

Cashmere, silk and wool blended woven fabrics: an investigation of physical and handle properties

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ABSTRACT – REZUMAT

Cashmere, silk and wool blended woven fabrics: an investigation of physical and handle properties

This study investigates the physical, mechanical, and handle properties of woven fabrics produced using various luxury animal fibres, including 100% cashmere, superfine wool, wool/silk (70/30), and cashmere/silk (70/30) blends. All fabrics were woven under identical construction conditions, with only the weft yarn composition varying. Comprehensive testing, covering breaking strength, tear resistance, seam slippage, dimensional stability, elongation, air permeability, and bending rigidity, was conducted before and after finishing processes. Results showed that 100% cashmere fabrics exhibited the highest breaking strength, while wool/silk blends offered comparable performance with significant cost advantages. Coarser wool yarns (21.5 µm) provided superior tear strength, whereas silk blends enhanced elongation and resilience. Wool/silk fabrics also demonstrated the best seam slippage resistance and the highest air permeability. Cashmere and silk-containing fabrics, though softer and more drapable, showed greater dimensional shrinkage after finishing. Statistical analysis revealed that fabric properties were significantly influenced by weft yarn composition ($p < 0.05$), with finishing treatments affecting elongation, permeability, and rigidity. Notably, wool/silk (70/30) fabrics emerged as the most balanced option, combining mechanical performance, tactile comfort, and economic feasibility. These findings highlight the potential of superfine wool and silk blends as viable alternatives to cashmere in premium textile applications.

Keywords: cashmere, wool, silk, woven fabrics, fabric performance, handle, yarn blend

Țesături din amestec de cașmir, mătase și lână: o analiză a proprietăților fizice și tactile

Prezentul studiu analizează proprietățile fizice, mecanice și tactile ale țesăturilor realizate din diverse fibre animale de lux, inclusiv cașmir 100%, lână superfină, amestecuri de lână/mătase (70/30) și cașmir/mătase (70/30). Toate țesăturile au fost obținute în condiții identice de fabricație, variind doar compoziția firului de bătătură. Au fost efectuate teste cuprinzătoare care au acoperit rezistența la rupere, rezistența la sfâșiere, alunecarea cusăturii, stabilitatea dimensională, alungirea, permeabilitatea la aer și rigiditatea la îndoire, înainte și după procesele de finisare. Rezultatele au arătat că țesăturile din 100% cașmir au prezentat cea mai mare rezistență la rupere, în timp ce amestecurile de lână/mătase au oferit performanțe comparabile cu avantaje semnificative din punct de vedere al costurilor. Firele de lână mai groase (21,5 µm) au oferit o rezistență superioară la rupere, în timp ce amestecurile cu mătase au îmbunătățit alungirea și reziliența. Țesăturile din lână/mătase au demonstrat, de asemenea, cea mai bună rezistență la alunecarea cusăturilor și cea mai mare permeabilitate la aer. Țesăturile care conțin cașmir și mătase, deși mai moi și cu o drapabilitate mai bună, au prezentat o contracție dimensională mai mare după finisare. Analiza statistică a relevat că proprietățile țesăturilor au fost influențate semnificativ de compoziția firelor de bătătură ($p < 0,05$), tratamentele de finisare afectând alungirea, permeabilitatea și rigiditatea. În mod deosebit, țesăturile din lână/mătase (70/30) s-au evidențiat ca fiind opțiunea cea mai echilibrată, combinând performanța mecanică, confortul tactil și fezabilitatea economică. Aceste descoperiri evidențiază potențialul amestecurilor de lână superfină și mătase ca alternative viabile la cașmir în aplicațiile textile de lux.

Cuvinte-cheie: cașmir, lână, mătase, țesături, proprietățile țesăturilor, textură, amestec de fire

INTRODUCTION

The use of luxury animal fibres in textiles, such as cashmere, silk, and wool, plays a crucial role in improving the aesthetic appeal, tactile comfort, and thermal insulation of high-end garments. These fibres, known for their softness, luster, and breathability, are commonly used in premium segments of the fashion industry [1, 2].

Cashmere, obtained from the undercoat of *Capra hircus laniger* goats native to the Himalayan and Central Asian regions, is especially prized for its

exceptional softness, fine diameter (often < 16.5 µm), and limited global availability, estimated at just 16,000 tons annually [3]. However, its extremely high market price (up to €219/kg) poses challenges for large-scale industrial use, prompting researchers and manufacturers to explore more cost-effective alternatives that maintain similar tactile and performance qualities [4].

Silk, derived from the cocoon of the *Bombyx mori* silkworm, offers a combination of high tensile strength, elongation capacity, and a smooth hand feel due to its long filament structure [5, 6]. Its inclusion in

blends often enhances softness and reduces pilling, while maintaining good mechanical strength [7].

Wool, especially superfine wool with diameters around 15.5 μm , is another potential substitute for cashmere. It provides elasticity, warmth, and natural resilience. Moreover, it is more readily available and less costly than cashmere, especially when sourced from well-established sheep breeds [8, 9].

