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Physical and mechanical properties of Eri-silk/jute blended fabrics

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In the present study, an effort is made to blend Eri-silk fibre with jute in different blended ratios (Eri-silk: Jute ratios of 100/0; 75/25, 50/50, 25/75 and 0/100) to develop a range of blended yarns. These yarns are then used as weft yarn to produce a value-added woven textile of plain weave design, while keeping the cotton yarn in the warp direction. The resulting fabrics are evaluated comprehensively to identify the blend ratio that provides superior physical, mechanical and comfort-related properties. Areal density, thickness, crease recovery angle, stiffness, tensile and tearing strengths, elongation percentage, cover factor, water wicking, air permeability and drapability are assessed in detail. Based on the findings, the Eri-silk: jute (75/25) blend is observed to exhibit the most favourable overall performance across the tested parameters. Different apparel textile products are also developed from blended fabrics, demonstrating their potential for functional and aesthetic applications.

Keywords: Blend ratio, Comfort, Eri-silk, Jute, Eri-silk/jute product, Fibre blending

1 Introduction

Natural fibre serves as an important source of green and environment-friendly engineering material, owing to its biodegradability, renewability and minimal health or ecological hazards. Many natural fibres also possess inherent medicinal benefits, ultraviolet protection, and desirable mechanical and chemical properties, making them suitable for a wide range of textile applications. Plant-based fibres, in particular, do not contribute to environmental pollution during use or decompositions[1]. The most important property of natural fibres is their eco-friendliness, and hence they are also referred to as hygiene fibres[2,3]. Historically, natural fibres have been integral to human civilisation since the earliest use of plant leaves and bark for body covering, followed by the extraction of fibres for handmade textiles. Nature offers an abundant variety of fibres of plant, animal and mineral origin, each with distinct properties.

Blending is one of the suitable processes for combining different fibres to create value-added products that integrate the strengths of individual components while compensating for their limitations. Beyond aesthetic appeal, blending supports cost optimisation, performance enhancement and product customisation, making it an essential practice in modern textile development. Blended yarns and fabrics typically express averaged contributions from each constituent fibre[4].

Among India's diverse silk varieties—eri, muga, mulberry, and tassar—eri silk holds particular significance due to its natural warmth, characteristic greyish hue, and cultural importance in the Northeastern region. Eri culture dominates in Assam, Nagaland, Meghalaya and Manipur, contributing nearly 98% of India's eri silk output. It is also cultivated on a smaller scale in other states of the country, namely Bihar, Odisha, West Bengal, and Andhra Pradesh, with total production of 6.91 thousand metric tonnes in 2019[5]. Eri silk is a soft, strong, heavy and absorbent protein fibre with excellent drape and thermal properties, offering strong potential for premium textile applications. However, its relatively high cost and limited production necessitate blending with other fibres to achieve desirable performance and affordability. In the past, silk fibre has been blended with cotton and pineapple fibres to produce different blended textiles[6,7].

Jute, one of the most abundant natural fibres, offers several inherent advantages, including lustre, high tensile strength, moderate heat resistance and long

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staple length. Traditionally used for packaging and industrial applications, jute has recently gained prominence in decorative textiles, fashion accessories, composites and apparel. Blends of jute with fibres such as yak, banana, coconut, polyester and acrylic have yielded promising results in both apparel and technical textiles[8-13].

Given their regional availability, complementary properties and similar natural hues, eri silk and jute present a compelling combination for blended yarn production. Eri-silk is one of the varieties of silk that possesses both the properties of wool and silk[14]. Blended yarns or fabrics with a component of eri-silk can be used for both summer and winter apparel. While Eri silk has been blended with fibres such as cotton and pineapple in earlier studies, research on Eri silk–jute blends remains limited. This gap motivates the present investigation, which aims to develop and evaluate woven fabrics produced from Eri silk/jute blended yarns for enhanced value addition and apparel suitability.

