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Development and Evaluation of Eco-Friendly Blended Fabrics from Silk Waste and Organic Cotton for Enhanced Performance

Dr. Pooja Kanodia[1], Dr. Sunita Dixit[2]

[1]Assistant Teacher, Govt. High School, Department of Secondary Education, Chandauli
[2]Associate Professor, Vasant Kanya Mahavidyalaya, Kamachha, Varanasi, 221010

Abstract

This study investigates the development of sustainable, high-performance fabrics by blending organic cotton with silk waste in various ratios (67/33, 33/67, 50/50, 100% silk, and 100% cotton). The blended yarns were woven into fabrics and evaluated for mechanical, structural, and aesthetic properties. Among the blends, the 67% silk waste and 33% organic cotton combination exhibited superior performance, with enhanced strength, uniformity, and visual appeal. This research demonstrates that integrating silk waste not only enhances fabric properties but also provides an environmentally responsible and consumer-friendly alternative for the textile industry. The study highlights the potential of natural fibre blends to drive sustainable innovation in modern apparel, offering a practical solution for eco-conscious production without compromising performance or affordability.

Keywords: silk waste, organic cotton, blended fibres, sustainable textiles, mechanical properties, eco-friendly fabrics

1. Introduction

Textile history dates back thousands of years, when only a limited number of fibres; linen, wool, silk, and cotton were in use. Since the second century AD, the development of new fibres has greatly expanded the diversity of textiles available today, offering consumers a wide range of options. Within each fibre type, variations are produced to meet specific end-uses, such as nylons for brushes, belts, hosiery, footwear, and tyres.

All fabrics are fundamentally constructed from fibres, which are hair-like, slender units that are spun into yarns and subsequently woven or knitted into fabric. While modern textiles offer an extensive selection of natural and synthetic fibres, no single fabric possesses all desirable properties. Each fibre and fabric has inherent strengths and limitations. The pursuit of an ideal fabric has led to the development of blended fabrics, which combine two or more fibres in a single yarn to optimize performance.

Blending can be performed at different stages of yarn production. Although fibres can be mixed at the opening stage, it often presents processing challenges. More commonly, blending occurs at the sliver stage, using overdrawing or roving frames, with the overdrawing frame being the preferred method in contemporary spinning. In this process, slivers of different fibres are combined according to the desired blend ratio, drawn to form a uniform sliver, and then spun into yarn. Common blended fabrics include polyester–cotton, nylon–wool, nylon–acetate, ramie–polyester, wool–cotton, linen–silk, linen–rayon, silk–wool, and rayon–cotton, among others.

Previous research has demonstrated the advantages of fibre blending. **Haque et al. (2016)** compared 100% cotton yarn with cotton–polyester blends in 50/50 and 20/80 ratios, analyzing yarn count, faults, irregularities, and strength. The study found that polyester's superior fibre qualities enhanced yarn strength, uniformity, and reduced faults, with performance improving as polyester content increased.

Silk, recognized for its fineness and luster, is primarily used in delicate and luxurious applications such as sarees, suitings, curtains, and high-end interiors. **Jeyaraj et al. (2015)** investigated silk–polyester and silk–lyocell blends and reported that blended fabrics exhibited improved water absorbency, wicking, air permeability, colour fastness, and antimicrobial properties compared to 100% silk, expanding silk's practical applications.

Chollakup et al. (2005) studied the effect of silk–cotton blending on the tactile properties of knitted fabrics. Their results indicated that while the proportion of silk influenced fabric characteristics, the blending technique had a greater impact on the tactile feel than the silk content itself. Mechanical properties, yarn count, and processing parameters were found to play a significant role in determining fabric quality.

Overall, fibre blending offers a practical approach to enhance fabric functionality, combining the advantages of multiple fibres to meet both structural and comfort-related performance requirements.