Due to increasing consumer expectations, cost pressures, and sustainability concerns, textile manufacturers are increasingly exploring fibre blends to strike a balance between luxury, performance, and economic feasibility [10]. Blending wool and silk or using superfine wool offers a way to emulate the luxurious hand of cashmere while reducing dependency on rare and expensive fibres.

Previous studies have extensively investigated the influence of animal fibres on yarn and fabric properties, especially in the context of luxury applications. For instance, McGregor and Naebe evaluated the tactile characteristics of knitted fabrics made from superfine wool and cashmere blends, showing that increasing cashmere content improved softness and elasticity but also raised production costs [11]. Similarly, Supüren Mengüç compared the physical performance of various animal/viscose blended yarns and emphasised the contribution of silk and angora to comfort properties such as warmth and hand feel [7]. In another study, Gürkan Ünal et al. (2019) explored the substitution of wool with alpaca and silk in woven fabric weft yarns, concluding that silk inclusion altered dye uptake and air permeability while enhancing tactile properties [12]. Atav, Ergünay, and Gürkan Ünal developed a methodology to accurately distinguish between yak and cashmere fibres using microscopic and spectroscopic analyses, aiming to prevent mislabelling in textile products [13]. Gürkan Ünal, Atav, and Ergünay evaluated the permeability and tactile handle properties of hand-knitted fabrics made from wool, yak, and cashmere fibres, highlighting significant differences across materials with respect to breathability and fabric hand characteristics [14].

However, most of these studies focus either on knitted structures or on yarn-level comparisons without isolating the effects of weft composition in woven fabrics under consistent manufacturing parameters. Moreover, there remains a lack of comprehensive investigation that compares 100% cashmere fabrics with superfine wool and wool/silk blends across a full spectrum of performance parameters, such as tensile strength, pilling, dimensional stability, air permeability, and tactile response, in a woven fabric context.

This study aims to examine the effects of various animal fibre blends, specifically 100% cashmere, cashmere/silk, wool/silk, and superfine wool, on the physical, mechanical, and tactile properties of woven fabrics. By holding production parameters constant (weave type, warp yarn, finishing treatments), the influence of weft fibre composition is isolated and quantitatively evaluated. This study seeks to answer a key industrial question: Can silk or superfine wool

blends replicate the premium qualities of cashmere while significantly reducing cost?

Ultimately, this research contributes to the technical literature on luxury textiles and provides practical guidance for manufacturers aiming to optimise performance-to-cost ratios in high-end fabric collections.

MATERIALS AND METHOD

This study focused on woven fabrics produced with various luxury and semi-luxury animal fibre blends, using 100% wool yarns in the warp and differing yarn compositions in the weft. The weft yarns used include:

- 100% cashmere
- 70% cashmere / 30% silk
- 70% wool / 30% silk
- 100% wool with varying fibre diameters (15.5 μm , 18.5 μm , 21.5 μm)
- 100% wool yarns produced via both conventional and Siro-spinning methods.

All weft yarns were spun to a fineness of Nm 60/2. Fabric construction was kept constant using a plain weave, uniform warp yarns, and consistent production parameters. This uniformity allowed for an isolated evaluation of how different weft yarn compositions influenced the resulting fabric properties. The produced fabrics were summarised in table 1. The fabrics in question were washed at only 60°C and then dried in a stenter machine at 100°C at a speed of 25 m/min.

The experimental workflow involved three major stages: characterisation of fibres, yarn testing, and evaluation of fabric performance using industry-standard methods.

Fibre Length was measured with the Almetre AL-100 according to the IWTO 17-85 E standard, which employs electrostatic variation to detect fibre lengths. Each measurement was conducted three times [15]. Fibre Fineness was determined using the micro-projection method based on ASTM D2130. This approach evaluates the average diameter from cross-sections of fibre bundles under magnification, taking 400 samples per test [16]. Fibre Tenacity was evaluated using the Presley tester. The Presley Index (P.I.) was calculated and converted to cN/tex using standard formulas. Performance was classified according to industry scales for wool fibre strength [5]. After fibre conditioning, yarns were produced using both conventional ring spinning and siro-spinning (for selected samples). Supplier-sourced yarns (for silk and cashmere) were evaluated for quality assurance. Yarn tests included:

Count (Nm) was measured using the skein method in accordance with TS 244 EN ISO 2060. Twist (T/m) was determined via the Mesdan Twist Tester using the untwist-retwist method (TS 247 EN ISO 2061). Tensile strength and elongation tests were conducted on Uster Tensorapid 3 under TS EN ISO 2062 conditions. Yarn evenness and hairiness tests were analysed with Uster Tester 4. Imperfections such as thin places (-50%), thick places (+50%), and neps (+200%) were reported per 1000 m. Hairiness Index