2 Materials and Methods

2.1 Yarn Preparation

The jute fibre was first cleaned and processed through a softener machine to partially open the fibre reed. An oil-in-water emulsion (38 % on the weight of fibre), composed of 2.5 % castor oil, 35.5 % water, 0.5 % non-ionic softening agent and 0.5 % glycerine, was applied uniformly. The treated fibre was then stored in a closed container for 48 h to enable adequate absorption of the emulsion and to develop the softness required for subsequent processing. Thereafter, the softened jute fibre was carded using a breaker card to open its mesh-like structure, followed by finished carding, three passages of drawing, and apron-draft spinning to produce the desired yarns. The twist level during spinning was maintained at 4 twists per inch. Eri-silk fibre was cleaned and blended with jute during the carding stage to ensure uniform distribution within the yarn. This preparation method facilitated the production of consistent, well-blended yarns suitable for weaving.

2.2 Preparation of Woven Fabric

Different union fabrics were produced using cotton yarn as a warp and the following eri-silk/jute blended yarns in the weft, in the following proportions: 100 % eri-silk, 75/25, 50/50, and 25/75 eri-silk/jute blends, and 100 % jute. From these blended yarns, five different plain-weave fabrics were produced while maintaining constant loom parameters: reed count, 48s; loom pick, 56; cloth width, 52 inches; and shuttle type, fly.

2.3 Physical Properties of Fabrics

The physical characteristics of the woven fabrics were assessed and compared. Fabric counts (ends and picks per inch) were measured using a pick glass following BS 2862:1957. The fabric cover factor, which describes the openness of the structure and can also influence the air permeability of the samples, was evaluated using the standard formula below in Eq. 1.

$$K=\frac{n}{N} \quad \dots (1)$$

where K is fabric cover factor; n, thread/inch; and N, yarn count. Thus, the cover factor of any fabric is separately calculated in the warp and weft directions, and finally, the fabric cover factor was calculated using Eq. 2.

$$Kc = K_1 + K_2 - \frac{K_1 K_2}{28} \quad \dots (2)$$

where Kc is cloth cover factor; K_1, warp cover factor; and K_2, weft cover factor.

The data obtained from the experiments were further analysed through a completely randomised design and subjected to analysis of variance by the F-test.

Areal density was determined by weighing 5 cm × 5 cm samples (g/m^2)[15]. Fabric thickness was determined using a fabric thickness tester, as per the BS 2544-1954 method, bending length as per BS test method 3356-1961, and crease recovery using the IS 4681-1968 method using a Shirley stiffness tester. The multidirectional fabric's bending property, i.e. drapability, was also evaluated by measuring the drape percentage using Eq. 3.

$$\text{Drape percentage (F\%)} = \frac{As - Ad}{(AD - Ad)} \times 100 \dots \quad (3)$$

where AD is the area of the standard template (bigger disk); Ad, area of the supporting disk (smaller disk); and As, actual projected area recorded by the individual eri-silk/jute blended fabric.

Drape coefficient, "F" is the ratio of the projected area of the draped specimen to its undraped area, after deduction of the area of the supporting disk.

Flexural rigidity and bending moduli were also calculated as per the method adopted[15]. Flexural rigidity is a measure of stiffness associated with the handle. It was calculated by using the formula $G=WC^3$ mg/cm (W=cloth weight in g/cm^2). Bending modulus is the intrinsic thickness, which was calculated by using formula $q = 12GX10^{-6}/g^3$.

2.4 Evaluation of Mechanical Properties of Fabrics

The important mechanical properties of the woven fabrics, such as tensile strength (kgf) and elongation (%), were tested using an Instron tensile tester by the "strip test" method, following the ASTM test method D12676-1989. The tearing strength of the fabric was measured according to the IS 6489-1971 method, and the value was calculated using the following expression:

Mean tearing strength (g) = K x (mean scale reading)

where *K* is 16 (no augmenting weight), 32 (with augmenting weight of 3200 g), or 64 (with both augmenting weights).