2. Material and Method

2.1 Selection of Fibres

The two types of fibres, organic cotton, a natural cellulosic fibre procured from a certified source, and silk waste, a protein-based fibre were used in this study. These fibres were chosen for their distinct physicochemical characteristics and their complementary performance, making them suitable for developing blended textiles with enhanced mechanical and comfort-related properties.

2.2 Blending of Organic Cotton and Silk Waste Fibres

The fibres were initially blended manually to ensure a preliminary mix. To prevent electrostatic charges, a fibre lubricant was lightly sprayed over the hand-blended fibres, which were then allowed to rest for 24 hours. Following this, the fibres were processed through a blow room machine, ensuring uniform mixing. The output was collected in the form of a lap, representing evenly blended fibres ready for yarn formation.

2.3 Yarn Development

The blended laps were processed into yarns using standard textile operations, including carding, drawing, roving, and spinning. Five different yarn samples were produced with varying fibre proportions: 67:33, 50:50, 33:67, and 100% of each fibre type. Yarn development was carried out at NITRA, Ghaziabad, under controlled laboratory conditions.

2.4 Fabric Formation

The prepared yarns were woven into fabrics on a handloom. The weaving was conducted at the Weavers Service Centre (WSC), Indian Institute of Handloom Technology, Chaukaghat, Varanasi, ensuring consistent fabric structure across all samples.

2.5 Mechanical Analysis of Developed Fabrics

The woven fabrics were subjected to a comprehensive mechanical characterization, including tests for tensile strength, elongation, pilling resistance, abrasion resistance, yarn count, and fabric mass (GSM).

These evaluations provided insights into the performance and structural behavior of the blended fabrics, highlighting the effect of fibre composition on mechanical properties.

2.6 Methods of Characterization of Fabric Properties

All fabrics developed from the different blend ratios were evaluated for their mechanical properties. Prior to testing, the specimens were conditioned to moisture equilibrium by maintaining them under standard atmospheric conditions of 65 ± 5% relative humidity and 27 ± 2°C temperature for at least six hours. The mechanical and structural properties of all five types of blended fabrics were evaluated using standardized methods. Yarn count was determined according to IS: 3442–1980 to assess yarn fineness and uniformity, while fabric mass (GSM) was measured following IS: 1964–01 to evaluate the weight per unit area and overall fabric density. The fabric weave pattern was examined using an in-house method to confirm consistency and uniformity of interlacement. Tensile strength and elongation were assessed as per IS: 1969–1985 to determine the load-bearing capacity and extensibility of the fabrics in both warp and weft directions. Additionally, pilling resistance (IS: 10971–1984) and abrasion resistance (IS: 12573) were tested to evaluate the surface durability and wear performance of the fabrics under frictional stress.

3. Result and Discussion

Table 3.1: Yarn Count of the Blended Fabric (IS: 3442 – 1980)

S.No.	Blending Ratios of the Fibre	Yarn count/ Linear Density	
		Warp	Weft
1	67% (SW) + 33% (O.C)	18 Ne	16 Ne
2	33% (SW) + 67% (OC)	18 Ne	16 Ne
3	50% (SW) + 50% (OC)	18 Ne	18 Ne
4	100% (SW)	15 Ne	16 Ne
5	100% (OC)	18 Ne	18 Ne