FABRIC WEAVING DETAILS							
Fabric composition	100% Wool	100% Wool	100% Wool	100% Wool	50% Cashmere	35% Cashmere	85% Wool
	15.5 μm	18.5 μm	21.5 μm	21.5 μm siro	50% Wool	50% Wool	
Warp Yarn	Nm 60/2 Double Plied 100% Wool 21.5 μm 750 T/m S Twisted Conventional Production						
Reed No	100/2						
Weft Yarn	Nm 60/2						
	100% Wool	100% Wool	100% Wool	100% Wool	100% Cashmere	70% Cashmere	70% Wool
	15.5 μm	18.5 μm	21.5 μm	21.5 μm	15.5 μm	15.5 μm	15.5 μm
	Conv.	Conv.	Conv.	Siro	Conv.	Conv.	Conv.
Weft Density	20 picks/cm						
End fabric (g/m ²)	142.5	149.5	151.5	152	152	150	164.5
Width of end fabric (cm)	144	141.5	145	144.5	144.5	144.5	143

(S3) was quantified by surface fibre length per unit yarn length.

All fabrics were woven on Dornier looms using a plain weave structure and the same warp setup. Finishing included a 60°C washing followed by drying at 100°C using a stenter at 25 m/min. The conditioned fabrics under standard laboratory conditions were subjected to the following standardised tests: fabric mass per unit area was measured according to TS 251 using circular fabric samples and a precision scale. Tensile strength in the weft direction was applied according to TS EN 13934-1 to determine maximum breaking force and elongation using CRE testers. Tear strength in the weft direction was assessed using ISO 13937-2 with adapted jaws on the same tensile tester. Seam slippage resistance was conducted via the fixed seam opening method to measure displacement under a 200 N force. The Hoffman shrinkage test was applied to estimate dimensional stability under steam and pressure using Hoffman pressing equipment. Elongation and residual elongation tests were measured under load and after relaxation, according to Dupont TTM 075 A procedure. Air Permeability was measured over a 20 cm² area at 100 Pa using the Prowhite Airtest II in compliance with TS 391 EN ISO 9237. Bending Rigidity of the fabrics was calculated using Shirley Stiffness following the BS 3356 cantilever method, a reliable indicator of fabric softness and flexibility.

Data were analysed using the General Linear Model (GLM) to determine the significance of fibre type and finishing effects on dependent variables. Where ANOVA revealed statistical differences ($p < 0.05$), Tukey's post-hoc test was employed to identify group differences. This ensured rigorous evaluation of performance trends among fibre compositions.

RESULTS AND DISCUSSION

This section presents and interprets the physical, mechanical, and comfort-related performance results

of fabrics produced with different weft yarns composed of wool, silk, and cashmere in various proportions. All fabrics were woven under constant construction parameters, which enabled the attribution of performance differences directly to fibre content and yarn structure.

The physical characterisation of fibres used in this study revealed clear distinctions in fineness, length, and short fibre content across wool, cashmere, and silk. These inherent differences critically influence the spinnability and quality attributes of the resulting yarns. Table 2 presents the average measurements for fibre fineness, staple length, and proportion of short fibres (<30 mm) in the raw materials used.

The following key observations were made:

- Silk fibres had the finest and longest structure (11.12 μm , 80 mm), making them ideal for producing smooth, lustrous yarns with low hairiness and high tensile strength.
- Cashmere fibres, although finer than wool, had much shorter lengths (~45 mm) and higher short fibre content (~25%), which negatively impacted yarn evenness and hairiness.
- Superfine wool (15.5 μm) offered a promising compromise: low micron value, moderate-to-high staple length (~70 mm), and low short fibre percentage, making it a viable alternative to cashmere in terms of hand feel and yarn performance.
- Coarser wool fibres (18.5 μm and 21.5 μm) provided better cohesion and strength due to longer average fibre length, with the lowest proportion of short fibres (down to 9.7%).

These findings support the assertion that fibre morphology, particularly fineness and length, is a primary determinant of yarn and fabric performance [1,7]. While cashmere delivers unmatched softness, superfine wool and wool/silk blends offer technically viable and economically attractive alternatives.

When the fibre and yarn analysis results presented in table 3 are evaluated together, it is clearly seen that

Table 2

SUMMARY OF FIBRE PROPERTIES				
Yarn type	Fibre	Fineness (m)	Length (mm)	Short fibre percentage (<30 mm) (%)
100% Wool 15.5 µm	Wool	15.3	70	9.1
100% Wool 18.5 µm	Wool	18.3	66.4	13.3
100% Wool 21.5 µm	Wool	21.4	79.5	9.7
100% Wool 21.5 µm	Wool	21.3	79.5	9.7
100% Cashmere	Cashmere	15.86	45	26.7
70% Cashmere-30% Silk	Cashmere	15.7	46	24.5
	Silk	11.12	80	7.8
70% Wool-30% Silk	Wool	15.5	70	9.1
	Silk	11.12	80	7.8