2.5 Evaluation of Other Properties

Wicking is the tendency of a fabric to spontaneously absorb liquid, which is important to measure in order to understand the comfort properties of the fabric. Likewise, the air permeability of the fabric also plays a crucial role in cloth comfort and was determined according to the ASTM D-737 standard. During the measurement, the air flow was recorded by a rotameter at a specimen area of 38 cm^2 and a pressure differential of 125 Pa.

3 Results and Discussion

3.1 Fabric Physical Properties

The physical parameters of the eri-silk/jute blended fabrics are presented in Table 1. All samples use 15s cotton yarn in the warp, whereas the weft yarn count varies across blends. The highest weft yarn count (13s) is observed in the 100 % jute (EJ 0/100) and the 25/75 Eri-silk/jute blends (EJ 25/75), indicating the formation of comparatively finer yarns.

The cover factor values show clear variation with blend composition. The 100 % Eri-silk fabric (EJ100/0) exhibits the highest weft cover factor (4.07) and overall cloth cover (4.72). This is followed by EJ 75/25 blend, while the lowest values appear in the EJ25/75 blend. Among all the blended yarns/fabrics, the maximum cover factor is consistently associated with pure eri-silk, and the lowest with pure jute. This trend can be attributed to the fineness of the yarn and the beating action during weaving, which enhances packing density in finer yarns. The statistical result displays the highest cover factor and cloth cover in Eri fabric, which might be due to its highest count.

Fabric thickness and areal density also follow a systematic pattern. The highest thickness of 0.71 mm is observed in 100 % jute fabric with an areal density of 250 g/m^2. The thickness value gradually decreases as the proportion of eri-silk increases, reaching a minimum of 0.41 mm in the 100% eri-silk fabric (areal density, 170 g/m^2). Among blended fabrics, the EJ 25/75 blend exhibits the highest thickness (0.66 mm) and weight (230 g/m^2), followed by the EJ 50/50 blend (0.62 mm; 224 g/m^2), and the lowest in the EJ 75/25 blend, with a thickness of 0.55 mm and a weight of 215g/m^2. These differences likely arise due to variations in yarn density and the yarn's structure.

Air permeability can be defined as the rate of air flow through a specific area of fabric under a standard pressure between the two surfaces of the fabric. Factors such as weave, cloth areal density, thickness, cover factor, and finishes applied can have an appreciable effect on air permeability by altering the length of the air flow path through the fabric structure. Yarn twist is also an important factor in that, as twist increases, the circularity and density of yarn increase, thus reducing the yarn diameter and fabric's cover factor, which helps in enhancing the air

Table 1 —Physical parameters, air permeability and wicking height of Eri-silk/jute blended fabrics

Fabric code	Yarn count		Fabric weight, g/m^2	Ends/ inch	Picks/ inch	Thickness, mm	Cover factor			Air permeability, $cm^3/cm^2/s$	Wicking height, cm	
	Warp	Weft					Warp	Weft	Cloth cover		Warp	Weft
EJ 100/0	15	11	170	28	26	0.41	1.87	4.07	4.72	59.4	4.22	4.08
EJ75/25	15	11	215	28	26	0.55	1.87	2.36	4.46	59.7	4.64	4.45
EJ50/50	15	12	224	28	27	0.62	1.87	2.27	4.28	60.5	5.47	5.34
EJ25/75	15	13	230	28	27	0.66	1.87	2.07	4.06	63.3	5.81	5.63
EJ0/100	15	13	250	28	27	0.71	1.87	3.80	3.94	63.9	6.46	6.32

permeability of fabric[1]. Air permeability shows an inverse relationship with cover factor. Pure jute fabric (EJ 100/0) records the highest permeability (63.9 $cm^3/cm^2/s$), while pure eri-silk (EJ 0/100) shows the lowest (59.4 $cm^3/cm^2/s$). All the other blended fabrics fall between these extremes, following the decreasing order: EJ 25/75 (63.3 $cm^3/cm^2/s$), EJ 50/50 (60.5 $cm^3/cm^2/s$), and EJ 75/25 (59.7 $cm^3/cm^2/s$). The results indicate that yarn structure and fibre type strongly influence the ease of airflow through the fabric.

