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Comparative study on quality of shawls made from hand-and machine-spun pashmina yarns

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An attempt has been made to compare the quality of pashmina shawls developed on traditional and woollen handlooms using both hand-spun and machine-spun yarns for various physico-mechanical parameters. The experimental plan includes preparation of both hand-spun and machine-spun yarns followed by the preparation of pashmina shawls from these yarns on both traditional and woollen handlooms, and their quality evaluation. Number of fibres/cross-section, count, elongation percentage, tenacity and coefficient of friction show significant difference between hand-spun and machine-spun yarns. The quality evaluation tests of fabrics reveal that weight/m^2, thickness, picks/inch, extension percentage, bending rigidity, frictional properties and total hand value show significant difference, whereas ends/inch, breaking load, tenacity, bending length, abrasion loss and shrinkage loss do not show significant difference. The study reveals that the overall quality of pashmina shawls developed on traditional loom using hand-spun yarn is better than the other types of shawls developed and studied.

Keywords: Hand-spun yarn, Machine-spun yarn, Pashmina shawls, Traditional handloom, Woollen handloom

1 Introduction

Shawls are being prepared from almost all sorts of material like wool, silk, angora wool, pashmina, etc. Among these materials, shawls prepared from pashmina are most attractive, soft and elegant. Kashmir in India is famous around the world for producing pashmina shawls. These shawls are known all over the world for the way they are being prepared right from sorting of raw material to finishing of final product[1]. The raw material used for pashmina shawls is a king of fibres known as pashmina. It has derived its name from Persian word *pashm* meaning soft gold. It is known for its fineness, warmth, softness, desirable aesthetic value, and timelessness in fashion. It is the most luxurious fibre and command higher price among all natural fibre[2]. Traditionally, these shawls are being developed by hand spinning and hand weaving giving them long life (up to 25 years), with no pile formation and are designated as hand-spun hand-woven products, which fetches higher price in the market. With the introduction of machines at different levels of processing (dehairing, spinning, weaving, etc) which although reduces the laborious work and consume less time in product development, there may be a compromise with the quality parameters. Thus, the need of a time is to differentiate the quality of hand-spun hand-woven product from machine-spun products. Hence, the present study was envisaged with the objective of accessing the comparative quality of shawls developed on traditional and woollen looms using hand-spun and machine-spun yarn.

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2 Materials and Methods

2.1 Raw Material

The commercial grade-A Changthangi pashmina used for the study, was procured from All Changthangi Pashmina Growers Association, Leh Ladakh.

2.2 Spinning

Half of the procured pashmina was subjected to spinning on hand charkha and designated as hand-spun yarn. Another half was subjected to spinning on machine at Rampur Shimla after blending with nylon (70:30) and designated as machine-spun yarn.

2.3 Weaving

Both types of yarns were subjected to weaving on traditional and woollen looms resulting in four types of shawls, viz hand-spun on traditional loom (HSTL), hand-spun on woollen loom (HSWL), machine-spun on traditional loom (MSTL) and machine-spun on woollen loom (MSWL). The nylon component from the MSTL and MSWL shawls was dissolved with commercial grade HCL (36%). After dissolving the nylon component, the fabric was thoroughly washed with non-ionic detergent and dried.

2.4 Quality Evaluation

Both types of yarns, viz hand-spun and machine-spun were subjected to comparative analysis in terms of number of fibres/cross-section, twist/inch, count, tex (g/km), breaking strength (g.wt), elongation (%), tenacity (g.wt/tex), bending length (g.wt/cm^3), coefficient of friction (μ), and SEM images.

Yarn count was measured in accordance with ISI specification IS-681-1964. Number of fibres/cross-section was calculated by untwisting 0.5 cm parts of yarns and counting number of fibres. Twist/inch of yarn was estimated following the method specified as per ISI specification IS-832-1964 on twist measuring machine. Tensile properties, viz bundle strength, tenacity and elongation percentage, were measured on Instron tensile tester. Frictional properties and bending properties of both types of yarn were evaluated on Instron tensile tester and fabric stiffness tester respectively. Scanning electron microscopic images were taken with the help of Fibre Scan. All types of shawls were evaluated for various quality parameters.