OC = Organic Cotton, SW = Silk Waste

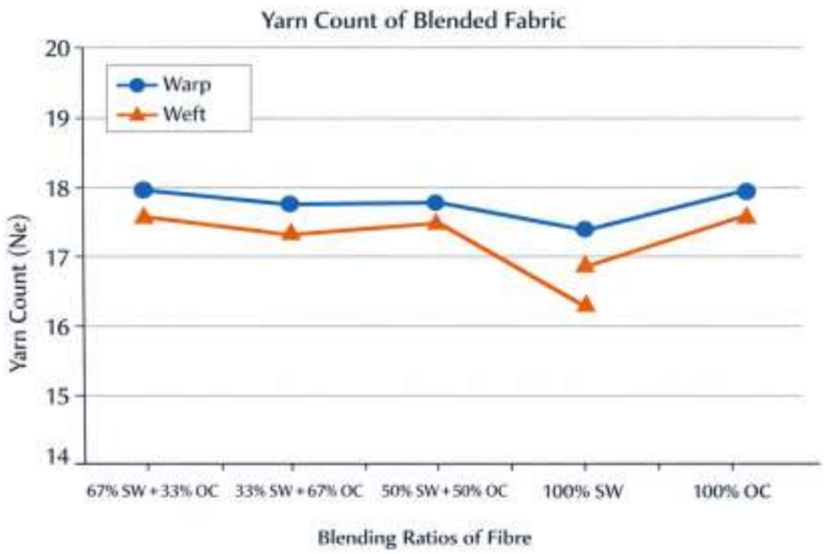
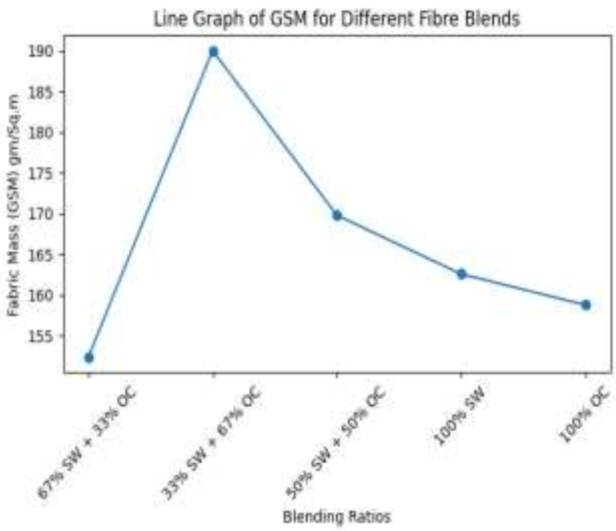


Table 3.1 presents the yarn count of the blended fabrics as per IS: 3442 – 1980. The yarn count for the warp remained largely consistent at 18 Ne across most blends, except for the 100% silk waste (SW)

variant, which exhibited a slightly lower count of 15 Ne, indicating a relatively coarser yarn. In contrast, the weft yarn count varied moderately, with the 50:50 blend and 100% organic cotton (OC) achieving a balanced 18 Ne, while other blends showed slightly lower values (16–18 Ne). The observed differences in yarn count can be attributed to the inherent physical characteristics of the constituent fibres. Silk waste, being finer and smoother, tends to yield yarns with lower linear density when used in higher proportions, whereas organic cotton, with its staple structure, stabilizes the yarn thickness in blended formulations. Overall, the data suggest that blending silk waste with organic cotton allows for controlled adjustment of yarn fineness, achieving an optimal balance between fabric strength and comfort-related properties. The 50:50 blend, in particular, demonstrates uniformity in both warp and weft counts, highlighting its potential for producing structurally balanced and aesthetically consistent fabrics suitable for apparel applications. **Juneja & Pant (2016)** reported that yarn count varied with soybean–wool blends, ranging from 45×46 for 100% soybean to 43×47 for 100% wool. Among the blends, the 50:50 ratio showed the highest yarn count, while 80:20 was the lowest. Similarly, in the present study, yarn count varied with silk waste–organic cotton ratios, with balanced blends tending to optimize warp and weft counts, likely due to improved fibre alignment and uniformity.

Table 3.2: GSM (Fabric Mass) of the Blended Fabric (IS: 1964 – 01)

S.No.	Blending Ratios of the Fibre	Fabric Mass (GSM) in gm/Sq. M
1	67% (SW) + 33% (O.C)	152.4
2	33% (SW) + 67% (O.C)	190
3	50% (SW) + 50% (OC)	169.8
4	100% (SW)	162.6
5	100% (OC)	158.8



The fabric mass (GSM) values indicate noticeable variation among the different blending ratios of silk waste (SW) and organic cotton (OC). The highest GSM was recorded in the 33% SW + 67% OC blend (190 g/m²), showing that a higher proportion of organic cotton contributes to increased fabric weight. Organic cotton fibres, being comparatively denser and bulkier, may have enhanced yarn compactness and fabric thickness, resulting in greater mass per unit area.

