End-Use Performance of Some Indian and Crossbred Sheep Wools


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Fibre and fabric characteristics of Rambouillet and Merino crosses with Chokla and Nali, Chokla and Corriedale sheep wools are reported. Crossbreeding improves the fibre fineness and reduces the percentage medullation and length. The reduction in fibre length increases the noil extraction. Fabrics produced from crossbred sheep wools are better in terms of feel, visual appeal, etc. The presence of hetero and hairy fibres in halfbred wools imparts a rough feel and uneven surface appearance due to differential dye uptake.

Chokla (C) and Nali (N) breeds of Rajasthan produce medium and medium coarse wools which are utilized in the carpet sector. With the aim of improving the quality of these breeds, programmes of crossbreeding with exotic Rambouillet (R) and Merino (M) breeds are going on at the institute. Very little work has been done on the evaluation of crossbred wools. Pokharna and Patni evaluated the spinnability of Rambouillet and Chokla and their crosses at three blood levels and also compared these crosses with exotic crossbred Corriedale. Gupta et al. compared the fibre and yarn characteristics of Nali and Nali cross wools. In other countries work has been restricted to only fine Merino type of wools and their end-use suitability is established for fine worsted fabrics throughout the world. Dusenbury and Dansizer studied the effect of fibre diameter and crimp on the characteristics of wool fibres and other fibre assemblies by selecting six wools of varying fineness, crimp frequency and length. But no such work has been done for Indian wool, especially for crossbred wools. In the present study, efforts have been made to see the end-use suitability of the Indian crossbred wools being developed. The parental Chokla has been included with a view to working out the improvements in various crossbreds over it. A medium quality exotic crossbred Corriedale wool has also been included for comparison purpose.

Materials and Methods

The following wools of September 1976 clip were taken from the sheep flocks being maintained at the institute and its substation at Mannavanur: Chokla, R (50%) x C (50%), R (62.5%) x C (37.5%), R (75%) x C (25%), R (50%) x N (50%), M (50%) x N (50%), M (50%) x C (50%) and Corriedale. The processing of the material was done as reported elsewhere and from each wool 18 Nm warp and 11.5 Nm weft yarn were prepared keeping a TM of 120 and 100 respectively. Since warp yarn was required to be used as double yarn in fabric construction, plying was done on a Torigoe Japanese doubler. Fabrics were prepared on Cimmco, Gwalior, loom (width, 40 in) fitted with loose reed, negative let-off and seven wheel takeup motion. Special care was taken to keep the tension uniform throughout the preparation of the eight experimental fabrics. Dyeing (Khaki colour) was done simultaneously in one bath under actual mill conditions and standard dyeing practices were employed. Finishing was done as per IS specifications.

Representative wool samples were drawn from the experimental wools and staple length, crimp/cm, fibre length, diameter, percentage medullation, breaking tenacity and extension were estimated. The values for work to yield point and work to rupture were calculated from the curves obtained on Instron chart. The vegetable matter content was estimated as per IS specifications.

Ten skeins, each of 100 m, were prepared from each yarn sample on warp reel and weighed on Sauter monopan balance to 0.01 g accuracy. Yarn number (Nm) was obtained by dividing the skein length with its weight. Tenacity and elongation tests were performed on Instron tester. The crosshead speed was so adjusted as to break the yarn in 20 ± 3 sec. The tenacity value in g/tex was obtained by dividing the breaking load with tex. Yarns were tested for their evenness in terms of CV% on YET evenness tester (Hungary made). For counting the number of fibres per cross-section, a continuous length of yarn was spread on a velvet board and from an equal distance of 1 m, 0.5 cm of yarn was cut with the help of a sharp razor blade; this was
untwisted and each fibre was counted with the help of a
telecounter. From one bobbin five observations were
recorded and for each yarn number, 25 observations
from a set of five bobbins were recorded.