Fabric Weight

For estimation of weight/m^2, a piece of fabric of the size 25×25 cm was cut with the help of scissor. The piece of fabric was weighed on a sensitive electronic balance. Fabric weight/m^2 was calculated by dividing the weight of the fabric by area of the fabric in square metre.

Thickness

Thickness of shawls was measured by Wira Carpet Thickness Gauge at 0.25 lb/cm pressure as per the ISI specification IS-7702-1975.

Fabric Count

Ends and picks per inch of the shawls were determined as per ISI specification IS-1963-1969.

Fabric Shrinkage

For estimation of shrinkage, the test sample of fabric of the size 25×25 cm was prepared. The sample was immersed in a detergent solution (0.1%) for 30 min. The specimen sample was rinsed with tap water and allowed to drip dry without tension. The length of the fabric piece was again recorded and the shrinkage percentage was calculated.

Abrasion Loss

Abrasion loss (%) of fabric was measured on the W.I.R.A. abrasion machine. Six circular test samples of 38 mm diameter each from a test fabric were prepared. The initial weight of sample was taken and recorded. The instrument was set at 250 revolutions. The samples were mounted on sample holder of abrasion machine. After 250 revolutions, the samples were taken out of the sample holder and weighed again. The loss in weight of the test samples was taken as abrasion loss and the abrasion loss percentage of the sample was evaluated.

Tensile Property

Tensile properties, viz breaking strength, tenacity and extension percentage, of shawls were determined both along the warp way and weft way on Instron (Table top model) as per the method of Booth[3].

Bending Property

The bending property of fabric was evaluated by using fabric stiffness tester. The sample from each type of fabric was prepared by cutting a strip of the size 1.5 × 10 cm along the warp direction. Similarly strip of same size was cut along the weft direction to estimate the bending property of a fabric along the weft direction. The strips were weighed individually on the sensitive electronic balance up to 0.0001 mg and recorded on the data sheet. The strips were allowed to move on the stiffness tester in forward direction till the fabric strip bends and coincides with the marked line seen on the mirror of tester. The bending length was estimated with the help of scale attached with the tester. On the basis of weight and bending length, the bending rigidity of fabric was calculated using the following formula:

$$\text{Bending rigidity} = \text{Weight of test strip} \times \text{Bending length}^3$$

Frictional Property

Frictional properties of fabrics were measured on the Instron (table model). The strip of fabric size (2.5 × 10 cm) was prepared and used for determining the friction of fabric. The fabric to teflon friction was recorded in terms of coefficient of friction (μ). The input tension was kept constant at 1 cN/tex for all fabric samples.

Total Hand Value

Total hand value was estimated by adapting the methodology given by Kawabata and Niwa[4].

2.5 Statistical Analysis

Data obtained from the experiments were analyzed statistically following the method of Snedecor and Cochran[5]. The data was processed in a computer using statistical package for social sciences (SPSS). The ANOVA of group means was computed and significance of means was tested by using least significant difference test at 5% level of significance.

3 Results and Discussion

3.1 Yarn Properties

The physical properties of both types of yarns, viz hand-spun and machine-spun are shown in Table 1. It is observed that count (Nm) of hand-spun yarn is statistically higher than that of machine-spun yarn. This statistical difference shows that the fine yarn could be spun by hand spinning on charkha, whereas only up to 100 Nm could be spun on machine to avoid breakage of yarn. Number of fibres/cross-section for hand-spun yarn is found significantly lower than that for machine-spun yarn. The lower number of fibres/cross-section in hand-spun yarn than in machine-spun yarn indicates that lesser numbers of fibres are required which ultimately lead to more count for them. Our results are slightly lower than those reported by Ahmad and Gupta[6] which might be due to the variation in fibre diameter in both these studies, viz 13.37µ in case of Ahmad and Gupta[6] and 12.25µ in our study.

