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Value addition of mulberry silk waste/ wool blends to develop handloom fabrics

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ABSTRACT : The present study was carried out to add value to silk waste by developing blended as well as union handloom fabrics to increase the fabric range. Blending of mulberry silk waste and 24 micron wool was done at the Gillbox stage and the yarns were spun on worsted spinning system. The blend proportion of 65s:35w considered optimum was spun into 30s and 40s metric count (Nm) yarns to make twill woven fabrics. Two fabrics were developed using blended yarns having 2/30 Nm warp and 30 Nm weft (S_1) as well as 2/40 Nm warp and 40 Nm weft (S_2) yarns. Two union fabrics (S_3) and (S_4) were also made using pure wool warp and developed blended yarns in weft, respectively. Fabrics S_1 and S_2 exhibited excellent drapability, significantly lesser ($p \leq .05$) bending length and flexural rigidity and higher abrasion resistance. Union fabrics S_3 and S_4 had excellent crease recovery, better dimensional stability, good thermal insulation, high breaking as well as tear strength. Fabric S_4 exhibited more drapability, and less flexural rigidity. The cost of production with 65s:35w blended yarn was much lesser in comparison to the yarn made from 100 per cent mulberry silk waste whereas variability from other blends was found to be very less. The estimated cost of blended fabrics developed was Rs. 376.70 per meter whereas the cost of developed union fabric with 100 per cent wool warp and 65s:35w weft was Rs. 327.63 per meter. Such cost effective handloom blended and union fabrics have the potential to enhance domestic and export earnings of the handloom weavers.

KEY WORDS : Blended, Handloom, Mulberry silk waste, Union, Wool, Worsted

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Silk industry produces about 35 per cent reeling waste on the total quantity of raw silk produced and amount to about 5,000 metric tones of soft waste. The hard waste generated mainly during twisting and winding that is about 500 tones per annum in India. Ninety per cent of this is mulberry silk waste that is used to spin coarse count yarns for carpets (Vijaykumar *et al.*, 2007). Excessive generation of waste due to raw material characteristics, process parameters, machinery and technology affects the economics of the industry in a considerable manner. Hence, proper utilization of mulberry silk waste is of utmost importance for production of quality spun yarn as well as product diversification (Sanapapamma and Naik, 2008). Value addition of mulberry silk reeling waste through blending, spinning into finer counts and weaving on handlooms can lead to its diversified uses in apparel and home textiles. Mulberry silk waste can be put in better use by blending it with fine quality wools using worsted spinning mechanism (Verma, 2011). Introducing the technology will facilitate in developing diversified raw material for the handloom sectors. In terms of providing employment to 124 lakhs people, the handlooms stand next to agriculture in the unorganized sector.

Presently, the handlooms contribute only 20 per cent towards the total cloth production in the country. Though its share in the total textile exports is 10 per cent (EXIM:2001), its labour intensive character, decentralized nature and optimum utilization of scarce capital recourses give it a unique position in the Indian economy. It weaves a range of fibres like cotton, silk, tussar, jute, wool and synthetic blends. Introducing value added diversified fabrics leads to an increase in domestic and export earnings of handloom weavers.The strength of handlooms lies in introducing innovations and diversified creations which cannot be replicated by the power loom sector. Therefore, the present study was planned to develop value added, cost effective handloom mulberry silk waste : wool blended and union fabrics for strengthening the income generating capacity of the handloom weavers.

Objectives :

–To develop blended and union handloom fabrics using optimally blended mulberry silk waste/wool yarns and to study the cost of blended yarn and the cost effectiveness of the developed blended and union fabrics.

■ RESEARCH METHODS

Materials used in the study :

The raw material used in the study included multivoltine mulberry silk reeling waste in hank form and Australian merino wool of fine quality in tops form. Mulberry silk waste was degummed after analyzing the sericin content. The study was conducted in the Department of Clothing and Textiles, College of Home Science, PAU, Ludhiana, a private spinning and weaving mill in Kullu and North Indian Textile and Research Association (NITRA), Ghaziabad in the year 2010-11.

Blending and spinning of Australian merino wool /silk fibres:

Optimization for blending of mulberry silk waste and wool fibres was done by taking the fibres in the ratios of 100:0, 65:35, 50:50, 0:100. Gillbox (drawframe) blending method was adopted and the requisite amount of each fibre on weight basis was combined using worsted spinning system. The Z twist was inserted in all the yarns. Two counts of yarns 30s and 40s metric count (Nm) were spun for each blended proportion as well as 100 per cent silk and 100 per cent wool yarns. Most suitable blending proportion for each count of yarns was optimized on the basis of best mechanical and physical properties of the developed yarns. This optimized proportion was used to carry the study forward.

