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Production and Performance of Wool Blend Fabrics Composed of Yarns Spun on the Cotton System

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ABSTRACT

Two grades (62's and 80's) of 50.8 mm (maximum fiber length, 2 inches) cut-top wool were intimately mixed with cotton and with polyester fibers at varying blend levels. Subsequently, 13 yarns (36.9 tex, 16/1 N_c) were ring-spun using the short-staple system of mechanical processing and standard crepe fabrics were manufactured from each. Some production problems are highlighted together with their solutions. Simple finishing routines and resulting fabric properties are described.

Recent interest has been reported on the wider use of wool on the short-staple system. The processing of short and shortened wool was substantially reviewed by Taylor [28] and more recently by Erdurson and Hunter [10].

Wool has been blended on the cotton system with other fibers in various different ways and for several reasons. Adding small quantities of wool to either cotton or polyester improves aesthetics, drape, and hand, and gives other characteristics that cannot be obtained using one fiber alone. Similarly, adding relatively small quantities of cotton or synthetic fibers produces stronger, wool-rich yarns with increased utility, using the short staple system. The physical properties relating to durability and comfort are combined to obtain the best from both fiber types, while at the same time, less desirable properties of the individual fibers are suppressed.

One current rationale for performing research with short (or shortened) wool on the cotton system is explained as follows. For preparing knitting and weaving yarns there were only 392,057 worsted and 198,581 woolen spindles existing in the U.S.A. in 1978 [7] compared to 2,510,000 and 2,265,000, respectively, in 1930 [11]. This trend has been accompanied by a fall in the U.S. consumption of wool from 317.5 million kilograms in 1950 to 56.0 million kilograms in 1980 (see Table I) and a decline in domestic production from 120.3 million kilograms in 1960 to 56.4 million kilograms in 1980 (see Table II). It appears reasonable that these last two trends could be reversed by either the expansion of the U.S. worsted and woolen indus-

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TABLE I. U.S. fiber consumption, 1950–1980 (millions of kilograms).

Fiber type	1950[a]	1960[a]	1970[a]	1980
Noncellulosics	61.2	294.8	1723.7	3645.2[b]
Cellulosics (manmade)	635.0	499.0	725.8	341.4[b]
Cotton	2177.3	1905.1	1769.0	1416.0[b]
Wool (scoured)	317.5	222.3	127.0	56.0[c]

[a] Source: *Modern Textiles,* vol. LX, no. 3, p. 40, March 1979. [b] Source: *Textile Organon,* vol. 52, no. 11, 1981. [c] Source: Cotton and Wool, Outlook and Situation, March 1982, U.S. Department of Agriculture.

TABLE II. U.S. production of shorn wool[a] (millions of kilograms, clean basis).

Year	Total production
1960[a]	120.3
1965[a]	91.4
1970[a]	73.3
1975[a]	54.5
1980[b]	56.4

[a] Source: Cotton and Wool Situation, CWS-14, February, 1979, U.S. Dept. of Agriculture. [b] Source: Cotton and Wool, Outlook and Situation, March 1982, U.S. Dept. of Agriculture.

tries or by the adaptation of the wool fiber to the more prevalent short-staple system. This latter approach has interested the Textile Research Center and numerous other groups of researchers [1–6, 9, 13–27, 29, 30] for some time.

Wool in various forms (scoured and carbonized stock, top, cut top and stretch-broken top) has been blended with other fibers on the cotton system in four ways. Intimate blends have been produced by mixing the raw materials in the blowroom [1, 2, 14, 15, 20, 25, 26, 27]; wool in the form of sliver and cotton in the form of lap have been blended at the card [1]; slivers composed of different fibers have been blended at the drawframe using both conventional and slip drafting [1, 2, 5, 9, 13, 19, 29]; and wool has been blended with cotton on the cotton spinning frame using a double creeling technique in which one roving bobbin contains wool and the other roving the cotton [22].

If the processing of wool on the cotton system were to be extremely successful, shortages of suitable wools could result. Consequently, approaches using cut and stretch-broken top and short-shorn wool are being investigated. A financial advantage appears to exist when the last approach is compared to the other two [20]. A domestic shortage of short-shorn wool of suitable lengths and diameters for the cotton system existed at the start of our study. We used cut-top wool in this study rather than stretch-broken staple since the latter was also not available in reasonable quantities in the U.S. at the outset of this research project.

