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Effect of blending eri-jute on yarn properties

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Abstract
Marching to the ever-evolving trends in the fashion industry, the blending of fibers has become imperative to foster innovation. This study focuses on the development of Eri silk-jute blended yarn, aiming to diversify the utilization of Eri silk. The chemical analysis of the fibers yielded moisture content of 12.00%, ash content of 1.50%, lignin content of 13.31%, cellulose content of 65.35%, and hemicellulose content of 21.91%. Infrared spectroscopy and scanning electron microscopy were employed to evaluate the mechanical properties of both retted and treated fibers.
Blending of Eri fiber and jute fiber was conducted in three different proportions: EJ 25:75, EJ 50:50, and EJ 75:25. The resulting yarns underwent comprehensive physical property testing, and performance comparisons were made across various blend ratios. The study's findings demonstrate the successful blending of Eri fiber with jute fiber, resulting in blended yarns that exhibit properties conducive to fabric construction, thereby enhancing overall yarn quality. This research opens doors to innovative possibilities in textile production while aligning with the dynamic landscape of fashion.

Keywords: Eri, jute, chemical composition, blending, blended yarn, physical properties

Introduction
Eri cocoons are characterized by their open mouths, which preclude reeling and necessitate spinning, akin to cotton. Eri silk exhibits exceptional textile properties, as documented by Kulkarni (2007) [9] and Kariyappa *et al.* (2009) [8]. These properties, including fineness, density, cross-sectional shape, and surface characteristics, significantly influence the ultimate utility of the fiber. Eri silk stands out as the softest and warmest among all silk varieties, presenting substantial potential for commercial applications such as crafting top-tier blankets, sweaters, ties, and various knitwear items, as well as serving as a blending component.
The practice of fiber blending has been a longstanding tradition in the textile industry, spurred by the growing availability of numerous synthetic fibers. Blending fibers allows for the production of high-quality goods unattainable with a single fiber type and can also reduce costs by substituting more abundant, less expensive fibers for costly ones, as articulated by Das *et al.* (2009) [6]. The rationale behind developing blended fibers typically stems from economic considerations, whereby precious fibers can be extended through amalgamation with more readily available ones.
Among natural fibers, jute emerges as an especially promising choice due to its cost-effectiveness and wide availability in various forms. Jute fibers possess the requisite characteristics, including inherent bulkiness and robust tensile strength, making them well-suited for blending with other fibers in the creation of yarns for clothing and home textiles. In the present endeavor, we aim to blend ERI silk with jute fiber, with the goal of producing novel yarns endowed with enhanced properties suitable for the fabrication of clothing fabrics and household textiles.

Methodology
Selection of raw materials
Eri cocoons and jute fibre were selected for the study. Table 1 describe the details of fibres selected for the study.

Table 1: Details of fibres selected for the studies

Sl. No	Plant species	Local names	Botanical name	Family
1.	Eri	Eri	*Samia ricini*	Saturniidae
2.	Jute	Morapat	*Corchoru scapsularis*	Tiliaceae

Collection of raw Materials

Ericocoon (*Samia ricini*) were collected from Lakhimpur and Jorhat district of Assam based on their availability. The colour of the cocoon was creamy white.

Jute (*Corchorus capsularis* also known as white jute) were sourced from Regional Agricultural Research Station, Assam Agricultural University, Nagaon, Assam, which is the major jute production district of Assam. Depending upon the retting condition the colour of jute changes.

Eri cocoon Jute fibre

Fig 1: Figure of eri cocoon and Jute Fiber

Table 2: Eri cocoons characteristics

Parameter	Findings
Weight of cocoons (g)	2.1-2.7
Weight of cocoon shell (g)	0.26-0.41
Pupal weight (g)	1.87 -2.39
Shell ratio percentage (%)	12.45-22.3

Silk is consistently available in the form of cocoons, within which sericin gum resides. To enable smooth processing, the initial step involves degumming, followed by subsequent processes. The degumming of eri cocoons was conducted at Fabric Plus Pvt. Ltd. in Chayygaon, Guwahati, Assam, following the method established by the institution.