Twists/inch of yarn show non-significant difference between hand-spun and machine- spun yarn. The results for hand-spun yarn are found to be higher than those reported by Ahmad and Gupta[6]. This difference might be due to individual variation in spinners involved in two studies.

Mechanical properties of both the samples are presented in Table 1. Tex of hand-spun and machine-spun yarn shows non-significant difference. Although the difference is non- significant, the quality of hand-spun yarn is superior to machine-spun yarn in terms of tex. This shows that fine yarn could be made on traditional charkhas. Our results are not in agreement with the findings of Gupta *et al.*[7], wherein tex of pashmina yarn is reported as 19.056 g/km. The tensile properties, viz breaking strength and tenacity are found to be statistically higher for hand-spun yarn than for machine-spun yarn. The possible reason for the lower values in machine-spun yarn might be due to the damage of the yarn during chemical treatment employed for dissolving nylon portion of the yarns. The results of present study are not in agreement with the findings of Wani *et al.*[1], wherein the reported values are 52.00 g.wt and 3.3 g.wt/tex respectively for bending strength and tenacity. The elongation

Table 1—Physical and mechanical properties of double ply hand-spun and machine-spun pashmina yarns

Parameter	Hand spun yarn		Machine spun yarn	
	(Mean ± S.E)	Range	(Mean ± S.E)	Range
No. of fibre in cross-section	39.10 ± 2.23^a (23.02)	23-48	56.6 ± 2.61^b (14.62)	45-70
Twists/ inch	4.23 ± 0.31^a (7.40)	3.0-5.8	4.70 ± 0.20^a (13.56)	3.8-60.0
Actual count, Nm	56.65 ± 1.19^b (4.20)	53.9-59.34	49.02 ± 2.22^a (4.85)	40.41-53.33
Actual count, Nm (Single ply yarn)	112.69 ± 0.47^a (4.21)	107.8-118.7	98.04 ± 0.01^b (10.15)	80.80-106.66
Tex, g/km	17.75 ± 0.33^a (4.22)	16.80-18.50	20.0 ± 1.04^a (1.36)	18.65-24.60
Breaking strength, g.wt	60.9 ± 0.003^a (26.19)	30-100	56.2 ± 0.002^a (23.14)	30-80
Elongation, %	33.13 ± 2.37^a (22.46)	21.06-71.38	50.21 ± 4.31^b (34.17)	17.38-93.90
Tenacity, gwt/tex	3.41 ± 0.20^b (27.06)	1.85-5.35	2.80 ± 0.14^a (23.14)	1.65-3.85
Bending length, gwt/cm^3	21.83 ± 1.95^a (12.34)	15.90 -28.03	29.20 ± 3.10^a (4.29)	20.00-36.33
Coefficient of friction, µ	0.93 ± 0.006^b (2.18)	0.88 - 0.95	0.76 ± 0.004^a (1.70)	0.75-0.79

[a,b] Row-wise group means that with different superscripts the values differ significantly ($p < 0.05$).
Values in parentheses indicate CV%.

percentage is found to be statistically lower for hand-spun yarn than for machine-spun yarn, indicating better yarn geometry during machine spinning than hand spinning. These tensile properties observed in the present study are in close agreement with earlier findings of Ahmad and Gupta[6].

The bending length and frictional properties of hand-spun and machine-spun yarns are also presented in Table 1. The bending length (g.wt/cm^3) is found to be statistically non-significant between hand-spun and machine-spun yarns. The coefficient of friction for hand- spun and machine-spun yarn is found to be 0.93±0.06 and 0.76±0.04 respectively. The lower values for coefficient of friction for machine-spun yarn could be because of the damage to the fibres during chemical treatment.

