gm)	Lea strength of yarn (lb)	Average Lea strength of yarn (lb)	CV(%) of Lea strength	CSP	Average CSP	CV(%) of CSP
	1	5.54	130	140	4.41	1518.4	1670	5.74
	2	5.59	140			1617		
	3	5.89	142			1718.2		
	4	6.02	145			1676.2		
	5	6.13	145			1769		
Cotton ring yarn	1	5.21	240	232	2.46	2952	2835	3.50
	2	5.10	230			2806		
	3	5.15	235			2890.5		
	4	5.05	225			2722.5		
	5	5.20	230			2806		

Table 4 Twist, Maximum force, Elongation and Tenacity of 100% cotton and Robi-1-Cotton blended yarn

100% cotton ring yarn	S.N	Yarn count(Ne)	CV(%) of yarn count	Yarn twist(TPI)	Maximum force (N)	Elongation (%)	Tenacity (cN/tex)	CV(%)
	1	12.30	2.62	15	7.61	5.74	15.46	9.26
	2	12.20		16	9.39	7.04	19.09	
	3	12.30		15	9.25	7.17	18.81	
	4	12.10		16	8.35	8.56	17.46	
	5	11.90		17	8.89	7.36	16.58	
Robi1-cotton blended ring yarn	1	11.68	1.38	13	5.35	17.70	0.91	15.10
	2	11.55		14	7.21	21.60	1.22	
	3	12.1		15	7.74	18.90	1.31	
	4	11.56		14	7.08	15.60	1.19	
	5	12.2		15	7.24	16.72	1.25	

Figure 3 and Table 4 provide the test results for various parameters of 100% cotton yarn and Robi-1-Cotton blended yarn. These parameters include Twist per Inch (TPI), Maximum Force, Elongation, and Tenacity. The average count (Ne) for 100% cotton yarn is found to be 12.16, while for Robi-1-Cotton blended yarn, it is slightly lower at 11.82. The coefficient of variation (CV%) for the count is 2.62 for 100% cotton yarn and 1.34 for Robi-1-Cotton blended yarn. This indicates that the count of 100% cotton yarn is more variable compared to the blended yarn. Moving on to the strength of the yarn, the average Lea strength for 100% cotton yarn is measured to be 232 pounds, whereas for Robi-1-Cotton blended yarn, it is lower at 140 pounds. This suggests that 100% cotton yarn has higher strength compared to the blended yarn. In terms of twist, the TPI for 100% cotton yarn is recorded as 15.8, while for Robi-1-Cotton blended yarn, it is slightly lower at 14.2. This indicates that the 100% cotton yarn has a higher twist per inch compared to the blended yarn. The elongation value for 100% cotton yarn is recorded as 7.17%, while for Robi-1-Cotton blended yarn, it is vary higher at 18.1.Overall, these test results provide valuable information about the characteristics and performance of 100% cotton yarn and Robi-1-Cotton blended yarn.