Until recently, little information was available concerning the results of preparing, dyeing, and finishing wool and wool-blend fabrics composed of yarns manufactured on the short-staple system. Ellis *et al.* [8] compared the results of dyeing and finishing trials on a medium-weight trousering fabric prepared from conventional worsted spun wool-blend yarns with those from short-staple yarns of different blend content, twist levels, fiber length, and polyester type. They concluded that finishing in nonwool specific equipment produced fabrics with hand characteristics similar to those of worsted spun and finished fabrics but pointed out that some differences in fabric physical properties were observed and that pilling was an area for potential concern. In a later short communication [12] this particular problem was dismissed in light of the results of wear trials. The short-staple blend fabrics had lower breaking load, breaking extension, and abrasion resistance than their worsted counterparts.

This paper reports on the production of wool-blend ladies' wear fabrics on the short staple system, highlighting some production problems together with their solutions. An additional object is to suggest simple finishing routines that will produce satisfactory laundering performance of these fabrics. The initial stages of the study have been presented elsewhere [21] and only a brief summary of the spinning phase will be included here.

Raw Materials and Methods

The raw material characteristics of the wools, cotton, and polyester used in this study are shown in Table III. Table IV shows the fiber proportions of each blend studied up to the yarn but not necessarily into the fabric stage.

MECHANICAL PROCESSING

Figure 1 illustrates the sequence and types of mechanical processes to which the various blends were subjected. Following preliminary small-scale processing trials, it became apparent that the two 100% wools would require some kind of treatment before satisfactory mechanical processing performances (especially in carding and spinning) could be obtained. We tested various additives and found that Alubrasol 50-PI (1% owf, manufactured by Jordan Chemical Company, Folcroft, Pennsylvania) eliminated problems due to static electricity and increased interfiber cohesion. Consequently, both wool lots were sprayed with this

TABLE IIIa. Raw-material characteristics, wools.

Fiber property	Test method	62's	80's
Mean diameter, μm	Maturimeter	23.33	19.10
Mean diameter, μm	Microprojection, ASTM D2130	23.43	18.48
Coefficient of variation of mean diameter, %		23.05	20.55
Mean length, mm (in)	ASTM D1575	33.3 (1.31)	30.7 (1.21)
Coefficient of variation of mean length, %		35.70	40.10
Solvent extractables, %	Benzene/methanol azeotrope solvent, ASTM D1574	2.21	2.14
Vegetable matter, %	ASTM D1113	0.05	0.04

TABLE IIIb. Raw material characteristics, cotton.

Fiber property	Test method	Del Cerro cotton, avg. of 4 bale mix
Micronaire value	Micronaire, ASTM D1448	4.1
2.5% Span length, mm (in)	Fibrograph, ASTM D1447	31.7 (1.25)
Uniformity ratio, %	Fibrograph, ASTM D1447	44.3
Short fibers, %	Fibrograph, ASTM D1447	5.3
'0' Gauge strength, kN/mm^2 (1,000 lbs/in^2)	Pressley, ASTM D1445	0.726 (106.2)
1/8" Gauge strength, kN m/g (g/tex)	Stelometer, ASTM D1445	303.7 (31.0)
Elongation at break, %	Stelometer, ASTM D1445	5.6
Nonlint content, %	Shirley analyzer, ASTM D2812	2.4
Grade	Colorimeter, ASTM D2253	SLM+

TABLE IIIc. Raw material characteristics, polyester.

Fiber property	
Type	Hoechst, 351 (low pill)
Fiber mass per unit length, millitex (den)	167 (1.5)
Mean fiber length, mm (in)	38.1 (1.5)

TABLE IV. Fiber proportions in the blends studied.

Group A cotton/wool, 62's	Group B cotton/wool, 80's	Group C polyester/wool, 62's	Group D polyester/wool, 80's
100/0	–	100/0	–
75/25	75/25	75/25	75/25
50/50	50/50	50/50	50/50
25/75	25/75	25/75	25/75
0/100	0/100	–	–

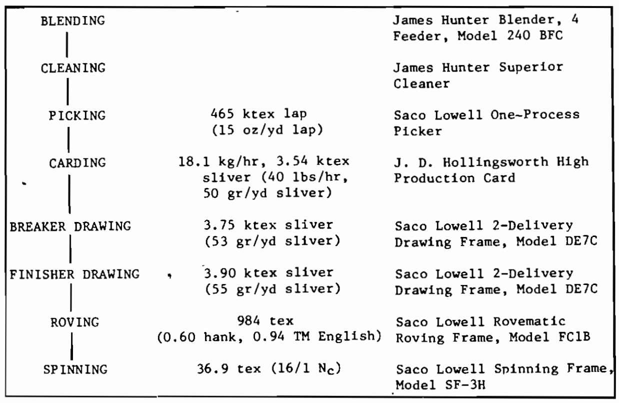

FIGURE 1. Mechanical processing of fibers into yarn.

product and were allowed to recondition prior to full-scale mechanical processing.