The 50% SW + 50% OC blend exhibited a moderate GSM value (169.8 g/m²), suggesting a balanced structural contribution from both fibres. The 100% silk waste fabric showed a GSM of 162.6 g/m², which is slightly higher than 100% organic cotton (158.8 g/m²). This marginal difference may be attributed to variations in fibre fineness, yarn structure, and fabric construction parameters.

The lowest GSM was observed in the 67% SW + 33% OC blend (152.4 g/m²). A higher proportion of silk waste appears to reduce overall fabric mass, possibly due to its comparatively lighter and smoother fibre characteristics, which can produce a less compact fabric structure.

Overall, the results suggest that increasing the proportion of organic cotton tends to increase fabric mass, while higher silk waste content contributes to relatively lighter fabrics. The 50:50 blend offers an intermediate fabric weight, indicating potential suitability where moderate thickness and balanced performance are desired.

Juneja and Pant (2016) reported that fibre blend composition significantly affects fabric weight and structural parameters, as variations in fibre proportion alter yarn compactness and mass per unit area. This supports the present finding that higher organic cotton content (33% SW + 67% OC) produced the highest GSM (190 g/m²). **Saville (2018)** explained that GSM is governed by fibre density, yarn linear density, and fabric construction, with denser fibres contributing to higher fabric mass, which aligns with the higher GSM observed in cotton-rich blends. **Sengupta and Ghosh (2019)** noted that incorporation of silk waste reduces overall fabric mass due to its lighter and less compact nature, supporting the lowest GSM recorded in the 67% SW + 33% OC blend (152.4 g/m²). Similarly, Majumdar, Mukhopadhyay, and Yadav (2010) confirmed that fibre composition influences thickness and weight, with intermediate blends showing moderate structural properties, consistent with the balanced GSM (169.8 g/m²) of the 50:50 blend. Lower fabric mass indicates a finer fabric structure. A similar trend was reported by **Mengüç (2016)** in their study on acrylic/wool/angora blended fabrics. They found that the 70% acrylic–30% angora blend exhibited higher fabric mass, whereas the fabric made from 100% acrylic yarn showed the lowest GSM. In both studies, fabrics made with the control yarn recorded the lowest GSM, while increasing the proportion of the blended component resulted in higher fabric mass.

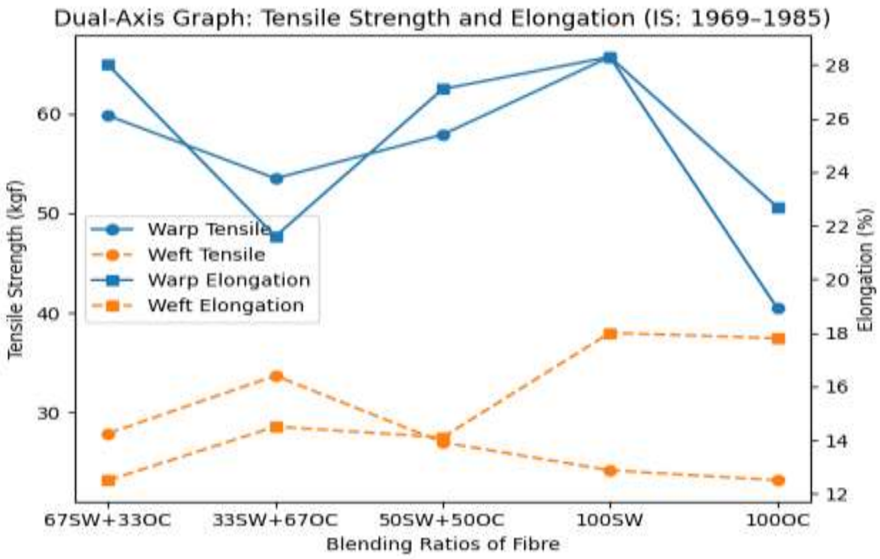
Table 3.3: Weave of the Blended Fabric (In-house method)