Both types of fibers were combined during the carding and drawing stages, resulting in the production of yarns featuring three distinct blend ratios, in addition to 100% eri silk and pure jute yarn. The blend proportions of the prepared yarn samples were as follows: 75:25, 50:50, and 25:75 for eri silk and jute, respectively

The nomenclature of the sample was done according to the blend proportions.

Table 3: Nomenclature of the samples

Sl. No.	Sample code	Yarn
1.	E	100% Eri
2.	J	100% Jute
3.	EJ75:25	Eri: Jute in 75:25 ratio
4.	EJ 50:50	Eri: Jute in 50:50 ratio
5.	EJ 25:75	Eri: Jute in 25:75 ratio

Chemical analysis of fibre

The fibres were tested to observe the following parameters:

Determination of moisture content

The fibers underwent testing to assess various parameters, including the determination of moisture content. The moisture content of the fiber was determined in accordance with APPI standards, method T-264 cm. A quantity of 1g of air-dried fiber, measured to the nearest 0.001 g, was placed in a pre-weighed container. It was then subjected to a 2-hour drying process in an oven maintained at 105±3°C, followed by cooling in a desiccator. Subsequently, the container's stopper was temporarily removed to equalize the air pressure, and the weight was recorded. The percentage of moisture in the fiber, rounded to the nearest 0.1%, was calculated using the provided formula.-

$$\% \text{ moisture content} = \frac{\text{Fresh weight - oven dry weight}}{\text{Fresh weight}} \times 100$$

Determination of ash content

The ash content of the fiber was determined in accordance with the TAPPI Standard method T-211 em-86 (1980). Two

representative samples, each weighing 1g and previously oven-dried, were carefully weighed into platinum crucibles. These crucibles were subsequently placed in a drying oven until a constant weight was achieved and then re-weighed. Next, the crucibles were introduced into a muffle furnace, where they were exposed to a temperature of 575±25°C for a duration of 4 hours. Following this ignition process, the crucibles were allowed to cool slightly and were then placed in a desiccator for further analysis.

Determination of cellulose content

Cellulose undergoes a process called acetolysis when treated with an acetic nitric reagent, resulting in the formation of acetylated cellodextrins. These cellodextrins can be dissolved and hydrolyzed into individual molecules when treated with 67% H_2SO_4. Among the products, glucose molecules are produced, and they undergo hydration to give rise to hydroxymethyl furfural. When hydroxymethyl furfural reacts with anthrone, it forms a green-colored product. The intensity of this green coloration is subsequently measured at 630 nm.

Determination of Lignin Content in Fiber

The quantification of lignin content in the fiber followed the TAPPI standard method T.13 m-54 (1980). A 1g sample, which was the residue remaining after conducting an alcohol-benzene solubility test, was taken. This sample was then combined with 15 ml of 72% H_2SO_4 at a controlled temperature of 20±1 °C and placed in a water bath for 2 hours, ensuring the temperature remained constant at 20±1 °C.

Subsequently, the material was transferred into a beaker, and water was added to achieve a total volume of 575ml. The solution was brought to a boil and maintained at that temperature for 4 hours. Afterward, the beaker was left to stand overnight, allowing the insoluble components to settle. The final residue was then subjected to filtration, washed, dried in an oven at 105±3 °C, and weighed to determine the lignin content.

Determination of sericin and fibroin content of Eri fibre

The determination of sericin content in ERI silk fiber was carried out using the Orlandi method, as described by Jolly and Krishnaswami (1985) [7]. In this method, minor constituents such as wax and carbohydrates were disregarded due to their presence in minute quantities.