Actual ends and picks per cm and wt/m² were
determined as per IS specifications. Strip strength
was observed on Instron keeping a gauge length of
200 mm and width of the specimen, 75 mm. From each
sample, five tests were performed each way. Shirley
stiffness tester of fixed angle type (41.5°) was used for
measuring the bending length in cm as per the
recommended method. The overall flexural rigidity
($G_o$) of the fabric was calculated as $G_o = (G_1 \times G_2)^{1/2}$,
where $G_1$ and $G_2$ are the flexural rigidity values in warp
and weft way. Flex abrasion testing was done on
Universal wear tester manufactured by the Custom
Scientific Instruments Inc., Kearny, New Jersey. The
fix weight was 3.5 lb. The number of cycles at which
rupture took place was noted. From each fabric, five
samples were tested each way. Crease recovery angles
were determined on Shirley crease recovery tester.
The number of pills was counted after every 2000
cycles from 10 × 10 cm fabric mounted on rubber tubes
using the apparatus manufactured by FORICOM,
Bombay. Three observations for each sample were
made for relaxation shrinkage and colour fastness to
artificial light. Visual assessment of the cloth was
made by five different judges (persons belonging to
different fields) and the final rank was given after the
statistical analysis.

Table 1—Physical and Mechanical Characteristics of Wool Fibres

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Wool</th>
<th>Staple length mm</th>
<th>Crimp fibre length mm</th>
<th>Fibre diameter µ</th>
<th>Medullation %</th>
<th>Tenacity g/tex</th>
<th>Extension %</th>
<th>Work to yield point g cm</th>
<th>Work to rupture g cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chokla</td>
<td>73.8</td>
<td>1.23</td>
<td>83.87 ± 1.43</td>
<td>32.27 ± 0.69</td>
<td>29.9</td>
<td>12.3</td>
<td>38.3</td>
<td>8.9</td>
</tr>
<tr>
<td>2</td>
<td>R(50%) × C(50%)</td>
<td>42.5</td>
<td>1.54</td>
<td>57.13 ± 0.88</td>
<td>26.59 ± 0.57</td>
<td>21.2</td>
<td>10.2</td>
<td>35.0</td>
<td>9.6</td>
</tr>
<tr>
<td>3</td>
<td>R(62.5%) × C(37.5%)</td>
<td>46.2</td>
<td>1.57</td>
<td>56.47 ± 0.98</td>
<td>22.09 ± 0.40</td>
<td>4.9</td>
<td>11.7</td>
<td>37.5</td>
<td>9.1</td>
</tr>
<tr>
<td>4</td>
<td>R(75%) × C(25%)</td>
<td>33.4</td>
<td>2.12</td>
<td>47.93 ± 1.18</td>
<td>21.36 ± 0.38</td>
<td>3.6</td>
<td>12.3</td>
<td>36.2</td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>R(50%) × N(50%)</td>
<td>39.9</td>
<td>1.36</td>
<td>55.70 ± 0.99</td>
<td>26.49 ± 0.69</td>
<td>25.9</td>
<td>10.6</td>
<td>36.1</td>
<td>10.3</td>
</tr>
<tr>
<td>6</td>
<td>M(50%) × N(50%)</td>
<td>32.9</td>
<td>1.96</td>
<td>59.28 ± 1.14</td>
<td>25.49 ± 0.76</td>
<td>16.4</td>
<td>11.8</td>
<td>38.5</td>
<td>12.7</td>
</tr>
<tr>
<td>7</td>
<td>M(50%) × C(50%)</td>
<td>37.7</td>
<td>1.91</td>
<td>60.55 ± 1.14</td>
<td>25.60 ± 0.71</td>
<td>16.8</td>
<td>11.7</td>
<td>42.3</td>
<td>11.5</td>
</tr>
<tr>
<td>8</td>
<td>Corriedale</td>
<td>47.5</td>
<td>2.06</td>
<td>78.58 ± 1.49</td>
<td>24.25 ± 0.47</td>
<td>5.2</td>
<td>13.1</td>
<td>35.6</td>
<td>15.7</td>
</tr>
</tbody>
</table>

*The values after ± are standard errors.
†The values given in parentheses are CV %.
Table 2 Characteristics of 11.5, 18.0 and 18.0/2 Nm Yarns