S.No.	Blending Ratios of the Fibre	Fabric Weave
1	67% (SW) + 33% (OC)	Plain Weave
2	33% (SW) + 67% (OC)	Plain Weave
3	50% (SW) + 50% (OC)	Plain Weave
4	100% (SW)	Plain Weave
5	100% (OC)	Plain Weave

The results presented in Table 3.3 show that all fabric samples, irrespective of blending ratio, were woven using a plain weave structure. This indicates that fabric construction was kept constant throughout the study to ensure uniformity in structural parameters. By maintaining the same weave for all samples, the influence of fibre composition on fabric properties can be assessed without interference from variations in weave design. Plain weave, being the simplest and most fundamental weave structure, provides maximum interlacement betweenwarp and weft yarns. This structure generally produces a firm, balanced, and comparatively stable fabric. Since all blended and 100% fibre fabrics were woven in plain weave, differences observed in properties such as GSM, tensile strength, or comfort characteristics can be attributed primarily to fibre blend proportion rather than structural variation. The uniform adoption of plain weave also enhances the reliability of comparative analysis. As weave type significantly affects fabric thickness, strength, porosity, and handle, keeping it constant ensures that any variation in performance is due to fibre composition and not due to differences in fabric construction. Thus, the study design effectively isolates the impact of silk waste and organic cotton blending on fabric behaviour. **Adanur (2001)** stated that weave structure significantly influences fabric performance through yarn interlacement. **Gong and Wright (2002)** described plain weave as the simplest and most stable construction, commonly used as a reference in comparative studies. **Hu (2004)** emphasized that fabric mechanical behaviour depends on interlacement geometry, while **Kadolph (2010)** noted that plain weave ensures uniform structural characteristics for reliable comparison. **Saville (2018)** further explained that controlling weave type allows variations in fabric properties to be attributed mainly to fibre composition rather than structural differences.

Table 3.4: Tensile Strength and Elongation of the Blended Fabric (IS: 1969 – 1985)

S. No.	Blending Ratios of Fibre	Tensile Strength(kg f)/ Breaking Force (kg)		Elongation%	
		Warp	**Weft**	**Warp**	**Weft**
1	67% (SW) + 33% (OC)	59.8	27.9	28	12.5
2	33% (SW) + 67% (OC)	53.5	33.7	21.6	14.5
3	50% (SW) + 50% (OC)	57.9	27	27.1	14.1
4	100% (SW)	65.7	24.2	28.3	18
5	100% (OC)	40.5	23.2	22.7	17.8



The tensile strength and elongation results show clear variation with fibre composition and direction of testing (warp and weft).

Tensile Strength

In the warp direction, the highest tensile strength was recorded for 100% silk waste fabric (65.7 kgf), followed by the 67% SW + 33% OC blend (59.8 kgf) and the 50:50 blend (57.9 kgf). The lowest warp strength was observed in 100% organic cotton fabric (40.5 kgf). This indicates that silk waste contributes significantly to strength in the warp direction, and increasing its proportion enhances the load-bearing capacity of the fabric.

In the weft direction, the 33% SW + 67% OC blend showed the highest strength (33.7 kgf), while 100% organic cotton recorded the lowest (23.2 kgf). The difference between warp and weft strength in all samples may be attributed to yarn density, twist level, and structural alignment in the respective directions. Generally, warp yarns are stronger due to higher twist and tighter tension during weaving, which explains the higher warp strength values compared to weft.

Overall, fabrics containing higher silk waste proportions demonstrated improved tensile strength, particularly in the warp direction, suggesting better fibre strength contribution and structural cohesion.