Table 3

YARN TEST RESULTS											
Fibre	Form	Nm	CV (%)	Twist (T/m)	Evenness (%)	Tenacity (cN/tex)	Elongation (%)	Thin places -50%	Thick places 50%	Neps 200%	Hairiness S3
Wool 15.5 µm Conv.	Package	59.40	1.80	845	14.50	4.10	8.00	658.00	48.50	18.50	731
	Plied	33.00	1.60	681	8.00	9.17	22.00	0.00	2.50	12.50	334
Wool 18.5 µm Conv.	Package	61.44	2.87	734	15.12	7.23	15.95	572.50	99.50	168.50	1002
	Plied	30.54	1.97	754	9.57	9.01	18.42	2.00	4.00	5.00	644
Wool 21.5 µm Conv.	Package	58.99	1.80	704	16.30	6.67	17.80	714.50	134.50	212.00	1706
	Plied	29.00	2.00	719	10.40	9.14	28.10	3.50	2.00	5.00	1143
Wool 21.5 µm Siro	Package	30.05	1.00	661	10.90	9.26	24.91	16.50	2.00	3.00	1180
Cashmere Conv.	Package	61.30	2.67	798	12.40	7.97	11.00	62.50	38.00	24.00	1031
	Plied	30.70	1.10	758	8.10	9.49	23.00	0.00	5.00	3.80	763
Cashmere/Silk Conv.	Package	60.10	1.21	704	10.70	13.58	8.00	5.50	8.50	15.00	852
	Plied	29.30	0.50	753	6.70	14.59	10.00	0.00	0.00	2.50	650
Wool/Silk Conv.	Package	55.45	0.63	545	9.57	14.53	9.00	1.00	2.00	12.50	324
	Plied	26.45	1.10	523	6.60	13.30	13.00	0.00	0.00	0.00	324

fibre properties directly reflect on yarn performance. Silk and superfine wool fibres, which stand out in terms of fibre fineness and length, provide advantages in yarn production with their low irregularity and high elongation values. Especially after the doubling process, yarns produced from wool fibres with a fineness of 15.5 µm stand out with their low hairiness (S3: 334) and high specific strength (9.17 cN/tex), while it was observed that the elongation rate was around (22%). On the other hand, in cashmere yarns with a high short fibre ratio, irregularity values (8.10%) and hairiness (S3: 763) were obtained after doubling. In the measurements made in the bobbin form of the cashmere yarns in question, the irregularity values and hairiness values are quite higher compared to the values of yarns produced from superfine wool fibres. This can be associated

with the fly and interrupted fibre distribution arising from the short structure of the fibre. In addition, when the cashmere/silk blended yarns were examined, a homogeneous structure due to the mixture was obtained; After winding and folding, the unevenness is 10.70% and 6.70 and the hairiness is 852–650, respectively. Here, it shows that the long and fine structure of the silk balances the short fibre structure of the cashmere. In wool/silk blended yarns, comfortable and smooth-surfaced yarns were obtained with low twist, low hairiness (S3: 324) and good elongation (13.0%). On the other hand, in yarns produced with 21.5 µm thick wool fibres, the hairiness and unevenness values increase significantly (S3: 1706), and this increase becomes more pronounced, especially in the siro spinning method. Folding with the conventional method offers an advantage in terms of

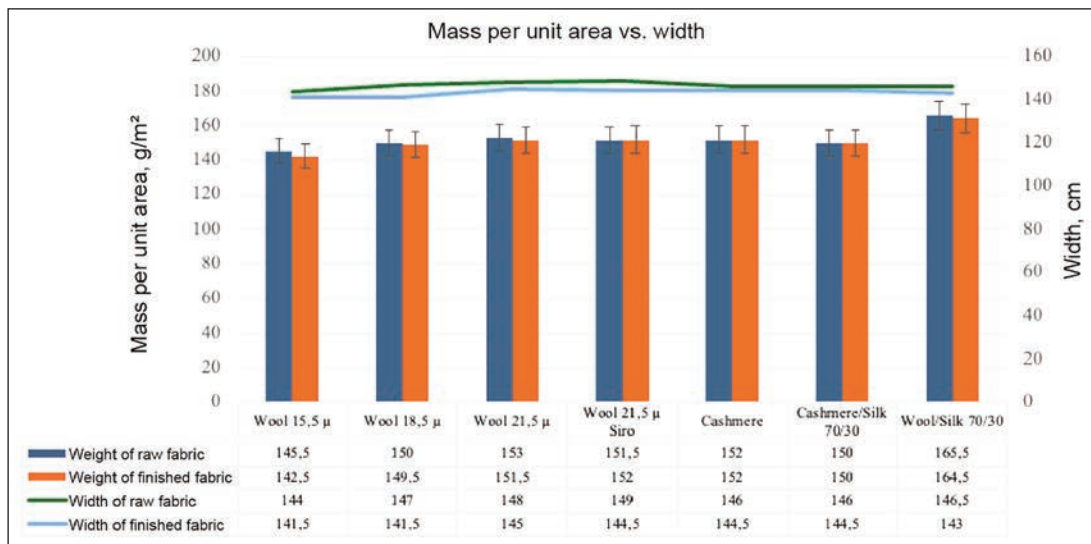


Fig. 1. Results of mass per unit area and width of the fabrics produced with different weft yarns

hairiness compared to the siro method. As a result, yarn quality increases as the fibre length and fineness increase; especially superfine wool and silk blends offer strong alternatives that can replace cashmere in terms of both production performance and fabric comfort.