From the scanning electron microscopic images of both types of yarn (Fig. 1), it is clear that the surface of machine-spun yarn has deteriorated compared to hand-spun yarn, probably because of the chemical treatment with HCl in which machine-spun yarn is dipped for dissolving nylon portion.

3.2 Fabric Properties

Physical properties of four different types of pashmina shawls, viz HSTL, HSWL, MSTL and MSWL used in the present study, are shown in Table 2. The weight of HSTL and HSWL is significantly higher than that of MSTL and MSWL. The lower weight of shawls developed from machine-spun yarn could possibly be due to chemical treatment done for removal of nylon, thus changing the gravity of the fabric. The values of fabric weight used in the present study are in agreement with that of the earlier reports published by Wani ***et al***[1]. Ends per inch for the four types of shawl, viz HSTL, HSWL, MSTL and MSWL, are found to be 55.8±1.85, 56.4±1.69, 54.40±0.92 and 54.80±1.85 respectively. The ends per inch values show non-significant difference among the treatments. However, the values are higher than those reported by Ahmad and Gupta[6]. This may be due to individual variation between different weavers. The numbers of picks for the HSTL, HSWL, MSTL and MSWL in present study are reported as 66.0±0.70, 60.8±3.15, 50.80±1.24 and 50.20±0.86 respectively. The

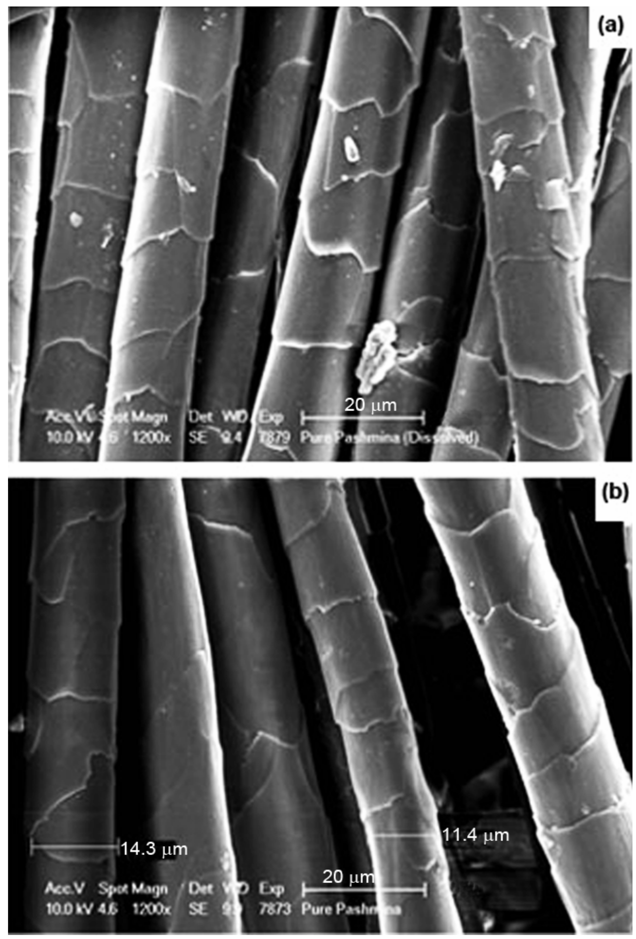

Fig. 1—SEM images of machine-spun (a), and hand-spun (b) pashmina yarns

Table 2—Physical properties of pashmina shawls made from hand-spun yarn and machine-spun yarn on traditional and woollen looms