Elongation Percentage

In terms of elongation, 100% silk waste fabric exhibited the highest elongation in both warp (28.3%) and weft (18%) directions. This indicates greater extensibility and flexibility of silk waste fibres. The 67% SW + 33% OC and 50:50 blends also showed comparatively higher warp elongation (28% and 27.1%, respectively), reflecting the influence of silk content.

The lowest warp elongation was observed in the 33% SW + 67% OC blend (21.6%), while weft elongation values were relatively closer among samples, ranging from 12.5% to 18%. Organic cotton fabrics showed moderate elongation, suggesting comparatively lower elasticity than silk waste.

The results indicate that increasing silk waste content enhances both tensile strength and elongation, particularly in the warp direction. Silk waste fibres appear to contribute to higher strength and extensibility, while higher organic cotton content tends to reduce strength but maintains moderate elongation. The balanced 50:50 blend demonstrates intermediate performance, combining reasonable strength with satisfactory elongation.

Since weave structure was kept constant (plain weave), the differences observed in tensile behaviour can be primarily attributed to fibre composition rather than structural variation. **Saikia et al. (2015)** evaluated the tensile strength and elongation properties of bamboo/silk woven fabrics in different blend ratios. The 50:50 bamboo/silk blend exhibited the highest tensile strength in the warp direction, while the 80B:20S ratio showed maximum tensile strength in the weft direction. The lowest tensile strength in both warp and weft directions was observed in 100% bamboo fabric.

Regarding elongation, the 50:50 blend recorded the highest elongation percentage in the warp direction, whereas 80B:20S showed maximum elongation in the weft direction. In both cases, 100% bamboo fabric demonstrated the minimum elongation.

Table 3.5: Pilling Resistance of the Blended Fabric (IS: 10971 – 1984)

S.No.	Blending Ratios of the Fibre	Pilling Resistance
1	67% (SW) + 33% (OC)	4
2	33% (SW) + 67% (O.C)	4
3	50% (SW) + 50% (OC)	4
4	100% (SW)	4.5
5	100% (OC)	3.5

OC = Organic Cotton, SW = Silk Waste

It is evident from the data that the 100% silk waste (SW) fabric exhibited the highest pilling resistance (4.5). This may be attributed to the relatively longer fibre length, smoother surface, and better cohesion of silk fibres, which reduce fibre protrusion and pill formation on the fabric surface. The blended fabrics containing 67% SW + 33% OC, 50% SW + 50% OC, and 33% SW + 67% OC all showed a uniform pilling rating of 4, indicating good performance. This suggests that blending silk waste with organic cotton improves the surface characteristics of the fabric, resulting in moderate resistance to pilling. The presence of silk fibres likely enhances yarn compactness and reduces fibre migration to the surface.
In contrast, the 100% organic cotton (OC) fabric showed the lowest pilling resistance (3.5). This may be due to the shorter staple length and higher hairiness of cotton fibres, which increase the tendency for fibre entanglement and pill formation during abrasion.
Overall, the results indicate that increasing the proportion of silk waste in the blend improves pilling resistance, while higher cotton content tends to reduce it. However, all blended samples demonstrated acceptable performance, making them suitable for practical textile applications where moderate to high resistance to pilling is required.

Table 3: Abrasion Resistance of the Blended Fabric (IS 12673)

S.No.	Blending Ratios of the Yarn	Abrasion Resistance
1	67% (SW) + 33% (OC)	Thread break at 10000 cycles
2	33% (SW) + 67% (OC)	No thread break
3	50% (SW) + 50% (OC)	Thread break at 8000 cycles
4	100% (SW)	No thread break
5	100% (OC)	Thread break at 8000 cycles