The results of mass per unit area and width of the fabrics woven with different weft yarns before and after finishing processes are presented in figure 1. All grey fabrics (before finishing) exhibited similar weights, ranging from approximately 145.5 g/m² (15.5 μm wool) to 165.5 g/m² (wool/silk 70/30 blend). After finishing, fabric weights slightly decreased due to mechanical relaxation and moisture loss during washing and drying, consistent with expectations in textile finishing [17]. The wool/silk 70/30 blend showed the highest final mass (164.5 g/m²), which may be attributed to the silk's high density and the coarser yarn count used in that blend.

Based on the results of the statistical analysis, fabric mass per unit area is significantly affected only by the type of weft yarn used ($p < 0.05$). The observed difference is primarily attributed to the fabric woven with wool/silk (70/30) blended weft yarn, which exhibited the highest fabric weight among all groups. This finding indicates that fibre type plays a decisive role in determining the final mass per unit area of the fabric.

Fabrics produced from wool/silk blends resulted in significantly higher mass values, whereas those made from pure wool and cashmere showed comparatively lower weights.

The differences between the grey (unfinished) and finished fabric weights can be explained by moisture loss and dimensional shrinkage occurring during the stenter drying process. However, this post-finishing variation was found to be less influential than the type of fibre used in the weft composition.

As shown in figure 2 in the left-hand chart, breaking strength values in the weft direction varied significantly across fibre types. The highest breaking strength was observed in fabrics woven with 100% cashmere (52.25 kgf in finished form), followed closely by the wool/silk 70/30 blend (54.4 kgf). This indicates that both cashmere and silk-rich blends contribute positively to tensile performance, likely due to their elastic and cohesive fibre structures.

Conversely, fabrics produced from finer and coarser pure wool yarns (15.5 μm and 18.5 μm) exhibited significantly lower breaking strengths (around 25–28 kgf), suggesting that wool alone, regardless of fibre fineness, does not achieve the same level of tensile performance. The increase in strength after finishing observed in all samples can be attributed to fibre

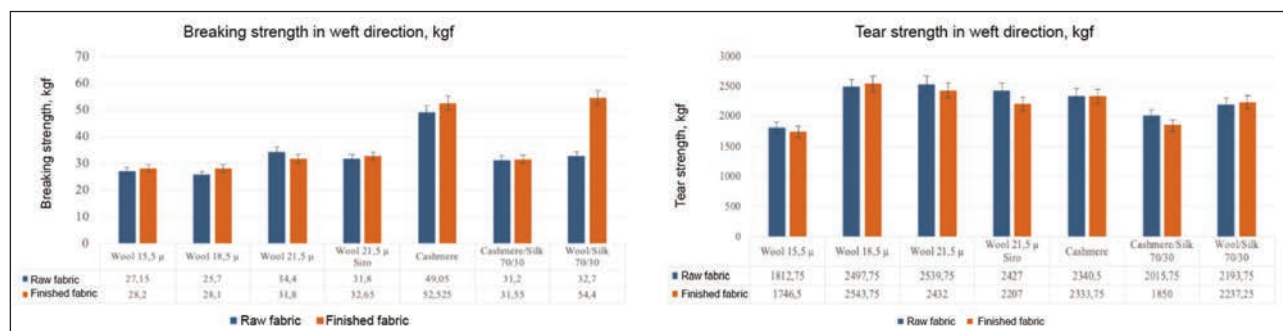


Fig. 2. Results of breaking strength and tear strength in the weft directions of the fabrics produced with different weft yarns

consolidation and residual shrinkage that increases fabric compactness.

As a result of the statistical analysis, the fabric weft direction breaking strength is affected by both the weft yarn used and the processes it undergoes after the raw material ($p < 0.05$). The effect of using different fibres in the weft yarn on the fabric strength in the weft direction has caused the formation of three classes according to the Tukey pairwise comparison analysis results: cashmere (A) > wool/silk (B) > cashmere/silk (C)-wool (C). The Tukey pairwise comparison results, which were made to see the difference between the raw and finished product, are as follows: finished product (A) > raw (B), and there is a statistically significant difference between the two averages. As a result, when the fibre structure, yarn quality and fabric construction are evaluated together, it is concluded that the woven fabrics produced using 100% cashmere fibres in the weft yarns show high performance in terms of breaking strength in the weft direction; however, the woven fabrics produced using wool/silk blended weft yarns also stand out as a cost-effective and high-strength alternative.