Parameter	Hand-spun traditional loom	Hand-spun woollen loom	Machine-spun traditional loom	Machine-spun woollen loom
Weight/m^2, g	138.4±1.97[b] (5.05)	137.6±1.64[b] (3.9)	93.19±1.45[a] (3.2)	92.54±1.08[a] (2.4)
Thickness, mm	0.2880±0.007[a] (7.9)	0.307±0.009[a] (9.5)	0.373±0.02[b] (11.9)	0.403±0.005[b] (7.58)
Ends/inch	55.8 ±1.85[a] (7.4)	56.4±1.69[a] (6.7)	54.40±0.92[a] (4.9)	54.80±1.85[a] (2.4)
Picks/inch	66.0±0.70[a] (2.3)	60.8±3.15[b] (9.2)	50.80±1.24[c] (2.3)	50.20±0.86[c] (6.9)

[a,b] Row-wise group means that with different superscripts the values differ significantly ($p < 0.05$).
Values in parentheses indicate CV%.

results show significantly higher values for HSTL and HSWL than for MSTL and MSWL. This may be due to added nylon used during machine spinning, thus increasing the overall density of yarn. However, the values for machine-spun yarn for both traditional loom and improved loom show non-significant difference and are almost same in both. Further, the reported value of HSTL is found to be higher than the earlier reports for pashmina shawl as reported by Ahmad and Gupta[6].

The thickness of HSTL and HSWL shows significantly lower value than the MSTL and MSWL. This might be due to higher count for the hand-spun yarn thus giving low thickness to the fabric. However, within the groups hand-spun yarn as well as machine-spun yarn for both types of loom do not show any significant difference, thus reflecting that woollen looms which increase efficiency can be effectively used for weaving pashmina shawl without affecting the quality in terms of thickness.

The tensile properties of pashmina shawls are presented in Table 3. The breaking load (kg) of HSTL, HSWL, MSTL and MSWL are found to be 4.86±0.63, 4.42±0.22, 4.06±0.63 and 4.05±0.26 warp wise and 5.07±0.36, 4.86±0.24, 4.52±0.20 and 4.19±0.54 weft wise respectively which shows non-significant difference among the treatments. The results obtained in present study are lower than the findings of Ahmad and Gupta[6], and Wani ***et al***.[1] for shawls developed from hand-spun on traditional loom. The tenacity of HSTL, HSWL, MSTL and MSWL along both warp way and weft way does not show any significant difference. Extension percentage of pashmina shawls made from HSTL is significantly lower than that of HSWL, MSWL, and MSTL along the warp-wise direction. The variation could be due to lower twist of yarn and also possibly due to variation in the type of yarn configuration. Further, extension percentage (%) along the weft direction for HSTL (10.49±0.35) and HSWL (10.09±0.25) shows significantly lower value than for MSTL (11.93±0.25) and MSWL (11.85±0.50). This is possibly due to difference in yarn quality of two types of fabrics. However, within the types of yarn used, no significant effect is observed due to different types of looms. The results obtained along both warps way and weft way are in agreement with the earlier findings by Ahmad and Gupta[6] and Wani ***et al.***[1].

Table 4 shows the results of bending length (cm) along warp way as 2.66±0.09, 2.76±0.09, 2.84±0.05

Table 3—Mechanical properties of pashmina shawls made from hand-spun yarn and machine-spun yarn on traditional and woollen looms

Fabric type	Breaking load, kg		Tenacity, g/tex		Extension, %	
	Warp	Weft	Warp	Weft	Warp	Weft
HSTL	4.86±0.63[a] (29.2)	5.07±0.36[a] (15.9)	2.73±0.35[a] (29.38)	2.92±0.16[a] (12.88)	8.19±0.35[a] (9.7)	10.49±0.23[a] (4.9)
HSWL	4.42±0.22[a] (12.6)	4.86±0.24[a] (11.4)	2.28±0.13[a] (12.73)	2.72±0.14[a] (11.59)	11.95±0.53[b] (9.9)	10.09±0.25[a] (5.7)
MSTL	4.06±0.08[a] (4.3)	4.52±0.20[a] (10.2)	2.20±0.03[a] (3.21)	2.60±0.35[a] (30.88)	12.72±0.20[bc] (3.2)	11.93±0.25[b] (4.8)
MSWL	4.05±0.26[a] (11.7)	4.19±0.54[a] (23.2)	2.10±0.15[a] (13.04)	2.60±0.27[a] (23.23)	13.57±0.09[c] (4.0)	11.85±0.50[b] (9.6)

[a,b,c] Column-wise group means with different superscripts differ significantly ($p < 0.05$).
Values in parentheses indicate CV%.