<table>
<thead>
<tr>
<th>Wool No.*</th>
<th>11.5 Nm</th>
<th>18.0 Nm</th>
<th>18.0/2 Nm</th>
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<tbody>
<tr>
<td></td>
<td>Tenacity g/tex</td>
<td>% Elongation</td>
<td>Uster CV%</td>
</tr>
<tr>
<td>1</td>
<td>4.97</td>
<td>6.9</td>
<td>16.0</td>
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<tr>
<td>2</td>
<td>5.06</td>
<td>8.3</td>
<td>15.7</td>
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<tr>
<td>3</td>
<td>5.03</td>
<td>11.1</td>
<td>15.8</td>
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<td>4</td>
<td>5.10</td>
<td>8.9</td>
<td>17.9</td>
</tr>
<tr>
<td>5</td>
<td>4.39</td>
<td>10.2</td>
<td>17.4</td>
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<tr>
<td>6</td>
<td>4.54</td>
<td>11.8</td>
<td>16.6</td>
</tr>
<tr>
<td>7</td>
<td>5.23</td>
<td>11.1</td>
<td>17.5</td>
</tr>
<tr>
<td>8</td>
<td>4.54</td>
<td>12.6</td>
<td>15.3</td>
</tr>
</tbody>
</table>

*Wool Nos correspond to wools at serial Nos 1 to 8 in Table 1.

Table 3—Vegetable Matter Content, Fibre Length of Raw Wool, Tops and Noils, and Noils Extracted

<table>
<thead>
<tr>
<th>Wool No.*</th>
<th>Vegetable matter content</th>
<th>Fibre length</th>
<th>Noils extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw wool</td>
<td>Tops</td>
<td>Noils</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>1</td>
<td>3.79</td>
<td>83.9</td>
<td>80.7</td>
</tr>
<tr>
<td>2</td>
<td>4.17</td>
<td>57.1</td>
<td>61.3</td>
</tr>
<tr>
<td>3</td>
<td>7.63</td>
<td>56.5</td>
<td>52.7</td>
</tr>
<tr>
<td>4</td>
<td>11.45</td>
<td>47.4</td>
<td>49.1</td>
</tr>
<tr>
<td>5</td>
<td>4.43</td>
<td>55.7</td>
<td>61.7</td>
</tr>
<tr>
<td>6</td>
<td>4.98</td>
<td>59.3</td>
<td>51.9</td>
</tr>
<tr>
<td>7</td>
<td>4.59</td>
<td>60.5</td>
<td>54.7</td>
</tr>
<tr>
<td>8</td>
<td>3.80</td>
<td>78.9</td>
<td>74.3</td>
</tr>
</tbody>
</table>

*Wool Nos correspond to wools at serial Nos 1 to 8 in Table 1.

The yarn tenacity and elongation results do not show any specific trend. Although in fineness Corriedale is almost similar to halfbred wools, its superior yarn strength is due to its better fibre length, whereas in the case of R(75%) x C(25%) and R(62.5%) x C(37.5%) it is due to the presence of higher number of fibres in their cross-section. R(75%) x C(25%), being the finest among all, contains maximum number of fibres per yarn cross-section followed by R(62.5%) x C(37.5%), Corriedale, halfbreds and Chokla. The Uster CV% values indicate that all the yarns can be placed in average category according to Uster standards. It is evident from Table 3 that the vegetable matter is exceptionally high in the case of R(75%) x C(25%) and R(62.5%) x C(37.5%) wool fabrics are much closer to 64s quality, but here again the fibre length seems to be the limiting factor for the improvement of strength. The stipulated minimum cut strip strength was converted to strength factor according to Whittier's formula. The values work out to 0.49 and 0.37 for warp and weft way respectively. Table 4 reveals that all the fabrics have higher value in warp way, whereas the values for weft way are lower, which may be because of the lower twist inserted in the weft yarn.

The flexural rigidity is highest for coarse Chokla and minimum for R(75%) x C(25%) wool fabric; all the four halfbreds, Corriedale and R(62.5%) x C(37.5%) lie in between. Though Corriedale wool is nearer to halfbreds in fineness, its overall fabric flexural rigidity is less, which may be due to the absence of coarse medullated fibres in this wool. Medullated fibres, being stiffer, lead to higher stiffness in the fabric. Also, the rigidity is greater in warp than in weft direction, which is due to the employment of doubled yarn in the warp direction. The correlation coefficient between overall fabric flexural rigidity and fibre diameter (0.7616) is significant at 5% level of significance, indicating that the fabrics prepared from coarse fibre wool will possess higher flexural rigidity and vice versa. These findings are in conformity with those of Dusenbury et al.