The right-hand chart illustrates tear strength in the weft direction for both grey and finished fabrics. In general, coarser wool fabrics (21.5 μm) showed the highest tear resistance (finished fabric: 2534.75 gf), followed by the wool/silk 70/30 blend (2237.25 gf) and wool 21.5 μm siro yarns (2402 gf). Tear strength is primarily influenced by the yarn's ability to resist sudden localised force, which is enhanced in coarser and more cohesive fibre structures. Notably, cashmere/silk blends and 100% cashmere fabrics demonstrated comparatively lower tear strengths (1859–2333 gf), indicating that despite their softness, they are more vulnerable to sudden rupture. The post-finishing reduction in tear strength across most fabrics may result from reduced extensibility and increased fabric rigidity due to shrinkage and heat exposure during processing. As a result of the GLM analysis, the tear strength of the fabric in the weft direction is affected only by the weft yarn used ($p < 0.05$), and the difference between raw and finished fabrics is insignificant. The effect of using different fibres in the weft yarn on the tear strength of the fabric in the weft direction has caused the formation of two classes according to the Tukey pairwise comparison analysis results: cashmere (A) > wool (A) > wool/silk (A,B) > cashmere/silk (B). Accordingly,

the differences between cashmere and cashmere/silk, wool and cashmere/silk are statistically significant.

Figure 3 the chart on the left presents seam slippage values in the weft direction for both raw and finished fabrics. Across all samples, finishing slightly reduced seam slippage resistance due to fabric relaxation and shrinkage-induced density increases. The highest seam slippage was recorded in wool/silk 70/30 blend fabrics, with values reaching 20 kgf after finishing, suggesting superior inter-fibre cohesion and yarn strength in this blend. In contrast, cashmere fabrics displayed the lowest resistance to seam opening (14.9 kgf finished), which can be associated with the smooth and slippery surface of short, fine fibres, whereas higher hairiness generally increases friction and thus can improve seam slippage resistance. All fabrics exceeded the minimum seam strength requirement (12 kgf) for quality garment applications, but silk-containing blends consistently outperformed pure wool and cashmere samples.

As a result of the statistical analysis, the fabric seam slippage is affected only by the weft yarn used ($p < 0.05$). The effect of using different fibres in the weft yarn on the fabric seam opening strength in the weft direction has caused the formation of two classes according to the Tukey pairwise comparison analysis results: wool/silk (A) > cashmere/silk (A, B) > wool (B) > cashmere (B). Accordingly, the differences between wool/silk and wool, wool/silk and cashmere are statistically significant. The difference between raw and finished fabrics is insignificant.

In figure 3, the right-hand chart shows the results of the Hoffman press test, which measures dimensional change under steam and pressure. All fabric types exhibited a greater negative dimensional change (shrinkage) after finishing compared to their raw states. While raw fabrics showed shrinkage values around -0.3% to -0.5% , finished fabrics reached -1.0% across all samples, indicating typical relaxation and structural tightening during finishing. Notably, no significant differences in shrinkage behaviour were observed between fibre types, suggesting that the finishing process itself (especially stenter drying and compression) was the primary contributor to dimensional reduction, rather than fibre composition. These findings align with prior research

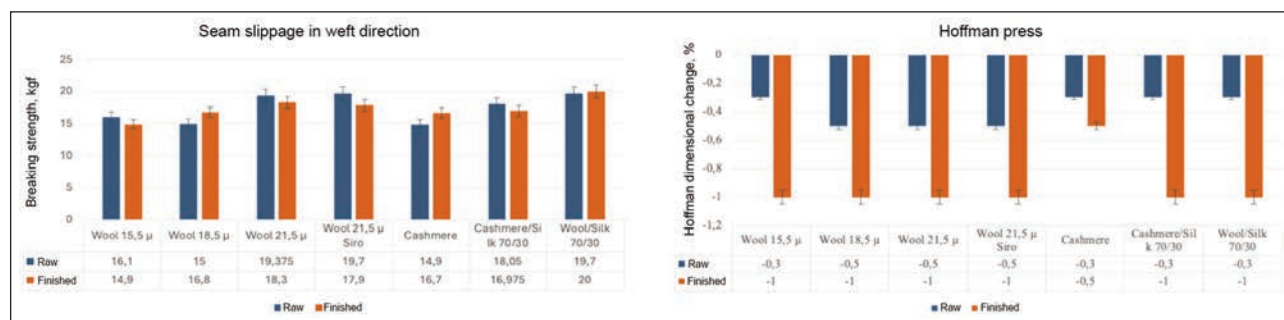


Fig. 3. Results of seam slippage in the weft direction and dimensional change under the Hoffman press