To begin, eri silk fiber was placed in a desiccator for a period of 4 days until a constant weight (A) was attained. Subsequently, 2 g of the samples were carefully placed into a pre-weighed crucible (B). A volume of 100ml of 5% NaOH solution was added to the crucible, allowing the fibers to dissolve over a 12-hour period. Following this, the fiber samples underwent thorough washing in distilled water and were boiled twice, each time for 0.5 hours, in distilled water. After the final wash, the crucible containing its contents was dried in an oven set at 90 °C for 24 hours.

Once this process was completed, the crucibles were removed and placed in desiccators for an additional 48 hours until a constant weight (C) was achieved. This weight was then used to calculate the sericin content.

The sericin content of fibre was calculated by following formula:

Sericin content: (A+B)-C

Sericin content (%) = (A+B) – C/weight of sample ×100

Fibroin content of fibre was calculated by subtracting sericin content from 100.

Physical properties of fibres

The fibres were tested to observe the following parameters:

Determination of tensile strength (g/tex) and elongation (%)

The tensile strength was determined according to ASTM procedure (1962-1964) [2].

Estimation of Density(gm/cm^2)

Density indicates the mass per unit volumes expressed as grams per cubic centimetre or pounds per cubic feet. Because density is commonly determined on balances or scales, the correct expression for density is mass per unit volume (ASTM, 1970) [2].

Scanning electron microscopy

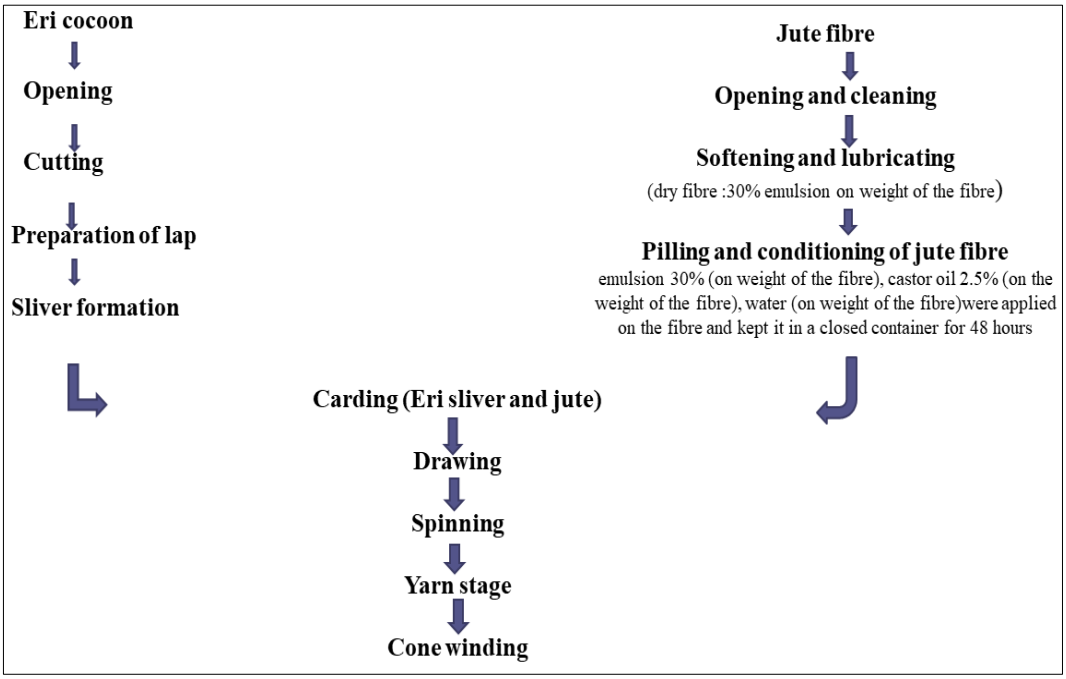
The scanning electron microscopy of eri and jute fibres were observed in JEOL, JSM-35M-35CF electron microscope at 15 kV on accelerating potential with 500 x magnification.