The machinery settings for the blending, opening, cleaning, and picking processes were those normally used for processing cotton with one exception. Due mainly to the relatively high bulk and sponginess of the wool and wool blends, as compared to cotton, it was necessary to produce only half-laps at the picker (average weight 11.3 kg). By restricting lap weights to this quantity, lap splitting was invariably eliminated.

The carding performances of the wools (after over-spraying) and wool/cotton and wool/polyester blends were entirely satisfactory using the card settings normally employed for cotton. The temperature and relative humidity of the card room were 298°K (25°C) and 50%, respectively. A production rate of 18.1 kg/h (40 lb/hour) was used to produce a 3.54 ktex (50 gr/yd) sliver.

The only adjustments made in drawing, roving, and spinning were to accommodate the longer fiber lengths of some of the wool. For numerous reasons, the bulks of each yarn were not spun at twist multipliers that would yield maximum strength. Generally, a compromise situation was reached between maximum yarn strength and yarn liveliness with consideration to subsequent utility and processing efficiency.

Slashing

The warp yarns (2496 ends of 36.9 tex yarn) were slashed using a mixture of polyvinyl alcohol (22.7 kg) and paraffin wax (227 g) in water (378.5 dm^3) to yield (approximately) a 5% solids add-on.

Weaving

A series of fabrics constructed in a 12 × 12 crepe weave (20.5 ends/cm × 19 picks/cm, 1.32 m width; Figure 2) was woven on a Crompton and Knowles C8 4 × 1 box loom. This (particular) construction was chosen so that the fabrics produced would have direct appeal to and utility in the women's wear segment of the market. Had the yarns produced in the earlier part of the study proved to be irregular, this weave would have effectively camouflaged the problem. Since yarn irregularity was not excessive in most of the yarns produced, this characteristic of the weave was not required.

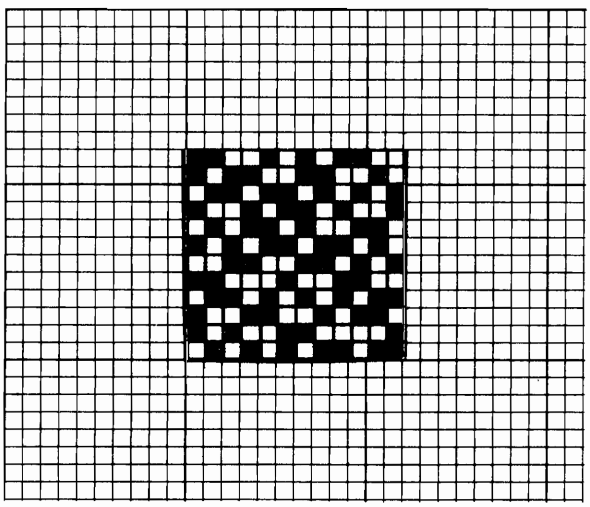

FIGURE 2. A 12 × 12 crepe weave.

Prefinishing Trials

While some of the fabrics were still in production, 10 fabrics that had already been woven were used to study the effects of laundering on physical properties with a view to ascertaining the specific shortcomings of the desized fabrics. In this way, it was possible to deduce and subsequently develop those physical and chemical fabric treatments necessary to produce dimensional stability while maintaining optimum hand.

Desizing was performed in open width in a jig and was continued until polyvinyl alcohol in the fabrics was undetectable. The desized fabrics were relaxed (probably to varying degrees) and dried simultaneously by overfeeding them into a two-drum heat exchange unit following tentering.

Ten specimens (76.2 × 76.2 cm) from each of the 10 fabric types were prepared for laundering and subsequent evaluation. The fabrics were evaluated initially and at laundering intervals of 5, 15, and 25 cycles using the indicated testing procedures.

Finishing

The cotton/wool fabrics were finished according to the scheme outlined in Figure 3. Figure 4 outlines the operations used to finish the wool/polyester fabrics. All wet processing was performed in open width in a jig.

```
Singe
|
Desize
|
Dry
|
Bleach (pad-cold batch)
|
Dye    (direct and acid)
|
Dry
|
Chemical Finish (crease, shrink and pill-resist)
|
Semi-decate
```

FIGURE 3. Finishing scheme for cotton/wool fabrics.

```
Singe
|
Heat set
|
Desize
|
Dye (disperse and acid)
|
Dry
|
Semi-decate
```

FIGURE 4. Finishing scheme for polyester/wool fabrics.