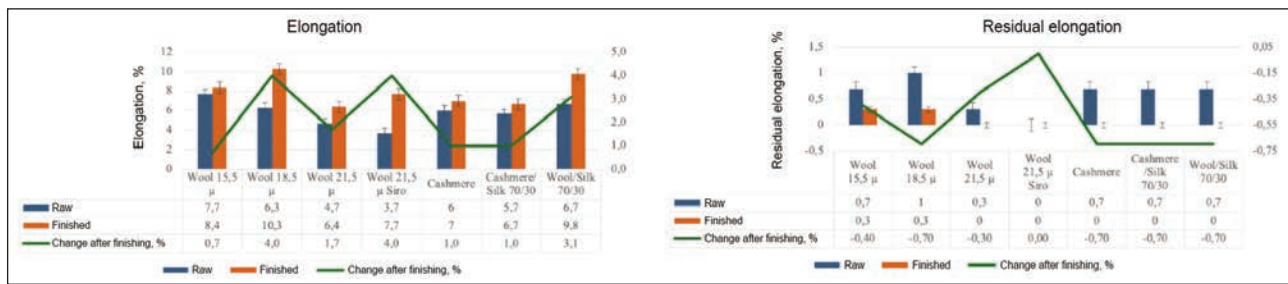


Fig. 4. Results of elongation and residual elongation of the fabrics produced with different weft yarns

emphasising the dominant role of mechanical processing over fibre morphology in determining steam-induced dimensional change.

As a result of the statistical analysis, Hoffman press results are affected by both the weft yarn used and the post-row processes ($p < 0.05$). The effect of using different fibres in the weft yarn on dimensional change behaviour has caused the formation of two classes according to the Tukey pairwise comparison analysis results: cashmere (A) > wool/silk (B) > cashmere/silk (B) > wool (B). The Tukey pairwise comparison results, which were made to see the difference between raw and finished, are as follows: raw (A) > finished (B), and there is a statistically significant difference between the two means.

Figure 4 illustrates the elongation and residual elongation behaviour of fabrics in raw and finished states. Across all fabric types, finishing processes led to a notable increase in elongation, with the most prominent change observed in wool 18.5 μ fabrics, which increased from 6.3% to 10.3% (a 4.0% gain). This increase can be attributed to the relaxation of internal yarn tensions and structural compactness introduced during finishing. Overall, wool/silk 70/30 and cashmere fabrics exhibited moderate elongation improvements (3.1% and 1.0%, respectively), indicating that silk-containing blends not only maintained but enhanced their elasticity after finishing. This outcome is favourable for applications requiring both dimensional resilience and wearer comfort.

The chart on the right shows residual elongation, which represents the permanent deformation remaining after a load is removed. All fabrics experienced a decrease in residual elongation after finishing, suggesting improved elastic recovery. For example, wool 15.5 μ and wool 21.5 μ fabrics showed a 0.4%

and 0.3% reduction, respectively. Importantly, the wool 21.5 μ siro yarn fabrics exhibited no residual elongation in either state, highlighting the benefits of sirospun yarn structure in resisting plastic deformation. Silk-containing fabrics also demonstrated a significant reduction (-0.7%), confirming silk's role in enhancing fabric resilience. These results underline the effectiveness of finishing in promoting structural elasticity and minimizing permanent set, crucial for high-performance woven garments.

In figure 5, the left-hand chart displays the air permeability results of raw and finished fabrics. Overall, finishing caused a slight reduction in air permeability across all samples, attributed to increased fabric density due to relaxation shrinkage. The highest air permeability was observed in wool 21.5 μ siro yarn fabrics (518.2 L/m²·s raw, 501.4 finished), followed by wool/silk 70/30 blends, indicating that both siro spinning and silk inclusion contribute to a more open fabric structure. In contrast, cashmere fabrics and cashmere/silk blends exhibited the lowest permeability values (around 250–270 L/m²·s), likely due to their higher surface fuzz and compactness. These results suggest that fibre fineness, yarn structure, and blend composition are key determinants of breathability. As a result of the statistical analysis, fabric air permeability is affected by both the weft yarn used and the processes it undergoes after raw ($p < 0.05$). The effect of using different fibres in the weft yarn on fabric air permeability has caused the formation of two classes according to the Tukey pairwise comparison analysis results: Wool/silk (A) > wool(A) > cashmere/silk(B) > cashmere (B). The Tukey pairwise comparison results, which were made to see the difference between raw and finished, are as follows: Raw (A) >

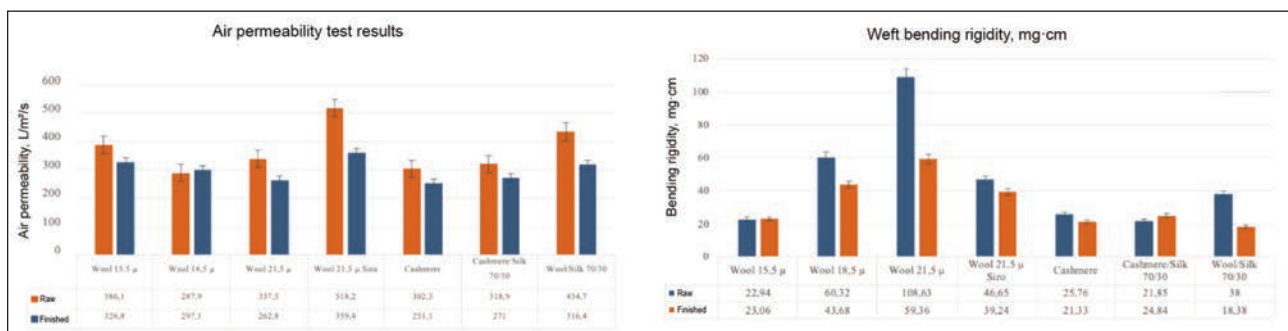


Fig. 5. Results of air permeability and weft bending rigidity of the fabrics produced with different weft yarns

finished (B), and there is a statistically significant difference between the two means.