Preparation of blended and union fabrics using developed yarns :

Blended as well as union fabrics were prepared on a handloom using the developed blended yarns of both the counts. One set of fabric samples was prepared using 30 Nm (S_1) and 40 Nm (S_2) blended yarns while 100 per cent wool in warp direction and the blended yarn of 30 Nm (S_3) and 40 Nm (S_4) yarn in weft in the other. Straight drafting system was adopted to produce four different sets of fabrics in twill weave. For adding strength yarn counts of 2/30 Nm and 2/40 Nm (changed to S twist) were kept in the warp for all the fabrics whereas yarn counts of 1/30 Nm and 1/40 Nm were used in weft. The constructional parameters *viz.,* reed width, denting order, weave and cloth width were kept constant for all the fabrics while the fibre content, yarn count, fabric structure and cloth cover varied.The physical and mechanical properties of the developed fabrics were analyzed using standard test methods.

Estimation of cost :

The cost of developed blended and union fabrics was estimated in Rs./mt. It included the cost of all the operations and the charges starting right from the procurement of the raw materials, degumming of silk, spinning and yarn making, including electricity and labour, wastage and finally the weaving .

■ RESEARCH FINDINGS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Processing and analysis of yarns :

Mulberry silk waste and Australian merino wool (24 microns) were blended in different ratios *i.e.* 100:0, 65:35, 50:50, 35:65 and 0:100 at the Gillbox stage to prepare yarns of 30 and 40 Nm on a worsted spinning system. The 65s:35w blended yarns for both the 30 Nm and 40 Nm counts were taken as the optimum blend due to higher strength, lesser hairiness and significantly improved ($p \leq .05$) evenness of yarn in comparison compared to pure silk.

Development of blended and union handloom fabrics and their characteristics :

Blended and union handloom fabrics were woven with 30 Nm and 40 Nm yarns developed using the optimized 65s:35w blend. Blended fabrics were made by taking blended yarns of 2/30 Nm (warp) and 30 Nm (weft) yarns for fabric S_1 while 2/40 Nm (warp) and 40 Nm (weft) for fabric S_2. The union fabrics had pure wool yarn in the warp with blended yarn of either 30 Nm (S_3) or 40 Nm (S_4) in the weft. All the fabrics were woven on a handloom with the following constructional parameters (Table 1).

It can be elucidated from Table 1 that for both weaving samples, reed width was 52″ and the denting order was 2 ends/dent. The fabrics were woven in twill weave. The width of the woven fabrics was 44″. The observed ends per inch for the blended fabric S_1 with 2/30 and 30 Nm yarn counts were 32 whereas picks were 30, the thread count being 32x30 sq″. The 40 Nm blended fabric S_2 had 35 ends per inch and 33 picks per inch while the total thread count was 35x32 sq″. The cloth cover was 15.141 for the 30 Nm blended fabric and 14.503 for 40 Nm blended fabric. Weft cover factor was observed to be 7.126 and 6.789 for S_1 and S_2 blended fabrics, respectively, whereas the warp cover factor was 10.750 and 10.183, respectively.

As far as the union fabrics were concerned, the fabric S_3 made from 2/30 and 30 Nm yarn counts exhibited 44 ends and 35 picks per inch, respectively and had a thread count of 44x35 sq″. The union fabric S_4 made from 2/40 and 40 Nm yarn counts, had 52 ends and 42 picks per inch while the total thread count was 52x42 sq″. The cloth cover was 18.708 for the 30 Nm union fabric (S_3) and 19.101 for the 40 Nm union fabric (S_4). The weft cover factor was observed to be 8.314 and 8.640 for 30 Nm and 40 Nm union fabrics, respectively while the warp cover factor was 14.782 and 15.129, respectively.

Both, the warp and the weftwise bending length and flexural rigidity of the blended fabrics S_1 and S_2, were significantly less as compared to the union fabrics S_3 and S_4, developed from 30 and 40 Nm counts, respectively. The lesser denier of silk fibre was responsible for making the blended fabrics more resilient (Table 2).