Wool/Cotton Procedure

Immediately after singeing, the fabrics were thoroughly desized in hot (368°K) water containing nonionic detergent (0.2% owf). The fabrics were then dried and padded (100% wet pickup) with a bleach solution containing 4.5% w/v hydrogen peroxide (35%), 4.5% w/v sodium silicate (42° Be), and 0.1% w/v Triton X100, and allowed to rotate on an A-frame, out of contact with air, for 16 hours at room temperature.

Subsequent rinsing rendered the fabrics suitable for dyeing, which was achieved in a standard manner using direct and acid dyes to produce solid shades. Using information acquired during the prefinishing trials and later in the finish-development experiments, the dyed fabrics were padded (70% wet pickup) with a finish formulation containing 20% w/v Rhoplex K3 (Rohm and Haas Company), 10% w/v Permafresh (2/3 LF + 1/3 197) (Sun Chemical Corporation), 2.5% w/v Catalyst KR (Sun Chemical Corporation), 5% w/v Mykon 333 (Sun Chemical Corporation), 0.2% w/v Triton X100 (Rohm and Haas Company), and 62.3% w/v water; dried at 110°C; and cured at 160°C for 1½ minutes. Finally, the fabrics were semi-decated using two 4-minute steam/2-minute vacuum cycles.

Rhoplex K3 is a self-crosslinking acrylic emulsion and undoubtedly serves several functions when applied to fabrics composed of cotton and wool. By coating the wool fibers, it can mask the effect of the wool scales and thus enhance dimensional stability during laundering. By coating both wool and cotton fibers, the acrylic polymer can serve as an effective barrier to wear by abrasion. As an adhesive compound, it can cause fibers to stick to each other in the body of the fabric and thus help prevent the formation of pills on the surface. In conjunction with the Permafresh compounds, Rhoplex K3 would enhance the smoothness of cotton/wool fabrics after laundering. When applied alone, Rhoplex K3 would cause tensile strength to increase slightly, but it would also have a deleterious effect on fabric hand. The Permafresh compounds are cellulose crosslinking chemicals used to improve resistance to creasing in cotton-containing fabrics. Improvements in fabric wrinkle resistance, dimensional stability, and appearance after laundering are achieved with concurrent reductions in resistance to abrasion and tensile strength. These compounds would also produce a relatively harsh hand. Mykon 333 is a fatty-amide cationic softener and was included in the formulation to compensate for the harshening effects of Rhoplex K3 and Permafresh (2/3 LF + 1/3 197). Catalyst KR catalyzes the crosslinking reactions of the Permafresh compounds and Triton X100 is a wetting agent.

Wool/Polyester Procedure

These fabrics were singed, heat set at 180°C for 30 seconds, and desized using hot (95°C) water and nonionic detergent (0.1% owf). Standard acid- and disperse-dyeing operations were performed in the jig to produce solid shades. The fabrics were semi-decated using two 3-minute steam/2-minute vacuum cycles.

Physical Testing

All physical testing of yarns and fabrics was performed at 294°K (21°C) and 65% relative humidity. All the tests reported were conducted in compliance with the referenced ASTM and AATCC test methods.

Results and Discussion

SPINNING

The physical properties of the card webs and slivers, drawframe slivers, rovings, and yarns have been presented in detail and discussed elsewhere [21]. Predictably, the quantity of neps in the wool/cotton blends tended to decrease as the proportion of cotton in the blends decreased. Neps were not observed in the wool/polyester card webs. A strong trend was observed in which the coefficients of variation of the drawn slivers and rovings increased with increasing wool content. Similarly, the amount of fiber waste in opening, picking, and carding also increased with increasing wool content.

Results of twist-multiplier studies performed on the 36.9 tex yarns are summarized in Table V where count-strength products are used as a measure of yarn strength. In order to yield maximum yarn strengths, twist multipliers (English, cotton count) between 4.00 and 5.00 were required for the cotton, wool, and cotton/wool blends. Twist multipliers of between 3.25 and 5.00 were required for the polyester, wool, and

TABLE V. Optimum twist multipliers and resulting yarn strengths for 36.9 tex (16/1 N_c) yarns.

Fiber content	Twist multiplier, English	Count-strength product, English
Cotton/wool, 62's		
100/0	4.00	2880
75/25	4.00	2070
50/50	4.40	1550
25/75	4.40	935
0/100	5.00	712
Cotton/wool, 80's		
75/25	4.00	2280
50/50	4.00	1570
25/75	4.17	1070
0/100	4.40	720
Polyester/wool, 62's		
100/0	3.50	3240
75/25	3.25	2510
50/50	3.50	1710
25/75	4.25	1160
Polyester/wool, 80's		
75/25	3.50	2610
50/50	3.50	1875
25/75	4.00	1360

polyester/wool blends. Generally, the polyester/wool yarns required less twist for maximum strength than their cotton/wool counterparts. In the cases of all blend categories, optimum yarn strength decreased as wool content increased. Similarly, the optimum strengths of the yarns containing 80's wool were always marginally higher than the corresponding yarns containing 62's wool. The optimum strengths, uniformities, and elongations at break of the yarns composed of polyester and wool were invariably higher than those of the corresponding cotton/wool yarns.