Air permeability is significantly affected by both fibre type and finished process. While siro yarns, silk-blended wool fabrics and more open weave structures provide advantages in performance textiles requiring high permeability, denser, shorter-fibred and high-hairiness yarn structures (e.g. cashmere) limit permeability. It was observed that the finished processes reduced the permeability in almost all groups, and this was attributed to the tightening of the porosity structure of the fabric during the process. In figure 5, the right-hand chart presents bending rigidity in the weft direction, which reflects the stiffness and drape characteristics of the fabric. A significant decrease in bending rigidity was observed after finishing for all fabrics. The highest raw rigidity was recorded in wool 21.5 μm fabrics (108.6 $\text{mg}\cdot\text{cm}$), which dropped to 59.36 $\text{mg}\cdot\text{cm}$ after finishing, highlighting the strong impact of wet and thermal processing on stiffness. Cashmere and wool/silk 70/30 fabrics had the lowest bending rigidity values in both raw and finished states, confirming their soft, drapable character. These findings indicate that fibre fineness and finishing processes strongly influence the tactile feel and mechanical behaviour of luxury fabrics, which is crucial for their end-use performance in apparel. As a result of the statistical analysis, the weft direction fabric bending strength is affected by the weft yarn used ($p < 0.05$). The effect of using different fibres in the weft yarn on the weft direction fabric bending strength has caused the formation of two classes according to the Tukey pairwise comparison analysis results: Wool (A) > wool/silk (A > cashmere (B) \approx > cashmere/silk (B). Weft direction bending strength varies significantly with the effect of fibre thickness, yarn form and especially the processed structure. While wool fibres provide high bending strength as they form a more rigid structure, cashmere and silk added fabrics stand out with their softer handle and lower bending strength. The finished processes have reduced the bending strength in all fabric groups and influence increasing the drape and comfort of use of the fabric.

CONCLUSION

This study comprehensively evaluated the influence of luxury animal fibre compositions, namely cashmere, silk, and wool, on the physical, mechanical, and tactile properties of woven fabrics. All samples were produced under identical construction parameters, enabling a focused assessment of weft yarn variation. The primary aim was to determine whether more affordable fibre blends could serve as effective alternatives to high-cost cashmere without compromising fabric quality and user comfort.

Key findings from the experimental results include:

- Yarn quality: superfine wool (15.5 μm) and wool/silk 70/30 blends demonstrated superior tenacity and low hairiness compared to cashmere yarns, which showed high unevenness due to their shorter fibre length. The inclusion of silk substantially improved yarn strength and surface regularity.
- Fabric strength and durability: while 100% cashmere fabrics exhibited the highest breaking strength, wool/silk blends provided comparable results. Tear strength was highest in coarse wool fabrics and wool/silk combinations, affirming the structural advantage of longer and thicker fibres.
- Pilling resistance: coarse wool fabrics displayed the best resistance to pilling. Cashmere and cashmere/silk blends performed poorly due to their short fibre lengths and higher surface fuzz. Silk additions slightly mitigated pilling, but not sufficiently to match the wool-based alternatives.
- Seam slippage and stability: wool/silk blends achieved the highest seam strength, while cashmere-containing fabrics were more prone to slippage. All fabrics showed improved dimensional stability post-finishing, though cashmere and silk blends exhibited more shrinkage due to their hygroscopic nature.
- Air permeability and handle: wool/silk and siro-spun wool fabrics offered high breathability, suitable for comfort-driven applications. In contrast, cashmere blends produced denser fabrics, ideal for winter wear. Bending rigidity results showed that cashmere and silk significantly enhanced softness and drapability, while wool contributed to fabric firmness and structure.
- Cost-to-performance analysis: while 100% cashmere delivers premium tactile and thermal qualities, its market price limits its scalability. Wool/silk 70/30 blends emerged as the most promising substitute, offering high tensile and tear strength, good pilling and seam performance and excellent air permeability and comfort.

This blend provides a compelling balance of luxury, functionality, and affordability.

Additionally, conventional 21.5 μm wool yarns (at only €7/kg) presented an optimal solution for lower-budget collections where mechanical durability and acceptable comfort are prioritised over luxury softness.

This research thus supports the strategic substitution of cashmere with superfine wool and wool/silk blends in fabric engineering. These alternatives not only reduce costs but also offer strong performance in key areas of mechanical durability, comfort, and appearance. The findings have valuable implications for sustainable fabric sourcing, luxury textile innovation, and high-value product development.

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