Wicking height displays similar fibre-dependent behaviour. The highest wickability occurs in the 100% jute fabricin both warp (6.46 cm) and weft (6.32 cm) directions, whilethe lowest values occur in the 100% eri-silk fabric (warp: 4.22 cm; weft: 4.08 cm). Among the other blended fabrics, the EJ 25/75 fabric exhibits the maximum wicking height (warp: 5.81 cm; weft: 5.63 cm), followed by the EJ 50/50 fabric (warp: 5.47cm; weft: 5.34cm). The least value was measured in the EJ 75/25 fabric, having a warp of 4.64 cm and a weft of 4.45 cm. Increased wicking in jute-rich blends is attributed to the hydrophilic nature and polygonal cross-sectional geometry of jute fibres, which promote capillary action. Conversely, the lower wicking values of eri-silk fabrics may result from the presence of sericin and other fatty residues that impart hydrophobicity.

3.2 Bending Length, Drape Coefficient and Recovery Angle

The bending length of the samples is measured using the Shirley bending length tester and is presented in Table 2. Pure jute fabric shows the highest stiffness (weft: 4.90 cm; warp: 2.62 cm), while pure eri-silk fabric exhibits the lowest stiffness (weft: 2.50 cm; warp: 2.48 cm). As jute is a much stiffer fibre, compared to silk, it shows the highest bending length of 3.90. With the introduction of silk, a much softer fibre in the blended yarn, the bending length gets reduced from 4.88 cm to 2.50 cm. As the jute content in the yarn increases, so does the yarn's stiffness. The variation in stiffness of the various blended fabrics may be due to fibre type, thickness, and weight of the fabric, as well as to different blend proportions. Flexural rigidity and bending modulus follow patterns consistent with the bending length values. Heavier and thicker fabrics, such as those with higher jute content, naturally show higher rigidity.

Drapability of a fabric is the combined effect of several factors, including stiffness, flexural rigidity, weight, and thickness. Stiffness, an attribute of fabric hand, is one of the most important factors determining the draping quality of fabric. For example, a soft fabric drapes closer to the body, forming ripples, whereas a stiffer fabric drapes away from the body. From Table 2, it can be inferred that a lower drape coefficient percentage for Eri silk fabric depicts good draping behaviour. Hence, eri-silk fabric has more drapability, and the blended fabrics with a larger amount of eri-silk show better drapability compared. The drape coefficient ranges from 45.2 % in the 100 % eri-silk fabric to 70.6 % in the 100 % jute fabric. Fabrics with higher eri-silk content (e.g., EJ 75/25: 50.5 %) exhibit superior draping behaviour owing to the inherent softness and flexibility of eri-silk fibres. Conversely, jute-rich fabrics tend to drape poorly due to their higher stiffness and modulus. Cheng and Govindraj[16] also reported that the drape is closely related to weaving parameters, and the fabric's cover also has a large effect on the drape behaviour of the fabric.

Crease recovery follows a similar directional trend. Pure eri-silk fabric shows the highest crease recovery angles (warp: 110°; weft: 124°), whereas pure jute fabric yields the lowest (warp: 80°; weft: 87°). Blended fabrics exhibit intermediate values, with EJ 75:25 (warp: 107°; weft: 115°) followed by EJ 50:50 (warp: 97°; weft: 103°) and EJ 25:75 (warp: 89°; weft: 95°). It is observed that the blended fabrics exhibit intermediate

Table 2 — Bending behaviour, drape and crease recovery of Eri-silk/jute blended fabrics