Blending Process

The process began with degumming the eri cocoon, followed by passing the dried material through a double-cylinder opener. Subsequently, the material was opened using spikes and formed into sheets measuring 3x8 feet. These sheets were then divided into three parts with scissors. The cut sheets were further processed through a cutting machine, resulting in small pieces measuring 6 inches in length. The cut material was fed into a hopper feeder to prepare a lap for subsequent processing. This lap was then introduced to a semi-high production carding machine, where silk fibers were transformed into a sliver.

Prior to this, the jute fibers underwent a series of treatments. The first step involved splitting or cleaning the jute fibers. Following that, a dry fiber treatment was applied, consisting of 30% emulsion based on the weight of the fiber. Pilling and conditioning of the jute fiber were carried out using a 30% emulsion, 2.5% castor oil (both based on the weight of the fiber), and an appropriate amount of water. The conditioned jute fibers were placed in a sealed container for 48 hours.

The eri sliver and the conditioned jute fibers were blended together according to the required proportions to create a sliver. This sliver was then processed to reduce its thickness, and four to six slivers were simultaneously combined in the drawing process. The sliver underwent three stages of drawing frames: first drawing (3 times), second drawing (2 times), and third drawing (1 time). Yarns were subsequently produced from the sliver obtained from the third drawing, with a yarn count of 6 pounds per spindle, a twist rate of 6 twists per inch, and a spinning speed of 3000 revolutions per minute.



Evaluation of the physical properties of the yarns

The blended and controlled yarns were tested to observe the following parameters:

Determination of Twist

Twist in yarn is a measurement of the number of spiral turns imparted to the yarn to secure its constituent fibers or threads together. Yarn twist is typically quantified in units such as twists per inch (TPI) or twists per meter (TPM). The assessment of twist in the yarns adhered to the BIS method as per IS: 83

Determination of the count of the yarn (Ne)

Yarn count is a numerical representation that characterizes its fineness. It signifies the quantity of yarns needed to construct a single strand of a three-strand rope with a 3-inch circumference. The count is precisely defined as a numerical value denoting either the mass per unit length or the length per unit mass of the yarn. This count is typically expressed in units known as "Ne."

Determination of Density of yarn (gm/cm³)

The blended yarns were meticulously cut into extremely fine pieces using sharp scissors. Subsequently, individual samples were carefully placed into measuring cylinders, ensuring they reached a 10ml level. Following this, the yarns were removed and weighed on an electronic balance. This procedure was repeated ten times for each yarn, and the density was calculated as grams per cubic centimeter (gm/cm³) by determining the average.

Determination of tenacity (g/tex) and Elongation (%)

Tenacity was determined in accordance with the ASTM procedure (ASTM 2256T, 1964) [2] using an Instron apparatus. The values for tenacity and elongation of the test specimens were directly obtained from a chart.

The tensile strength, or tenacity, of the fibers was assessed using a stelometer. This involved taking a bundle of fibers measuring 25cm in length and measuring the tenacity at a half-gauge length. The breaking load was indicated by a pointer that moved along a large-scale graduated from 0 to 10 kg of load. The calculation of tensile strength for the fiber bundle was carried out following Booth's method (1968).

Tensile strength (g/tex) = ×125

Wicking test

A test specimen, previously conditioned at 25±2ºC and 65±2% relative humidity, was hung vertically. Its lower end was submerged in a reservoir containing distilled water. The height that the water in the yarn reached above the water level in the distilled water reservoir was measured and recorded after a consistent time interval of 2 minutes, following Booth's method from 1967

Results and Discussion

The result of the experiment works carried out along with discussions on the results achieved is included. The findings of the investigation with appropriate illustrations have been presented under the relevant headings as follows:

Table 4: Chemical composition of ERI fibre

Constituent	Eri (%)
Moisture	8.20
Ash	1.20
Sericin	9.20
Fibroin	68.26

From table 4, it was evident that Eri silk fibre has the lowest amount of ash percentage (1.20%) among the different chemical constituent. The moisture content was recorded as (8.20%) and the ash content was found to be (1.23%) whereas sericin content of the fibre was recorded as (9.20%). It was also revealed from the table that Eri fibre had comparatively higher percentage and fibroin content (68.26%)Similar result was found by Saikia (2014) [11] stated that ash, sericinfibroin of Eri silk were (1.01%, 8.35%, 66.51%) respectively. Srivastava and Purwar (2014) [12] also reported that sericin content was found in between (4-5%) and fibroin content was found in between (80-90%).