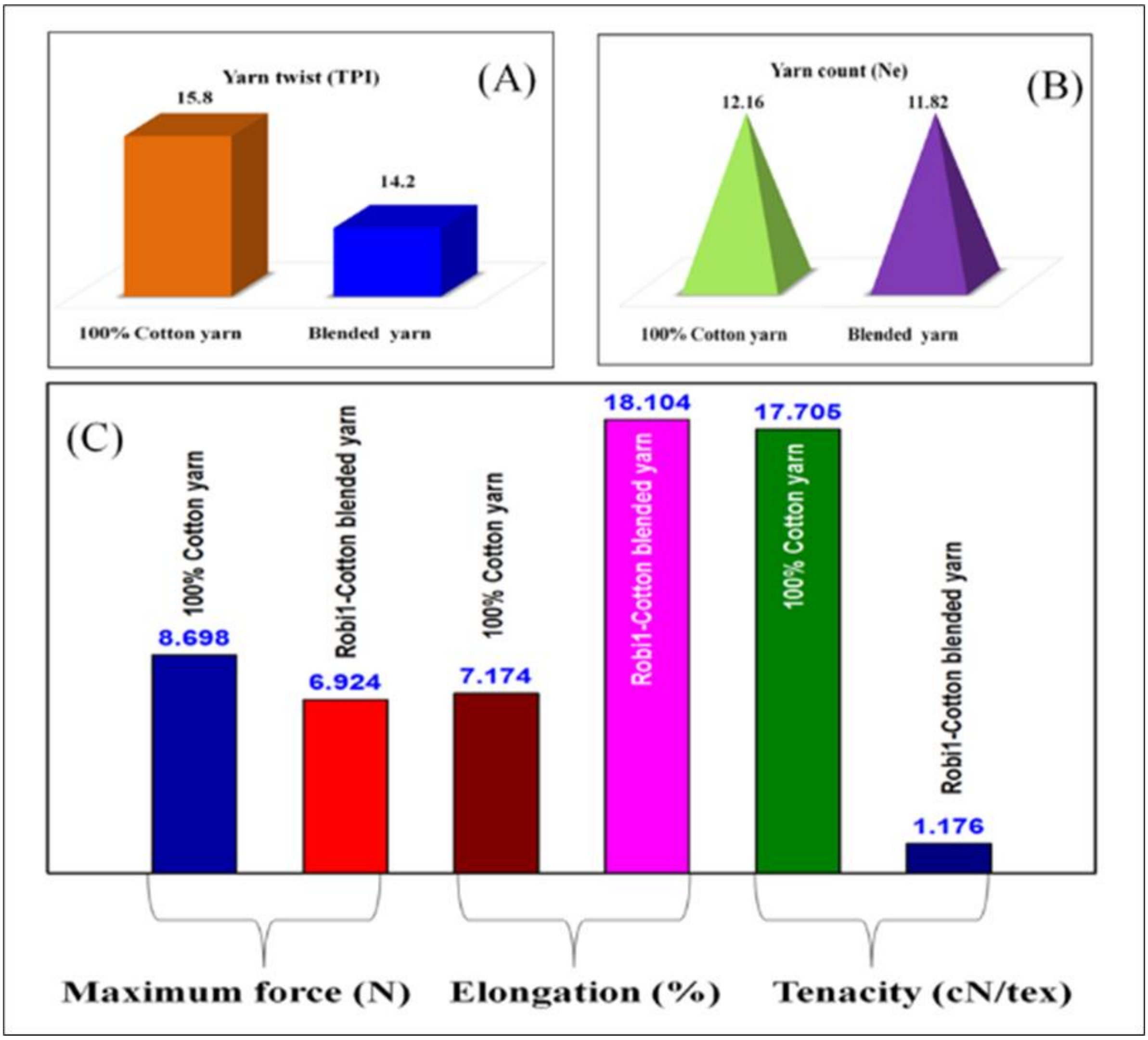

Figure 3 (A) Average TPI of yarn, (B) Average Count of yarn, (C) Average Maximum force (N), Average Elongation (%), Average Tenacity (cN/tex); the difference between 100% cotton yarn and Robi-1- cotton blended yarn

The average tenacity for 100% cotton and Robi-1-Cotton blended yarns are 17.48 (cN/tex) and 1.18 (cN/tex), respectively. These findings suggest that the elongation (%) of Robi-1-Cotton blended yarn is higher than that of 100% cotton yarn, while the tenacity CV% of 100% cotton yarn is higher than that of Robi-1-Cotton blended yarn. Therefore, the newly developed Robi-1-Cotton blended yarn exhibits average regularity.

4. Conclusion

The utilization of a ring frame in a cotton spinning line facilitated the diverse application of jute-blended products. Jute (Robi-1) and cotton fibers were intermingled in a ratio of 30% and 70%, respectively, to produce jute-cotton blended yarn. The physical properties of both Robi-1-cotton blended yarn and entirely made of cotton yarn, including count, Lea, strength, and CSP, were measured and comparatively analyzed. The average count of the two yarns was found to be similar, although slight disparities were observed in their CSP and yarn Lea strength. Both yarns demonstrated consistency in terms of CV%, SD, and PMD. The incorporation of Robi-1, a fiber with a high lignin content, into the spinning process alongside cotton posed challenges, such as sliver slipping in the speed frame and untwisting. Nevertheless, the physical characteristics of the Robi-1-cotton blend yarn were deemed acceptable. It is anticipated that the quality of the blended yarn can be enhanced through the meticulous selection of raw materials and precise dosing of chemical and mechanical processing. Further research is necessary to develop low-cost, fashionable textile products using Robi-1-cotton blended yarn for both domestic and international markets.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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