PREFINISHING TRIALS

The results of the prefinishing trials are summarized in Tables VI through X. All fabrics shrank progressively as the number of launderings increased, the extent of shrinkage increasing as the wool content increased. The cotton/wool blends shrank significantly more than the polyester/wool fabrics, which led to the conclusion that the former fabrics require chemical stabilization in order to achieve domestic acceptance. In addition to improving dimensional stability, the chemical finish for the cotton/wool fabrics is necessary to improve resistance to abrasion, pilling, and fabric appearance. At the same time, any reduction in tensile strength or modification of hand should be minimized. Subsequently, we developed a chemical finish to overcome some of the problems of the cotton/wool fabrics and this is described in the Methods section. We also developed a finishing scheme to improve the polyester/wool fabrics.

TABLE VI. Dimensional changes of the fabrics after multiple launderings (warp + filling, % shrinkage).[a]

Fabric composition	Number of launderings		
	5	15	25
Cotton/wool, 62's			
100/0	11.2	14.8	17.0
75/25	9.8	15.5	19.5
50/50	18.7	34.3	49.8
Cotton/wool, 80's			
50/50	21.0	40.8	57.3
25/75	37.0	75.0	103.0
Polyester/wool, 62's			
100/0	0.2	0.2	0.2
75/25	0.5	2.2	3.7
50/50	2.0	2.8	4.3
Polyester/wool, 80's			
75/25	1.5	2.7	4.3
50/50	3.7	5.3	6.7

[a] Measured in accordance with AATCC Test Method 135-1978 with a wash temperature of 70 ± 2°F and a drying temperature of 60 ± 11°C.

TABLE VII. Abrasion resistance of the fabrics after multiple launderings (cycles).[a]

Fabric composition	Number of launderings			
	0	5	15	25
Cotton/wool, 62's				
100/0	387	374	301	236
75/25	371	357	301	293
50/50	327	365	567	750
Cotton/wool, 80's				
50/50	348	391	1119	1645
25/75	495	597	1879	3575
Polyester/wool, 62's				
100/0	657	409	385	370
75/25	544	372	345	344
50/50	434	427	343	348
Polyester/wool, 80's				
75/25	434	423	400	392
50/50	441	449	432	418

[a] Measured in accordance with ASTM D 1175-71 using the Taber rotary platform double-head abraser (1000 g weights and CS-10 abrasive wheels).

TABLE VIII. Resistance to pilling of the fabrics after multiple launderings.[a]

Fabric composition	Number of launderings			
	0	5	15	25
Cotton/wool, 62's				
100/0	3.9	3.6	3.6	3.6
75/25	4.4	3.9	3.6	2.6
50/50	4.3	3.9	3.6	1.8
Cotton/wool, 80's				
50/50	3.8	2.9	2.5	1.7
25/75	4.0	2.5	2.0	1.8
Polyester/wool, 62's				
100/0	4.9	4.8	4.7	4.4
75/25	4.4	3.1	2.9	2.8
50/50	3.9	3.6	3.4	3.2
Polyester/wool, 80's				
75/25	4.4	3.2	3.1	3.0
50/50	4.7	3.9	3.4	3.0

[a] Measured in accordance with ASTM D3512-76 (random tumble pilling test) on a scale from 5 (no pilling) to 1 (very severe pilling).

WET PROCESSING AND FINISHING

The amounts of size picked up by each warp are shown in Table XI. These quantities reflect the amounts retained by the various yarns when slashed in an identical manner. For the cotton/wool blends, size retention generally decreased as wool content increased. For the wool/polyester blends, size retention would again be expected to decrease as wool content increased, but the actual measurements indicate erratic retention.