OC = Organic Cotton, SW = Silk Waste

From the data, it is evident that the fabrics with 100% silk waste (SW) and 33% SW + 67% organic cotton (OC) exhibited no thread break, indicating excellent abrasion resistance. This suggests that these compositions possess better ability to withstand repeated rubbing without structural failure. In the case of 100% SW fabric, the inherent strength, smooth surface, and better fibre cohesion contribute to enhanced resistance against wear. Similarly, the 33% SW + 67% OC blend may have achieved a balanced structure, where cotton provides bulk and flexibility while silk contributes strength and reduced surface friction.
The fabric with 67% SW + 33% OC showed thread break at 10,000 cycles, which still indicates good abrasion resistance, though slightly lower than the best-performing samples. The higher proportion of silk waste maintains durability, but the reduced cotton content may slightly affect fabric resilience under continuous abrasion.
On the other hand, fabrics with 50% SW + 50% OC and 100% OC exhibited thread break at 8,000 cycles, reflecting comparatively lower abrasion resistance. In the case of 100% cotton fabric, this behavior can be attributed to the shorter staple length, higher hairiness, and lower fibre strength, which make the yarn more prone to rupture under repeated mechanical action. The 50:50 blend, although balanced, may not have sufficient silk content to significantly enhance resistance, resulting in performance similar to that of pure cotton.

Conclusion

The results clearly indicate that the blended fabrics, particularly those with 67:33 SW/OC and 50:50 SW/

OC compositions, exhibited superior overall performance across most of the tested parameters. These blends demonstrated an optimal balance of strength, durability, and surface characteristics, outperforming both pure fibre fabrics and other blend ratios.The enhanced performance of these blends can be attributed to the synergistic effect of silk waste and organic cotton, where silk contributes strength, smoothness, and durability, while cotton imparts comfort, breathability, and flexibility. Furthermore, the use of natural and biodegradable fibres makes these fabrics environmentally sustainable and skin-friendly, supporting the growing demand for eco-conscious and health-oriented textile products. Therefore, such blended fabrics hold significant potential for diversified applications and can be promoted as eco-friendly ("green") textiles with improved functional and consumer-oriented properties.

Reference

1. Adanur, S. (2001). Handbook of weaving. CRC Press.
2. Chollakup, R., Schacher, L., Sinoimeri, A., & Adolphe, D. C. (2005). The Influence of Silk/Cotton Blending in Microspinning on the Tactile Feeling of Knitted Fabrics. Research Journal of Textile and Apparel, 9(3), 71–79. https://doi.org/10.1108/RJTA-09-03-2005-B011
3. Gong, R. H., & Wright, R. M. (2002). Fancy Yarns: Their Manufacture and Application. Woodhead Publishing.
4. Haque, M. M., & Maruf, N. H. (2016). Evaluation of Processing Performance and Properties of 100% Cotton and Cotton/ Polyester Blended ring yarns. Journal of Textile Science and Engineering, 6(2).
5. Hu, J. (Ed.). (2004). Structure and mechanics of woven fabrics. Woodhead Publishing.
6. Jeyaraj, J. M., Arumugam, M., & Kulandaiappan, V. (2015). A study on the functional properties of silk and polyester / lyocell mixed fabric. Matéria (Rio de Janeiro), 20(04), 924–935.
7. Juneja, S., & Pant, R. (2016). Effect of blending soybean fibre with wool fibre on dimensional properties of fabrics. International Journal of Applied Home Science, 3(3–4), 125–130.
8. Kadolph, S. J. (Ed.). (2010). Textiles (11th ed.). Pearson.
9. Majumdar, A., Mukhopadhyay, S., & Yadav, R. (2010). Thermal properties of knitted fabrics made from cotton and regenerated bamboo fibres. International Journal of Thermal Sciences, 49(10), 2042–2048.
10. Saville, B. P. (2018). Physical testing of textiles (2nd ed.). Woodhead Publishing.
11. Saville, B. P. (2018). Physical testing of textiles (2nd ed.). Woodhead Publishing.
12. Sengupta, A., & Ghosh, A. (2019). Blending: An eco-friendly approach to utilize silk waste. Journal of Pharmacognosy and Phytochemistry, 8(4), 596-598.
13. Süpüren Mengüç, G. (2016). A research on yarn and fabric characteristics of acrylic/wool/angora blends. Textile and Apparel, 26(1), 40–47.