Table 4—Bending properties of pashmina shawls made from hand-spun yarn and machine-spun yarn on traditional and woollen looms

Fabric type	Bending length, cm		Bending rigidity, g.cm^2	
	Warp	Weft	Warp	Weft
HSTL	2.66 ±0.09[a] (7.9)	2.54 ±0.06[a] (5.9)	7.95 ± 0.85[b] (23.97)	7.82 ± 0.66[b] (18.95)
HSWL	2.76±0.09[a] (7.9)	2.72±0.08[a] (6.57)	10.22 ±1.06[ab] (23.23)	9.63 ± 0.73[b] (17.01)
MSTL	2.84 ±0.05[a] (4.0)	2.74±0.09[a] (7.5)	13.03 ± 1.07[a] (18.37)	10.54 ± 0.97[ab] (20.28)
MSWL	2.78±0.08[a] (6.4)	2.74±0.11[a] (9.1)	13.10 ± 1.37[a] (23.37)	12.87 ± 1.62[a] (28.19)

[a, b] Column-wise group means the with different superscripts the values differ significantly ($p < 0.05$).
Values in parentheses indicate CV%.

Table 5—Frictional properties of pashmina shawls made from hand-spun yarn and machine-spun yarn on traditional and woollen looms

Fabric type	Frictional force, g		Co-efficient of friction	
	Warp	Weft	Warp	Weft
HSTL	162.4±1.28[a] (1.77)	162.8±3.23[a] (4.43)	0.81±0.005[a] (1.51)	0.81±0.007[a] (4.70)
HSWL	161.8±4.16[a] (5.75)	162.6±1.16[a] (1.60)	0.80±0.002[a] (5.85)	0.80±0.001[a] (1.61)
MSTL	159.0±3.88[a] (5.46)	159.8±1.11[b] (1.42)	0.79±0.002[a] (5.74)	0.79±0.005[b] (1.40)
MSWL	158.2±5.35[a] (3.38)	159.6±1.53[b] (2.15)	0.78±0.001[a] (3.63)	0.78±0.005[b] (2.10)

[a,b] Column-wise group means that with different superscripts the values differ significantly ($p< 0.05$).
Values in parentheses indicate CV%.

and 2.78±0.08 and that along weft way as 2.54±0.06, 2.72 ±0.08, 2.74±0.09 and 2.72 ±0.11 respectively for HSTL, HSWL, MSTL and MSWL. The bending length both warp-wise and weft-wise shows non-significant difference. The warp-wise bending rigidity ($g.cm^2$) of MSTL, MSWL and HSWL is significantly higher than that of HSTL and differed non-significantly among each other. The weft-wise bending rigidity of HSTL and HSWL is significantly lower than that of MSWL. This variation could be due to difference in type of yarn used and effect of looms. It further shows that shawls made from hand-spun yarn have superior properties in terms of bending length and rigidity than those made from machine-spun yarn. The values of bending length and bending rigidity for pashmina are than those reported for other fabrics.

Frictional properties of pashmina shawls woven on two types of loom from hand- spun and machine-spun yarns were evaluated in terms of frictional force and coefficient of friction (Table 5). The frictional forces on both warp way and weft way do not show any statistical significance, indicating that the types of loom and yarn do not affect frictional force of the pashmina shawls. The coefficient of friction along the warp direction is reported as 0.81±0.005, 0.80±0.002, 0.79±0.002, and 0.78±0.001, while along the weft way, it is found as 0.81±0.007, 0.80±0.001, 0.79±0.005 and 0.78±0.005 for HSTL, HSWL, MSTL and MSWL respectively. Although the results do not show any significant difference, the value for hand-spun yarn is slightly higher on warp direction. Along the weft way, coefficient of friction for hand-spun yarn made on both traditional and woollen loom are significantly higher than shawl made from machine-spun yarn on traditional and woollen loom.