All desized fabrics were analyzed for fiber content. The results of these analyses are shown in Table XII. The fabric weight per unit area and thread counts are shown in Tables XIII and XIV, respectively. Generally,

TABLE IX. Tensile strength of the fabrics after multiple launderings (warp direction breaking load, kg).[a]

Fabric composition	Number of launderings 0	5	15	25
Cotton/wool, 62's				
100/0	47.2	44.8	45.6	43.2
75/25	32.4	31.8	31.4	31.0
50/50	25.2	24.0	23.8	23.6
Cotton/wool, 80's				
50/50	29.6	29.8	25.6	18.4
25/75	21.8	21.6	19.8	18.2
Polyester/wool, 62's				
100/0	58.4	57.8	59.0	59.0
75/25	45.0	44.4	42.8	43.4
50/50	34.8	34.4	30.4	28.4
Polyester/wool, 80's				
25/75	50.0	49.8	49.8	48.0
50/50	36.4	35.6	34.8	34.2

[a] Measured in accordance with ASTM D1682-64.

TABLE X. Durable press ratings of the fabrics after multiple launderings.[a]

Fabric composition	Number of launderings 5	15	25
Cotton/wool, 62's			
100/0	2.8	2.7	2.3
75/25	3.8	3.2	2.7
50/50	3.8	3.2	2.0
Cotton/wool, 80's			
50/50	3.8	3.3	2.3
25/75	3.5	2.0	2.8
Polyester/wool, 62's			
100/0	4.2	3.5	3.0
75/25	4.2	3.5	3.0
50/50	3.7	3.0	3.0
Polyester/wool, 80's			
75/25	3.2	3.0	2.2
50/50	3.7	3.0	2.3

[a] Measured in accordance with AATCC Test Method 124-1978 on a scale from 5 (very smooth, pressed appearance) to 1 (crumpled, creased, and severely wrinkled appearance).

TABLE XI. Size retention.

Fabric composition	Size add-on, %
Cotton/wool, 62's	
100/0	7.15
75/25	5.91
50/50	5.97
25/75	3.38
Cotton/wool, 80's	
50/50	5.89
25/75	3.21
Polyester/wool, 62's	
0/100	6.63
25/75	4.83
50/50	5.69
75/25	3.22
Polyester/wool, 80's	
25/75	5.04
50/50	4.49
75/25	4.80

TABLE XII. Nominal and actual fiber contents of desized fabrics.

Nominal fabric composition	Actual fabric composition
Cotton/wool, 62's	
100/0	100/0
75/25	76.1/23.9
50/50	52.7/47.3
25/75	25.5/74.5
Cotton/wool, 80's	
50/50	52.7/47.3
25/75	25.9/74.1
Polyester/wool, 62's	
0/100	0/100
25/75	21.7/78.3
50/50	45.2/54.8
75/25	70.3/29.7
Polyester/wool, 80's	
25/75	21.7/78.3
50/50	46.4/53.6
75/25	69.3/30.7

TABLE XIII. Fabric weights, mass/unit area, g/m^2 (oz/yd^2).

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	151 (4.45)	163 (4.80)
75/25	151 (4.45)	157 (4.62)
50/50	149 (4.40)	163 (4.80)
25/75	163 (4.82)	168 (4.95)
Cotton/wool, 80's		
50/50	181 (5.35)	185 (5.45)
25/75	155 (4.58)	168 (4.95)
Polyester/wool, 62's		
0/100	183 (5.40)	197 (5.80)
25/75	151 (4.45)	164 (4.85)
50/50	149 (4.40)	156 (4.59)
75/25	156 (4.60)	156 (4.59)
Polyester/wool, 80's		
25/75	153 (4.50)	166 (4.90)
50/50	153 (4.50)	168 (4.95)
75/25	157 (4.62)	166 (4.90)

TABLE XIV. Fabric thread counts, p/cm + e/cm (p/in + e/in).

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	39.4 (100)	39.8 (101)
75/25	39.8 (101)	39.8 (101)
50/50	39.8 (101)	39.8 (101)
25/75	41.7 (106)	40.2 (102)
Cotton/wool, 80's		
50/50	40.9 (104)	40.9 (104)
25/75	39.4 (100)	40.9 (104)
Polyester/wool, 62's		
0/100	44.1 (112)	43.7 (111)
25/75	39.8 (101)	41.7 (106)
50/50	40.2 (102)	40.9 (104)
75/25	40.5 (103)	41.3 (105)
Polyester/wool, 80's		
25/75	40.2 (102)	41.3 (105)
50/50	40.9 (104)	41.3 (105)
75/25	40.9 (104)	39.8 (101)

decreases in fabric weights resulted from desizing, this weight loss corresponding to the removal of size but being tempered, to varying extents, by fabric shinkage. As expected, the weights of the cotton/wool fabric are increased by finishing while the thread counts of desized and finished fabric remain almost identical. Anomalously, the weights of the wool/polyester fabrics also increase, despite minimal differences in construction between desized and finished fabrics.