Fabric code	Bending length, cm		Flexural rigidity		Bending modulus		Drape co-efficient, %	Crease recovery angle, °	
	Warp	Weft	Warp	Weft	Warp	Weft		Warp	Weft
EJ 100/0	2.48	2.50	259.30	265.62	3800.04	3892.66	45.2	110	124
EJ 75/25	2.52	4.76	352.06	352.06	2380.57	2198.00	50.5	107	115
EJ 50/50	2.56	4.82	436.20	436.20	1786.89	1786.89	57.0	97	103
EJ 25/75	2.58	4.88	394.94	394.99	2337.41	2337.41	64.2	89	95
EJ 0/100	2.62	4.90	465.24	454.78	2143.82	2095.62	70.6	80	87

Table 3 — Mechanical properties of Eri-silk/jute blended fabrics

Fabric code	Tensile strength, kgf		Elongation, %		Tearing strength, N	
	Warp	Weft	Warp	Weft	Warp	Weft
EJ 100/0	82.1	78.2	25.2	23.9	25	30
EJ 75/25	74.4	68.3	24.3	21.7	31	35
EJ 50/50	68.4	64.1	21.2	19.2	36	40
EJ 25/75	61.4	68.3	18.1	16.2	41	55
EJ 0/100	52.4	47.4	15.1	14.2	50	55

values, with the EJ 75/25 blend showing the best crease recovery among the blends. The enhanced recovery in silk-rich fabrics may be due to their lower stiffness and greater flexibility, while jute's rigidity contributes to poorer recovery.

3.3 Mechanical Properties of Fabrics

Mechanical properties of the fabrics are summarised in Table 3. Tensile strength is highest in the 100% eri-silk fabric (warp: 82.1 kgf; weft: 78.2 kgf) and lowest in the 100 % jute fabric (warp: 52.4kgf; weft: 47.4 kgf). Among the blends, EJ 75/25 exhibits the highest tensile strength (warp: 74.4 kgf; weft: 68.3 kgf), followed by EJ 50/50 and EJ 25/75. Fibre strength, yarn fineness, and the number of fibres in the yarn cross-section contribute significantly to these variations.

Elongation follows a similar pattern. Pure eri-silk fabric shows the greatest elongation (warp: 25.2 %; weft: 23.9 %), reflecting the extensibility of silk fibres. Pure jute fabric shows the least elongation (warp: 15.1 %; weft: 14.2 %). Blends exhibit intermediate elongation values, with the EJ 75/25 blend again showing the highest elongation among the blended samples. The factors that influence the tensile strength of the fabric are yarn types, yarn count, the number of fibres in the yarn cross-section, the number of ends and picks per unit length, and fibre strength, which has a significant effect on the variation in tensile strength of woven fabrics[17].

Tearing strength displays a contrasting trend. The highest tearing strength is observed in 100 % jute fabric (warp: 50 N; weft: 55 N), while the lowest is recorded in 100% eri-silk (warp: 25 N; weft: 30 N). Among blends, EJ 25/75 achieves the highest tearing strength (warp: 41 N; weft: 45 N), followed by EJ 50/50 (warp: 36 N; weft: 40 N) and EJ 75/25 (warp: 31 N; weft: 35 N). These results reflect the inherent toughness and resistance to propagation of jute fibres, as well as the influence of yarn structure, frictional forces and density of interlacing points.

4 Conclusion

The present demonstrates that blending Eri-silk with jute in varying proportions results in fabrics with distinct physical, mechanical and comfort-related characteristics. Among the different blend ratios examined, the Eri-silk: jute (75/25) fabric is found to exhibit the most balanced overall performance, particularly in terms of strength, drape, air permeability and comfort parameters. The successful development of a range of apparel products from these blended fabrics further indicates that such material combinations hold significant potential for value-added textile applications. The findings, therefore, establish that Eri-silk and jute blends, especially at the 75/25 ratio, can be effectively utilised to produce functional and aesthetically appealing woven textiles.

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