Stress-Strain Properties of Sodium Thioglycollate Treated Wool in Air and Water

S PARTHASARATHY, S K CHOPRA, D L BAPNA and U S SINGH
Wool Science Division, Central Sheep and Wool Research Institute, Avikanagar 304 501, India

Received 31 October 1986; revised and accepted 29 June 1987

The fibres of Australian Merino, Chokla and Malpura sheep wools were treated with sodium thioglycollate solution of 0.5 M at 10.0 pH for 24 h at 0°C. The untreated and treated fibres were tested for stress-strain properties in air (65 ± 5% RH and 27 ± 2°C) and in water (27 ± 2°C). The different parameters of the stress-strain curve were analyzed taking into consideration their dependence on the tex value of the fibres. The genetic groups differed in certain characteristics. Also, the interaction was significant in many others. The treatment in general weakened the stress-strain parameters as the thioglycollate reduces the disulphide bonds in wool fibre. The percentage change in parameters differed among the breeds.

Keywords: Australian Merino wool, Chokla wool, Malpura wool, Sodium thioglycollate, Stress-strain properties, Wool fibre

Introduction

The stress-strain properties of wool depend on the medium of testing and the chemical modification brought about in it. The thioglycollate reaction brought about changes to different extents in white and canary coloured Chokla wool. In this work, the stress-strain properties of Australian Merino, Chokla and Malpura wool fibres and their thioglycollate-reduced fibres were studied in air (65 ± 5% RH and 27 ± 2°C) and in water (27 ± 2°C).

2 Materials and Methods

The Australian Merino wool was obtained from M/s Raymond Woollen Mills, Thane and the Chokla and Malpura wools were collected from the flocks being maintained at CSWRI, Avikanagar. The wool samples were cleaned thoroughly and 0.5 g of each wool was dipped in 15 ml of 0.5 M sodium thioglycollate solution and kept at 0°C for 24 h. The wool was filtered, washed thoroughly with distilled water and air-dried. The stress-strain curves were recorded and analyzed as reported earlier.

3 Results

The analysis of variance with Duncan's multiple range test for air and wet tests is given in Tables 1 and 2 respectively. The stress-strain curves for the control and treated wool fibres tested in air and water are given in Figs 1-3 for Chokla, Malpura and Australian Merino respectively.

4 Discussion

4.1 Air Test

A total of 128 fibres were studied for stress-strain properties. The stress and slope values fall in general owing to the thioglycollate treatment. The genetic groups differ significantly in F2, H, Y, PY and BE% (Table 1). The treatment effect is significant in all the cases except Y and BE%. Interaction is significant in F15, F30 and BE%.

Australian Merino (G3) has a significantly lower stress at 2% extension (F2) than the natives which group together. The stiffness in the native breeds may be a composite effect of stiffness both in matrix and microfibril. Also, the disulphide bond contributes to the hook region since after the thioglycollate reduction treatment the F2 value decreases. The decrease in F2 is 17.98, 16.52 and 16.76% for Chokla, Malpura and Australian Merino wool fibres respectively.

After the treatment, only Chokla (G1) differs significantly from Merino (G3) in F15. From Figs 1-3 it is clear that Chokla is affected maximum owing to the treatment. The decrease in F15 is 15.42, 7.02 and 2.83% for Chokla, Malpura and Australian Merino wool fibres respectively. The treatments significantly differ in all the
Table 1—Analysis of Variance of Stress-Strain Data Recorded at 65 ± 5% RH and 27 ± 2°C

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>F for G1</th>
<th>F for G2</th>
<th>F for G3</th>
<th>F for Y</th>
<th>H</th>
<th>F for G3×G4</th>
<th>F for G2×G3</th>
<th>F for G1×G2×G3</th>
<th>Y</th>
<th>Mean sum of squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic groups</td>
<td>2</td>
<td>2.2151</td>
<td>4.3983</td>
<td>0.4828</td>
<td>0.0524</td>
<td>0.5631</td>
<td>0.0254</td>
<td>0.6193</td>
<td>1.5625</td>
<td>0.01630</td>
<td>115.3560</td>
</tr>
<tr>
<td>Treatment groups</td>
<td>1</td>
<td>25.7129</td>
<td>12.6857</td>
<td>6.6535</td>
<td>2.6533</td>
<td>4.5942</td>
<td>2.9524</td>
<td>1.3761</td>
<td>2.3261</td>
<td>0.5778</td>
<td>169.4742</td>
</tr>
<tr>
<td>Interaction</td>
<td>122</td>
<td>1371.15</td>
<td>4371.71</td>
<td>4376.21</td>
<td>16326.27</td>
<td>978.15</td>
<td>18049.54</td>
<td>19649.54</td>
<td>35158.11</td>
<td>0.220</td>
<td>50625.55</td>
</tr>
<tr>
<td>Error</td>
<td>122</td>
<td>2049.54</td>
<td>9550.42</td>
<td>214.871</td>
<td>93.8310</td>
<td>4.6699</td>
<td>2.27641</td>
<td>2.7547</td>
<td>3.5462</td>
<td>0.0172</td>
<td>24816.11</td>
</tr>
</tbody>
</table>

*Significant at 5% level; **Significant at 1% level. Any two means in the same parentheses do not differ significantly.

Fig. 1—Stress-strain curves for Chokla wool fibre [A—control (air test); B—treated (air test); C—control (wet test); and D—treated (wet test)]

Fig. 2—Stress-strain curves for Malpura wool fibre [A—control (air test); B—treated (air test); C—control (wet test); and D—treated (wet test)]

Fig. 3—Stress-strain curves for Merino wool fibre [A—control (air test); B—treated (air test); C—control (wet test); and D—treated (wet test)]]
breeds except Merino, where the treatments group together.