Table XV shows the breaking strengths of the 13 fabrics in the desized and finished states. For both types of blend fabric, strength decreases as wool content increases. The wool/polyester blends are stronger than their cotton/wool counterparts. There are no significant differences in strength between fabrics of similar blend level containing 62's and 80's wool. The strengths of the cotton-rich cotton/wool fabrics are decreased (8.37%) by chemical finishing, whereas the strengths of the two 25/75 cotton/wool fabrics actually increase (3–10%). Heat setting and semi-decating of the polyester-rich wool/polyester fabrics caused fabric strength to increase (1–14%), whereas the same procedures performed on the two wool-rich fabrics caused decreases (2–7%) in strength.

TABLE XV. Fabric strength, W + F, Kg (lb).[a]

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	67.9 (149.6)	42.4 (93.4)
75/25	51.8 (114.3)	41.6 (91.7)
50/50	36.6 (80.7)	33.4 (73.7)
25/75	30.1 (66.3)	33.1 (73.0)
Cotton/wool, 80's		
50/50	45.5 (100.1)	41.7 (91.9)
25/75	31.5 (69.5)	32.6 (71.8)
Polyester/wool, 62's		
0/100	82.5 (181.9)	94.3 (208.0)
25/75	78.4 (172.9)	84.7 (186.8)
50/50	58.7 (129.4)	59.4 (131.0)
75/25	43.6 (96.1)	40.5 (89.4)
Polyester/wool, 80's		
25/75	74.1 (163.4)	80.1 (176.5)
50/50	58.9 (129.8)	64.6 (142.5)
75/25	45.0 (99.2)	43.9 (96.9)

[a] Measured in accordance with ASTM Test Method D 1682-64.

Fabric tear strengths are presented in Table XVI. As the wool content of the blends increases, tear strengths decrease. The wool/polyester fabrics have higher tear strengths than their cotton/wool counterparts. There are no significant differences between the tear strengths of fabrics containing 62's wool and those of the same blend level containing 80's wool. Large reductions (34–73%) in tear strength are caused by chemically finishing the cotton/wool fabrics; however, we note here that the actual percent reductions in strength after finishing decrease as the wool content increases, thus demonstrating that the cotton component of the blend is mainly responsible for the reduced strengths. The finishing processes performed on the wool/polyester fabrics caused considerable reductions (25–39%) in tear strengths. Again, we note that the percentage decreases in tear strength decrease as wool content increases, which suggests that the strength of the polyester component of the blend is being undermined in finishing.

TABLE XVI. Fabric tear strength, W + F, Kg (lb).[a]

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	12.7 (28.1)	3.4 (7.5)
75/25	9.9 (21.8)	3.5 (7.7)
50/50	6.9 (15.3)	3.0 (6.7)
25/75	4.8 (10.7)	3.1 (6.9)
Cotton/wool, 80's		
50/50	6.6 (14.7)	3.9 (8.7)
25/75	5.1 (11.2)	2.9 (6.4)
Polyester/wool, 62's		
0/100	TS[b] (TS)	5.0 (11.1)
25/75	12.2 (27.0)	7.5 (16.5)
50/50	10.6 (23.3)	6.9 (15.2)
75/25	7.4 (16.3)	5.4 (11.9)
Polyester/wool, 80's		
25/75	12.6 (27.8)	8.5 (18.8)
50/50	10.8 (23.8)	7.7 (16.9)
75/25	8.0 (17.7)	6.0 (13.3)

[a] Measured in accordance with ASTM Test Method D 1424-63. [b] TS = too strong to tear in warp direction.

The resistances to flex abrasion of the desized and finished fabrics are shown in Table XVII. Finishing drastically undermines the flex abrasion resistance of all the wool/cotton fabrics, whereas the wool/polyester fabrics show a small improvement after finishing. As the wool content of both blends increases, the resistance

TABLE XVII. Fabric flex abrasion resistance, W + F, cycles.[a]

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	2658	291
75/25	2689	512
50/50	1522	591
25/75	1254	910
Cotton/wool, 80's		
50/50	1586	1408
25/75	893	979
Polyester/wool, 62's		
0/100	2464	652
25/75	2250	2868
50/50	2187	2331
75/25	1424	1398
Polyester/wool, 80's		
25/75	2899	2945
50/50	2162	2450
75/25	1231	1364

[a] Measured in accordance with ASTM Test Method D 1175-71.

to flex abrasion decreases. The resistance to flex abrasion of wool/polyester fabrics is invariably higher than their wool/cotton counterparts. No significant differences appear to exist between the resistances to flex abrasion of the fabrics containing 62's wool and those of similar blend levels containing 80's wool.