Table 5: Chemical composition of jute fibre

Constituent	Jute (%)
Moisture	12.00
Ash	1.50
Lignin	13.31
Cellulose	65.35
Hemi-cellulose	21.91

It was apparent from table 5, that Jute fibre contains comparatively high percentage of cellulose (65.55%) content among the different chemical constituents of the fibre, followed by hemicellulose (21.33%), lignin content found to be (13.35%), ash content and moisture content recorded as (1.50% and 12.05%) respectively. The result obtained were more or less similar as reported by Bandyopadhyaya *et al.* (1999) [5].

Scanning Electron Microscopy (SEM) analysis of Eri and Jute fibre

The scanning electron microscopy view was determined in Eri and Jute fibre. Under the scanning electron microscopy view, Eri fibre was observed with tubular structure in zigzag manner with smooth outer lining whereas Jute fibre was observed with tubular structure aligned vertically. From the Fig 3, it was evident that Jute fibre was found with more extraneous substances and rough surface as compared to Eri fibre. This might be due to different treatment during fibre processing and removal of gummy substances.

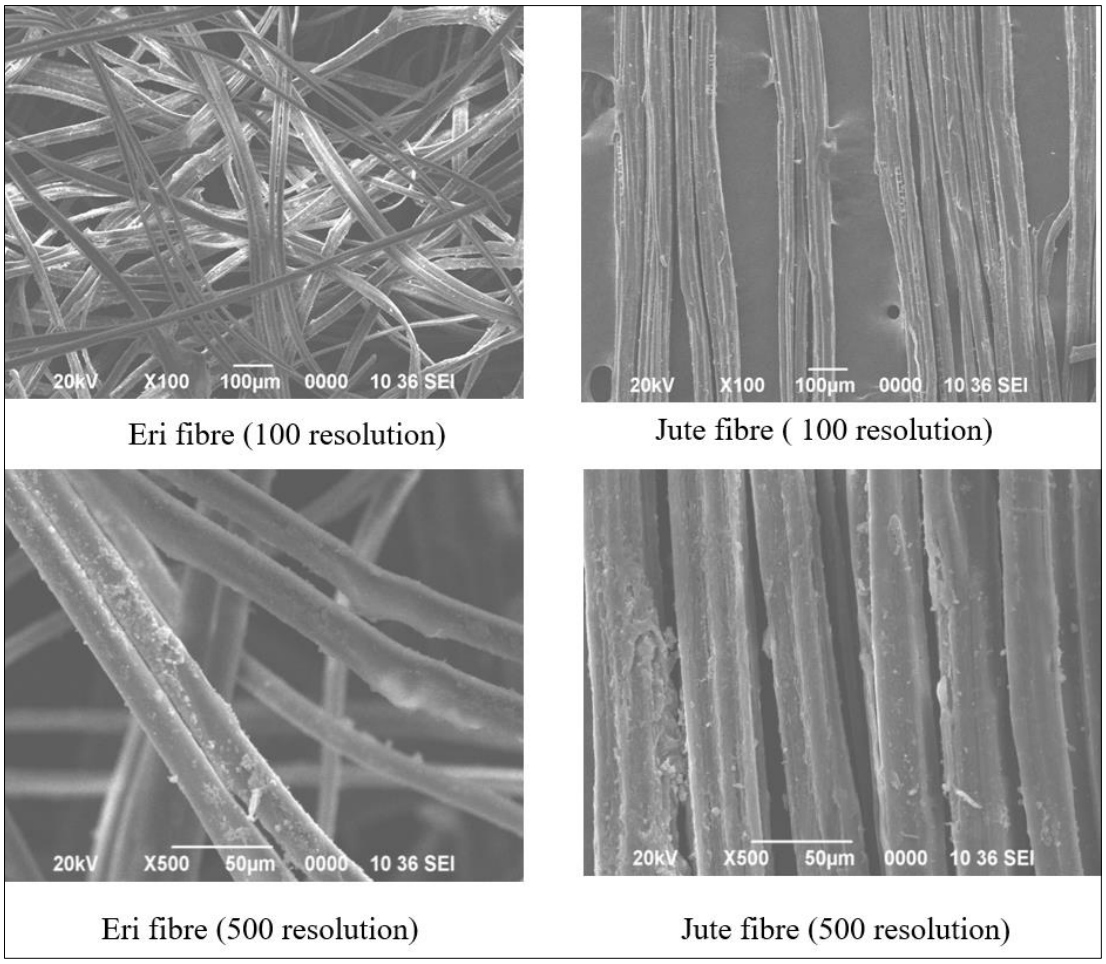


Fig 1: Scanning Electron Microscopy (SEM) of Eri and Jute fibre

Table 6: Physical properties OFERI and jute fibre

Fibre Fibre	Tensile Strength (g/tex)	Elongation (%)	Density (g/cc)
Eri fibre	29.30	22.20	1.25
Jute fibre	35.55	1.85	1.47

The analysed data on physical properties such as tensile strength (g/tex), elongation (%) and density (g/cc) of Eri and Jute fibre were presented in Table 6.

It was observed from the table that the maximum tensile strength of the fibre was recorded in Jute (35.55g/tex) and minimum in Eri (29.30g/tex). The elongation of fibre was recorded maximum in Eri fibre (22.20%) whereas the lowest recorded in Jute fibre (1.80%).Similar result was found by (Rajendran, 1998) [13] who stated that elongation at break of jute fibre was found to be about 1.6%. Sreenivasa *et al*., 2005 [10] also stated that the tenacity of eri silk is (22.5 g/ tex-31.5 g/tex).