The drape co-efficient of S_1 and S_2 (blended fabrics) was less than that of S_3 and S_4 (union fabrics). However, the difference among the fabrics made from yarns of the same count S_1 and S_3 as well as S_2 and S_4, was not found significant. The lower value of drape co-efficient of blended fabrics was responsible for its better drapability. The lesser denier of silk fibre as compared to that of wool was responsible for its better draping behaviour. Also the lesser number of interlacings in the weave repeat helped in better drapability of blended fabrics.Crease recovery angle of the union fabrics was significantly higher ($p \leq .05$) as compared to S_1 and S_2 (blended

Table 1 : Constructional parameters of the blended and union fabrics

Constructional parameters		Blended fabrics		Union fabrics	
Fibre content	(Warp)	65 % silk :35 % wool		100 % wool	
	(Weft)	65 % silk :35 % wool		65 % silk :35 % wool	
Yarn count	(Warp)	2/30 Nm	2/40 Nm	2/30 Nm	2/40 Nm
	(Weft)	30 Nm	40 Nm	30 Nm	40 Nm
Reed width		52″	52″	52″	52″
Denting order		2 ends/dent	2 ends/dent	2 ends/dent	2 ends/dent
Weave		Twill	Twill	Twill	Twill
Cloth width		44 ″	44″	44″	44″
Fabric structure	EPI	32	35	44	52
	PPI	30	32	35	42
	Fabric count (sq.inch)	32 x 30*	35 x 33**	44x35#	52x42##
Cloth cover (kc)		15.141	14.503	18.708	19.101
Warp cover factor (k1)		10.750	10.183	14.782	15.129
Weft cover factor (k2)		7.126	6.789	8.314	8.640

*S_1 = Blended fabric made from 65s/35w, 2/30x30 Nm yarn, #S_3 = Union fabric made from 100x65s/35w, 2/30x30 Nm yarn

*S_2 = Blended fabric made from 65s/35w, 2/40x40 Nm yarn ##S_4 = Union fabric made from 100x65s/35w, 2/40x40 Nm yarn

Table 2 : Analysis of physical properties of blended and union fabrics

Physical parameters		S_1	S_3	t-value	S_2	S_4	t-value
Bending length (cm)	Warp	1.631±0.076	1.975±0.038	5.334*	1.594±0.021	1.900±0.014	14.828*
	Weft	1.544±0.0434	1.667±0.030	2.909*	1.477±0.016	1.450±0.038	0.309
Flexural rigidity (mg/cm)	Warp	50.525±3.832	138.583±3.187	21.415*	46.161±1.338	107.398±1.254	39.163*
	Weft	44.173±0.900	97.685±7.996	6.673*	41.489±3.891	65.367±5.935	3.676*
Overall flexural rigidity		47.200±1.879	112.904±1.359	30.352*	44.323±3.113	83.584±2.600	9.920*
Drape coefficient		0.849±0.042	0.882±0.010	1.105	0.797±0.032	0.842±0.009	1.910
Crease recovery (degree)	Warp	126.000±1.870	149.600±1.631	9.509*	131.600±2.249	155.600±1.691	8.528*
	Weft	73.000±2.549	124.600±2.039	15.804*	104.000±1.378	90.00±1.581	6.674*
Pilling resistance		3.333±0.245	3.167±0.166	0.707	3.000±0	3.667±0.245	4.000*
Shrinkage (%)	Warp	2.920±0.195	1.760±0.097	5.295*	3.000±0	1.240±0.146	7.091*
	Weft	1.360±0.074	0.960±0.040	4.714*	1.400±0.187	0.960±0.040	2.300*
Thermal insulation (CLO)		0.600±0.491	1.200±0.230	1.897	0.400±0.491	0.800±0.461	1.265

*** =** Significant, t-value = Calculated value of t, for differences of two means at two tail and 5 per cent level of significant

S_1 = Blended fabric made from 65s/35w, 2/30x30 Nm yarn S_3 = Union fabric made from 100x65s/35w, 2/30x30 Nm yarn

S_2 = Blended fabric made from 65s/35w, 2/40x40 Nm yarn S_4 = Union fabric made from 100x65s/35w, 2/40x40 Nm yarn fabrics) in the warp direction. This could be attributed to the greater angle of crease recovery in wool as the warp used in union fabric was 100 per cent wool. The samples S_1 (blended) and S_3 (union) both made from 30 Nm yarn showed the same trend in the weft direction also. However, in the set made from 40 Nm yarns the crease recovery angle of S_4 (union) was found to be significantly less than that of S_2 (blended) fabric. This may be due to the higher cover factor of the union fabrics which is responsible for making it slightly stiff as compared to the blended fabric.