Table 6 presents the results of shrinkage and abrasion loss percentage. The shrinkage loss percentage for shawls made from hand-spun yarn and machine-spun yarn on traditional and woollen loom shows non-significant variation between both types of yarn as well as loom used. The range of the shrinkage percentage is found to be the same for all the four types of fabrics, ranging from 0-11. This indicates that within the fabric, the method of spinning and weaving adapted does not alter the shrinkage percentage of the shawls. However, the shrinkage in the present study is slightly higher than that reported earlier by Wani *et al*[1]. The abrasion loss percentage for four types of shawls in present study are 3.74±0.24, 4.0±0.77, 4.2±0.74 and 4.1±0.96 for HSTL, HSWL, MSTL and MSWL respectively. Although statistically no significant difference is

Table 6—Abrasion loss of pashmina fabric made from hand-spun yarn and machine-spun yarn on traditional and woollen looms

Fabric type	Abrasion loss, % (Mean± S.E)	Shrinkage, % (Mean± S.E)
HSTL	3.4 ± 0.24	4.3±1.35
HSWL	4.0 ±0.77	4.2±1.27
MSTL	4.2 ± 0.74	4.0±0.94
MSWL	4.1± 0.96	4.1±1.40

Table 7—Total hand value of pashmina fabric made from hand-spun and machine-spun yarn on traditional and woollen looms

Fabric type	Total hand value (score out of 5)*		
	Women	Men	Overall average
HSTL	4.7±0.30[c]	3.8±0.58[a]	4.25±0.34[b]
HSWL	3.6±0.25[a]	3.6±0.60[a]	3.60±0.30[b]
MSTL	3.2±0.20[a]	1.4±0.40[b]	2.30±0.36[a]
MSWL	2.1±0.01[b]	3.0±0.36[ab]	2.55±0.34[a]

*Kawabata and Niwa (1989) 6 point score card, where 0 means very poor and 5 means excellent.
[a,b,c] Column-wise group means the with different superscripts the values differ significantly ($p< 0.05$)..

found in the loss percentages of different types of fabrics, the losses are slightly higher on shawl made from machine-spun yarn on both traditional and woollen loom. This may be due to chemical treatment used for the removal of nylon. This indicates that hand-spun fabric has slightly better life span than machine-spun fabric.

Total hand value (Table 7) of the shawls, indicating the softness and feel of the person wearing the fabric, shows that women invariably use hand-spun products made on the traditional loom feel higher in terms of softness, whereas shawls made on woollen loom using hand-spun yarn show similar values as that of shawls made on traditional loom using hand-spun yarn. Further, the shawls made from machine-spun yarn on woollen loom are ranked the lowest. Similarly, men also show statistically higher preference in terms of hand value for shawls made from hand-spun yarn on traditional loom. The overall average is also statistically higher for shawls made from hand-spun yarn on traditional loom. This indicates the better liking for the shawls made from hand-spun yarn on traditional loom. This might be due to less abrasion loss, shrinkage loss and damage of the fibre during processing using hand-spun yarn on traditional loom. However, no reports are available on pashmina fibre on the total hand value. The total hand value, as reported by Shakyawar and Behera[8] for Australian merino, Bharat merino and Chokla woollen fabrics, indicates the values as 2.78, 2.73, and 2.27 respectively which are lower than the reported values in present study.

4 Conclusion

It is inferred that the overall quality of hand-spun and hand-woven pashmina shawls is far better than that of the shawls made from machine spun pashmina yarns.

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