In respect of density among the selected fibre, the higher density showed by jute fibre (1.47g/cc) and least was recorded in Eri fibre (1.25g/cc) respectively. The higher density of jute fibre may be due to the diameter of the fibre.

Controlled and Blended yarns

Fig 4a: Controlled Eri yarn

Fig 4b: Controlled Jute yarn

Fig 4c: Blended Eri: Jute yarn25:75

Fig 4d: Blended Eri: Jute yarn50:50

Fig 4d: Blended Eri: Jute yarn75:25

Assessment of physical properties of the controlled and blended yarn

The physical properties of controlled and blended yarn such as twist, count, density, tenacity, and elongation were evaluated according to ASTM and BIS method.

Table 7: Twist, count, density of controlled and blended yarn

Yarns	Twist (tpi)	Direction	Ply	Count	Density(g/cm^2)
Controlled yarn					
Eri	6.93	Z-twist	Single	40s	1.92
Jute	6.29	Z-twist	Single	40s	1.35
Blended yarn					
E:J 75:25	6.79	Z-twist	Single	40s	1.85
E:J 50:50	6.58	Z-twist	Single	40s	1.67
E:J 25:75	6.33	Z-twist	Single	40s	1.46
Variables	S.Ed(±)	CD	CV%		
Twist (tpi)	0.14	0.29	3.38		
Density(g/cm^2)	0.02	0.05	2.59		

It was apparent from table 7, that the twist was imparted into controlled and blended yarns in the Z direction and single ply was maintained for all the yarns during the investigation. Among the controlled yarns highest twist (tpi) was recorded in Eri yarn (6.93 tpi) and lowest was observed in Jute yarn (6.29 tpi). In terms of blended yarn, maximum twist per inch was recorded in blend proportion EJ 75:25 yarn (6.79 tpi) followed by EJ 50:50 yarn (6.58 tpi) and EJ 25:75 yarn (6.33 tpi) respectively.