The data on fabric shrinkage due to home launderings are presented in Table XVIII. The finish applied to the cotton/wool fabrics is shown to control shrinkage effectively, whereas the finishing sequence performed on the wool/polyester fabrics barely affects this property. In fact, the two wool-rich wool/polyester fabrics exhibit so much shrinkage that they obviously could not be recommended for home laundering. For desized cotton/wool blend fabrics, those containing 80's wool shrink more than similar fabrics containing 62's wool. There does not appear to be a similar trend in the case of the wool/polyester fabrics.

TABLE XVIII. Fabric shrinkage due to home laundering after 5 wash-tumble-dry cycles, W + F, %.[a]

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	18.7	2.1
75/25	20.1	2.4
50/50	18.3	3.6
25/75	21.5	7.1
Cotton/wool, 80's		
50/50	19.6	4.9
25/75	45.0	6.3
Polyester/wool, 62's		
0/100	2.4	2.4
25/75	3.5	2.7
50/50	6.9	6.6
75/25	12.5	11.3
Polyester/wool, 80's		
25/75	3.2	3.4
50/50	4.9	7.1
75/25	11.5	12.4

[a] Measured after AATCC Test Method 124-1978, Machine Wash Conditions III, Drying Procedure B.

Durable press (DP) ratings of the fabrics are given in Table XIX. Most of the fabrics exhibited DP ratings in the desized state between 3.0 and 3.5, the notable exception being polyester/wool (62's) 75/25 which was rated at 4.0 after desizing. The chemical finish significantly increased the ratings of cotton and the cotton-rich cotton/wool fabric, whereas lesser effects were observed for the 50/50 and 75/25 wool/cotton blends. Heat setting and semi-decating appeared to have no effect on the durable press appearance of the wool/polyester fabrics after washing. No significant differences in appearance were found between the cotton/wool and polyester/wool blends. The wool grade did not have a noticeable effect on fabric appearance.

TABLE XIX. Fabric durable press rating after home laundering (5 WTD cycles, scale 5-1).[a]

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	3.0	5.0
75/25	3.0	4.0
50/50	3.0	3.7
25/75	3.0	3.5
Cotton/wool, 80's		
50/50	3.5	3.5
25/75	3.5	3.5
Polyester/wool, 62's		
0/100	3.5	3.5
25/75	4.0	3.7
50/50	3.5	3.7
75/25	3.2	3.2
Polyester/wool, 80's		
25/75	3.7	3.5
50/50	3.5	3.5
75/25	3.2	4.0

[a] Measured in accordance with AATCC Test Method 124-1978, Machine Wash Conditions III, Drying Procedure B.

As shown in Table XX, the pilling propensities of the wool/cotton and wool/polyester fabrics in the desized state range from poor to very poor. These generally poor pilling properties were totally overcome in the case of the cotton-containing fabrics by applying the chemical finish. Similarly, the pilling properties of the wool/polyester fabrics were improved by heat setting and semi-decating. Again, the fineness of the wool did not cause significant differences in pilling propensity.

TABLE XX. Fabric pilling propensity (scale 5-1).[a]

Fabric composition	Desized	Finished
Cotton/wool, 62's		
100/0	2	5
75/25	1	5
50/50	1	5
25/75	2	5
Cotton/wool, 80's		
50/50	1	5
25/75	4	5
Polyester/wool, 62's		
0/100	5	5
25/75	1	4
50/50	1	5
75/25	2	4
Polyester/wool, 80's		
25/25	1	5
50/50	2	5
75/25	2	4

[a] Measured in accordance with ASTM Test Method D 3514-76T.

Conclusions

In all, 13 apparel fabrics were produced in this study. The fabrics were wholly composed of yarns which had been spun on the short-staple system. Generally, increasing the wool content of a fabric decreased its tensile properties; wool/polyester blends exhibited higher tensile properties than cotton/wool blends of a similar wool content; in this narrow range, the grade of wool used in a specific blend did not significantly alter the tensile properties, durable-press ratings, or pilling propensities. Cotton/wool fabrics containing 80's wool, however, shrank significantly more than their counterparts containing 62's wool. Most of the fabrics exhibited the expected, serious shortcomings in the desized state, these being primarily associated with excessive shrinkage and pilling. Finishing formulations and routines were developed, applied, and were ultimately reasonably successful in overcoming some of these problems. Minimal differences in fabric properties were caused by the substitution of 62's with 80's wool.

We achieved the objectives of our study and obtained further information concerning the processing of cut-top wools (in blends with polyester and cotton) on the short-staple system of spinning. Yarns produced in this manner were incorporated into a standard ladies' wear fabric and finishing procedures were developed to render most of the fabrics suitable for machine washing.

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