Malpura shows a higher value of \( F_{30} \) than Merino both in the untreated and treated conditions whereas it is the other way in \( F_{15} \). That is, after a part of the helices has been opened up to 15%, the remaining part of microfibril behaves differently in these two breeds. Initially, the microfibrils of Merino resist opening and once opening is initiated then the process continues with less resistance. However, in Malpura the initiation of opening takes place easily and later it develops resistance. The disulphide bond does not seem to control this effect since even in the treated fibres the order of stress is the same. The fall in stress due to treatment is highest in Chokla (19.5%), followed by Merino (10.43%) and Malpura (6.15%).

The effects on hookean slopes are similar to those on \( F_2 \). Treatment does not significantly affect the yield slope. However, Malpura differs significantly from Merino in yield slope. Both the breeds and treatments significantly differ in the post-yield slope. The reduction treatment lowers this slope significantly. The percentage reductions are 12.68, 12.15 and 19.39 in hookean slopes, 20.89, 22.11 and 6.60 in yield slopes and 32.82, 17.69 and 27.96 in post-yield slopes respectively for Chokla, Malpura and Australian Merino. The intensity of change in the Merino owing to thioglycollate is different from that in native fibres.

The treated fibres break at lower stresses than the control fibres. The fall in breaking stress is 19.71, 12.91 and 9.30% in Chokla, Malpura and Merino fibres respectively.

Malpura fibres are greatly affected in \( BE\% \) owing to the treatment and are significantly lower in extension than the other two which group together. The extensibility of Chokla fibres increases by 3.34%, whereas in Merino it is 7.66%. However, in Malpura the extension is significantly reduced by 10.6% owing to the treatment. The decrease in \( BE\% \) of Malpura and a very little increase in \( BE\% \) of Chokla indicate that the plasticizing effect of the treatment is poor in natives than in Merino.

### 4.2 Wet Test

A total of 158 fibres were studied for their stress-strain properties in water. The stress and slope values fall in general owing to the reduction treatments. The breeds differ significantly in all the curve parameters except \( Y \) (Table 2). The treatment effect is significant in all the cases except \( F_{30} \). Interaction is significant in all the cases except \( Y \).
The breeds differ significantly in both the control and the treated fibres for \( F_0 \). The fall in stress owing to the reduction treatment is 63.25, 33.92 and 29.5% in Chokla, Malpura and Merino respectively. The microfibrils of the natives (G1,G2) are stronger than Merino (G3), and Malpura (G2) exhibits its higher stiffness even after reduction.

The breeds differ significantly after reduction for \( F_{15} \). The fall in this stress is highest in Chokla (35.66%) followed by Merino (22.10%) and Malpura (19.15%). Malpura (G2) and Merino (G3) differ significantly in \( F_{30} \) before the treatment. After the treatment, only Chokla (G1) differs significantly from the others. From the results of \( F_{15} \) and \( F_{30} \) (wet test), it is observed that the microfibril of Malpura is not easily extended and probably in the air test, the easy extensibility of matrix has contributed to the lowering of \( F_{15} \).

The hookean slope and yield slope regress on tex. The hookean slope of untreated Merino (G3) is significantly lower than that of the other two which group together both before and after the consideration of the regression. After the treatment, only the natives differ significantly if regression is not considered. Otherwise, Malpura (G2) differs significantly from the other two which group together. This again confirms the stiffer microfibrils of Malpura. The treatment effects are the same in all the breeds, in both the treatments. The fall in \( H \) is 58.68, 40.18 and 33.05% for Chokla, Malpura and Merino fibres respectively. The highest fall in Chokla is clear in Fig. 1.

None of the effects is significant in yield slope before regression on tex is considered. However, the treatment effect is significant after tex is taken into account. The fall in yield slope owing to the treatment is 13.5, 4.5 and 9.5% for Chokla, Malpura and Merino fibres respectively on considering tex.

The post-yield slope of Chokla (G1) differs significantly from that of the other two which group together. Before treatment, Malpura (G2) differs significantly from the other two which group together after the treatment. The matrix-associated microfibrils are stiffer in the natives. The reduction treatment loosens this in Chokla, whereas the effect is less severe in Malpura.

The breaking stresses of the natives are significantly higher than those of the Merino fibres before the treatment. After the treatment, Chokla scores significantly the lowest value in comparison with others which group together. The treatment effects are similar to those for other stress values. The fall in stress is 39.47, 23.83 and 9.67% for Chokla, Malpura and Merino fibres respectively.

Malpura has a significantly higher extension than the other two which group together. The breeds differ significantly among themselves after the treatment. The Merino fibres have significantly the highest extension, followed by Malpura and Chokla. The treatment results in lowering the extension significantly in the native breeds. There is a slight increase in the extensibility of Merino owing to the treatment.

5 Conclusions
The stress-strain parameters are weakened by the thioglycollate reduction treatment. Chokla and Malpura fibres are stiffer than Merino when tested under standard conditions of humidity and temperature. On reduction, Chokla is affected to the maximum extent. The reduction treatment plasticizes Merino, which shows improved extensibility; the extensibility is on par in Chokla and it significantly decreases in Malpura. The percentage change in parameters differs among the breeds.

The microfibril stiffness differs among breeds. Natives are stiffer than Merino. Breaking stresses are also higher in natives. Extensibility is significantly higher in Malpura. The reduction treatment affects Chokla to the maximum extent. The extensibility significantly decreases in the natives.

References
3 Harvey W R, *Least square analysis of data with unequal sub-class numbers* (ARS—USDA, Maryland) 1966.