It is observed that the abrasion resistance is more in Corriedale and R(75%) x C(25%) sheep wool fabrics. This may be explained by taking into consideration the
number of fibres per yarn cross-section and fibre energy. The correlation coefficients between fibre breaking energy and the number of abrasion cycles for warp and weft way are -0.205 and +0.275 respectively, which are not significant. The correlation coefficients between work to yield point and number of abrasion cycles for warp and weft way are +0.710 and +0.395 respectively. This shows that correlation coefficient is significant in warp and non-significant in weft way. The positive sign indicates that the single fibre energy to yield point is responsible for the abrasion resistance of the fabric. The warp and weft way abrasion cycles indicate that warp is able to sustain more number of cycles as compared to weft, because warp is a doubled yarn. Trials conducted by Menkart and Detenback\(^{18}\) indicate that no relationship to fibre characteristics is apparent with the abrasion resistance and also the flex abrasion data have high replication variance.

The crease recovery angle is highest for Corriedale wool fabric and lowest for R(75%) x C(25%) wool fabric. The correlation coefficients between warp and weft way crease recovery angle and fibre length are 0.872 and 0.867 respectively, which shows that the fibre length affects the crease recovery angle at 5\% level significantly. The correlation coefficients between fabric crease recovery angle and fibre diameter are +0.495 and +0.2015 in warp and weft way respectively and are not significant. It is recognized that when fibres are too short, fibre to fibre cohesion in yarns is low and folding may displace fibres in the yarn, so that their failure to return to their original position produces permanent deformation and hence results in low crease recovery angle\(^3\). This phenomenon is evidently exhibited by R(75%) x C(25%) wool having the lowest fibre length (47.9 mm) among the experimental wools.

The highest number of pills are developed in R(75%) x C(25%) and Corriedale wools and the least in Chokla and R(50%) x C(50%) wools. This finding is in agreement with that of Pio Bertoli\(^{19}\), who found that finer fibre results in more pronounced pilling. Though native halfbreds approach Corriedale wool in fibre fineness value, they are less prone to pill formation because of the presence of coarse hetero and hairy fibres. These fibres lead to fuzzing but little or no pill formation, as the pills wear off easily: The number of pills formed is almost equal in Corriedale and R(75%) x C(25%) wools; pill retention is higher in Corriedale, which may be due to its higher fibre length and tenacity. The higher fibre tenacity and length lower the rate of wear off of the pills. The correlation coefficient between the number of pills and the fibre fineness is -0.6656, which is non-significant, but can be considered as a borderline case.

The values of the relaxation shrinkage of the experimental fabrics are well within the permissible limits\(^4\). However, within this range, the maximum
shrinkage was exhibited by the fabrics prepared from 
R(62.5\%) \times C(37.5\%) \text{ and Corriedale wools which may be due to their fibre fineness. Though R(75\%) \times C(25\%) is finest, its shrinkage is comparatively low due to its shorter fibre length}. The minimum shrinkage is observed in the case of Chokla wool, which is due to its coarseness. Kransy and Harris\textsuperscript{20} suggest that the surface to volume ratios of the fibres play an important role in fabric shrinkage, i.e. fibre of lower diameter may have appreciable areas of effective fibre to fibre contact in the fabrics during treatment, which results in the greater observed shrinkages of the fabrics prepared from the low diameter wools. The correlation coefficients between warp and weft way shrinkage and fibre diameter are \(-0.6174\) and \(-0.6962\) respectively, which are not significant, but are borderline cases.

The colour fastness grade assessment was 4 for all the fabrics, except Corriedale fabric for which it was better than 4. The grade is not up to the mark as per IS specifications.\textsuperscript{5} This may be due to the piece dyeing of the fabrics.

All the eight experimental fabrics were evaluated from the consumer preference point of view. For this purpose, five unbiased observers were asked to evaluate and rank the fabrics independently in the preferential order. The rating was done in terms of feel, surface appearance, colour brightness, etc. of the fabrics. Statistical analysis was done as suggested by Snedecor and Chochran\textsuperscript{15} and the fabric have been classified in the order of decreasing preference as: Corriedale, R(75\%) \times C(25\%), R(62.5\%) \times C(37.5\%), M(50\%) \times C(50\%), M(50\%) \times N(50\%), R(50\%) \times N(50\%) and Chokla.

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References