The density of the yarn found to be maximum in the Eri yarn (1.92 g/cm^3) and minimum in Jute yarn (1.35g/cm^3). Among the blended yarn EJ 75:25 yarn posed highest density (1.85g/cm^3) followed by EJ 50:50 yarn (1.67g/cm^3) and EJ 25:75 yarn (1.46g/cm^3) respectively. In the case of twist and density, the controlled and blended yarns showed a decreasing trend. The higher twist and density were observed in eri yarn might be due to low in diameter, wall thickness and the chemical structure of the fibre.

It was inferred from the table that the effect of twist per inch depends on the density of fibre in yarn. Usually, in a finer yarn, fibre density is higher. The density is changing according to the number of twist in the yarn. Higher the twist finer will be the yarn (Kumar and Mitra, 2005) [10].

Table 8: Tensile strength, elongation and wicking height of controlled and blended yarn (Ne)

Year	Tensile Strength (g/ tex)	Elongation (%)	Wicking height (cm)
Controlled yarn			
Eri	20.81	16.93	4.50
Jute	9.77	1.29	6.30
Blended yarn			
E:J 75:25	12.73	13.91	4.70
E:J 50:50	10.56	3.98	5.40
E:J 25:75	7.13	1.36	6.10
Variables	S.Ed (±)	CD	CV%
Tensile strength (g/tex)	0.34	0.71	4.40
Elongation (%)	0.23	0.49	4.96
Wicking Height (cm)	0.06	0.13	1.85

It was evident from the table 8, that among the controlled yarn, Eri yarn showed highest tensile strength (20.81g/tex) and while lowest tensile strength was observed in Jute yarn (9.77g/tex). In case of blended yarn, maximum tensile strength was seen in EJ 75:25 yarn (12.73 g/tex) followed by EJ 50:50 yarn (10.56 g/tex) and minimum in EJ 25:75 yarn (7.13 g/tex) respectively.

It was observed that the highest elongation was exhibited in Eri yarn (16.93%) and lowest Jute yarn (1.29%). Among the blended yarns, the maximum elongation was recorded in EJ 75:25 yarn (13.89%) followed by EJ 50:50 yarn (3.98%) and minimum in EJ 25:75 yarn (1.36%) respectively. It can be concluded form the above findings that the difference in the tensile strength and elongation might be due to the different process involved in the yarn blending.

The tensile strength and elongation of pure Eriwere found to be maximum may be due to its physicochemical properties and also may be due to its higher twist per inch and density. The highest wicking height was observed in Jute yarn (6.31cm) and minimum in Eri yarn (4.52cm). In case of blended yarn of blended yarn, the maximum wicking height was recorded in EJ 25:75 yarn (6.10cm) followed by EJ 50:50 yarn (5.43cm) and minimum in EJ 75:25 yarn (4.72) respectively. The differences in tenacity, elongation and wicking height of the controlled and blended yarn might be due to the different the different treatment of the fibre varying physical properties as well as processes involved in the blending of yarn.

Conclusion

In conclusion, our research has demonstrated that the blending of eri fiber and jute fiber was a strategic endeavor aimed at harnessing the complementary properties of each fiber type while simultaneously achieving cost savings. Through an extensive array of physical tests, it is evident that all blend proportions yielded favorable results, meeting the requirements for clothing materials. Among these combinations, the Eri:Jute ratio of 75:25 emerged as particularly promising, exhibiting excellence across various aspects. This blend not only lends itself well to effective dyeing with reactive dyes for furnishing materials but also holds potential as a viable enterprise to promote cost-effective eri products.

Furthermore, the practice of blending has unlocked opportunities for a diverse range of products, offering something novel and distinctive to the market. By leveraging the unique qualities of both eri and jute fibers, we have not only enhanced product quality but also broadened the scope

of innovation and market appeal. As we move forward, the prospects for continued exploration and development within this blending paradigm are indeed promising, offering a wealth of possibilities for the textile industry and beyond.

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