Data pertaining to pilling resistance showed that the S_4 union fabric was more resistant to pilling as compared to the blended fabric S_2 and the difference was found to be significant ($p \leq .05$). However, the difference between S_1 (blended) and S_3

Table 3 : Analysis of mechanical properties of blended and union fabrics

Mechanical parameters		S_1	S_3	t-value	S_2	S_4	t-value
Elongation (%)	Warp	12.200±0.634	23.760±0.706	12.181*	11.880±0.501	19.440±0.770	7.583*
	Weft	18.080±0.439	17.080±0.007	1.175	18.360±1.273	17.900±1.070	1.175
Breaking strength	Warp	62.834±2.763	86.273±0.986	7.988*	60.918±2.987	74.940±2.051	3.869*
(kg/sq.cm)	Weft	43.507±1.303	75.708±1.171	18.380*	41.060±2.845	68.407±1.402	8.622*
Tearing strength (Newton)	Warp	51.800±3.441	84.000±1.870	8.221*	46.200±4.543	80.400±1.860	6.967*
	Weft	38.000±1.998	73.400±1.536	10.550*	31.600±1.166	67.400±2.358	13.609*
Abrasion resistance (cycles)		1766.66± 35.465	1546.667± 17.732	5.154*	1506.667± 17.732	1126.667± 40.552	8.984*

*** =** Significant, t-value = Calculated value of t, for differences of two means at two tail and 5 per cent level of significant
S_1 = Blended fabric made from 65s/35w, 2/30x30 Nm yarn S_3 = Union fabric made from 100x65s/35w, 2/30x30 Nm yarn
S_2 = Blended fabric made from 65s/35w, 2/40x40 Nm yarn S_4 = Union fabric made from 100x65s/35w, 2/40x40 Nm yarn

Table 4 : Estimation of cost per meter of blended and union fabrics

Cost of item/processing	Proportions				
	100% Silk	65 S:35 W	50 S: 50 W	35 S: 65 W	100% Wool
Cost of raw material					
Cost of silk waste (900 Rs./kg)	900.00	585.00	450.00	315.00	-
Cost of wool (600 Rs./kg)	-	210.00	300.00	390.00	600.00
Total cost of fibre (Rs./kg)	900.00	795.00	750.00	705.00	600.00
Cost of degumming (100 Rs./kg) (In case of silk waste only)					
	100.00	65.00	50.00	35.00	-
(Electricity and labour charges)					
Carding machine (30 Rs./ kg)	30.00	30.00	30.00	30.00	30.00
Gill box machine (30 Rs./kg)	30.00	30.00	30.00	30.00	30.00
Drawing (30 Rs./kg)	30.00	30.00	30.00	30.00	30.00
Spinning (30 Rs./kg)	30.00	30.00	30.00	30.00	30.00
Winding (30 Rs./kg)	30.00	30.00	30.00	30.00	30.00
Wastage during	60.00	34.40	24.00.00	14.80	-
processing (Rs.)	(6 %)	(4 %)	(3 %)	(2%)	-
Total cost estimated (Rs./kg yarn)					
	1210.00	1044.40	974.00	904.80	750.00
	100% Silk	65 S:35 W	50 S: 50 W	35 S: 65 W	100% Wool
Weaving charges Rs./m	28.57	28.57	28.57	28.57	28.57
Total cost estimated (Rs./m fabric)					
	431.90	376.70	353.25	330.17	278.57
Estimated cost of developed fabrics (Rs./m)					
		Blended		Union	
		376.70		327.63	

One kg yarn is equivalent to three meters of fabric

(union) fabric was not significant and both the fabrics showed moderate pilling. The union fabrics were found dimensionally more stable than the blended fabric in both the directions and the difference was found to be significant ($p \leq .05$). Better dimensional stability of the union fabric was due to its higher cloth cover in which less space was left for shrinkage.

Thermal insulation of the union fabrics was more as compared to the blended fabrics.This was attributed to the greater wool content of the union fabrics as the warp yarn consisted of 100 per cent wool fibre. The crimp of wool and its scaly structure caused porosity in the wool blended yarns and fabrics which are responsible for their excellent thermal properties (Behra and Mishra, 2007). Also, the union fabric S_3 exhibited less compact yarn and fabric structure but more thickness due to its lower count. Both these properties are responsible for its higher CLO value as more airspaces were there in S_3 fabric that insulated more heat (Table 2).

Union fabrics made from both the counts had significantly higher ($p \leq .05$) elongation as compared to the blended fabrics in the warp direction that was made from highly extensible pure wool yarn. In the weft direction, the difference among union and blended fabrics was not found to be significant. The breaking as well as the tearing strength of both the union fabrics was higher than the blended fabrics and the difference was found to be significant ($p \leq .05$). Relatively more compact fabric structure and the higher cloth cover were responsible for the higher strength of the union fabrics. Abrasion resistance of both the blended fabrics was significantly higher ($p \leq .05$) than that of the two union fabrics. Greater abrasion of the union fabrics was attributed to the 100 per cent wool warp that had more scales leading to higher friction and hence more abrasion (Table 3).

Estimation of cost per meter of blended and union fabrics :

Table 4 depicts that the cost of mulberry silk waste fibre was 900 Rs.kg whereas the cost of Australian merino wool was 600 Rs./kg. The total cost of fibre for five proportions came to 900 Rs./kg for 100 per cent mulberry silk waste fibre, 795 Rs./kg for 65s:35w, 750 Rs. /kg for 50s:50w blend, 705 Rs./kg for 35s:65w blend and 600 Rs./kg for 100 per cent wool. The silk was degummed after analyzing its sericin content and its cost was 100 Rs./kg. The cost of degumming was also added accordingly to each proportion also. The cost of each for carding machine, gill box machine, drawing, spinning and winding was 30 Rs./kg of yarn. Wastage for 100 per cent silk was found to be 6 per cent which got reduced by 4, 3 and 2 per cent as the wool content in the yarns increased while no wastage was added for 100 per cent pure woolen yarn.

The total estimated cost for 100 per cent silk yarn came out to 1210 Rs./kg which was the highest, followed by 1044.4 Rs./kg for 65s:35w blended yarn, 974 Rs./kg for 50s:50w blended yarn and 904.8 Rs./kg for 35s:65w blended yarn, at 750 Rs./kg the cost was the lowest for pure wool yarn. The reason for this was that silk was more expensive and charges of degumming and wastage of silk during processing the yarn were added to other proportions. However, the overall difference among the blended yarns did not vary much while a higher reduction in the cost of 65s:35w was observed in comparison to 100 per cent mulberry silk waste yarn. This may be due to the fact that the wastage during processing was effectively reduced when mixed with 35 per cent wool. After estimating the cost of yarn, weaving charges (Rs.28.57 per meter) were also added. The estimated cost of blended fabric developed in 65s:35w was Rs. 376.70 per meter whereas the cost of developed union fabric with 100 per cent wool warp and 65s:35w weft was Rs. 327.63 per meter. The cost of weaving was slightly high due to low production rate on account of hindrance by the number of breaks in yarn encountered while weaving and by the frequent manual clearing of the healds to remove the stuck slubs. However, as the wool content increased, the number of breaks in the weaving decreased, which led to the conclusion that it is easier to weave mulberry silk waste when it is blended with a fibre having less variable diameter or keeping the 100 per cent wool in warp direction for constructing union fabrics. Consequently, the cost of weaving will certainly be reduced.

Conclusion :

Mulberry silk waste and fine wool (24 microns) can be blended at the gillbox stage to prepare yarns of 30 and 40 Nm on a worsted spinning system. The 65s:35w blended yarn of 2/30 x 30 Nm can be used to make twill woven fabrics of 32 x 30 square inch thread count and GSM 125. These fabrics have good mechanical and thermal insulation properties where 65s:35w blended yarns of 2/40 x 40 Nm can be used to make twill woven fabrics of 35 x 33 square inch thread count and GSM 119 that exhibited good drape, crease recovery, lesser stiffness that ultimately contributed to its hand value. The 100 w x 65s:35w blended yarns of 2/30 x 30 Nm counts can be used to make twill woven fabrics of 44 x 35 square inch thread count and GSM 179 that have good mechanical and thermal insulation properties. The 100 w x 65s:35w blended yarns of 2/40 x 40 Nm counts can be used to make twill woven fabrics of 52 x 42 square inch thread count and GSM 151. These fabrics exhibited good drape, dimensional stability, crease recovery and lesser stiffness. The estimated cost of blended fabric developed in 65s:35w was Rs. 376.70 per meter whereas the cost of developed union fabric with 100 per cent wool warp and 65s:35w weft was Rs.327.63 per meter. Such cost effective handloom blended and union fabrics has the potential to enhance domestic and export earnings of the handloom weavers, thereby strengthening their income generating capacity.

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