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STRENGTH AND RESISTANCE TO COMPRESSION OF U.S. WOOLS[1,2]

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Summary

A selected sample of the 1988 U.S. wool clip (600 fleeces) was characterized in terms of staple strength and resistance to compression. Mean fiber diameter, staple length and yield of individual fleeces were also measured. A high proportion (72.7%) of the fleeces were determined to be sound (stronger than 30N/ktex) and a majority (59.7%) of the fleeces exhibited resistance to compression greater than 11 kPa and were regarded as being highly resistant to compression.

(Key words: Resistance to compression, staple strength, wool)

Introduction

Staple strength of wool is customarily measured as either the maximum load (newtons, N) or the energy (joules, J) needed to break a staple. To correct for differences in the size of the staple being tested, these strength values are standardized by the amount (mass in grams) or linear density (grams/meter = kilotex) of clean wool.

Staple strength is of practical importance because it is significantly related to processing performance (card waste, noilage, machine speeds and efficiency). Wool with low strength will generally suffer more breaks in processing and produce a top with lower mean fiber length than higher strength wool. Routine measurements of staple strength would provide producers with important information on the performance of their sheep. Since staple strength is affected by changes in sheep health due to age, environment, nutrition, pregnancy, lactation, stress and disease, including parasite load, its measurement quantifies these influences and provides another management tool (Teasdale, 1985). The force applied to staples in manual or subjective strength appraisals is approximately 30 N, ranging from 15-50 N. It is physically difficult to apply much more force than this to a wool staple. The thinnest staples normally selected for manual strength appraisal would be about two kilotex. Therefore, the upper limit of staple strength that can be manually determined is about 25 N/ktex. Above this, even the trained hand cannot distinguish different levels of strength. Below 20 N/ktex, these assessments can effectively rank wools of varying staple strength.

Resistance to compression (R to C) is the force per unit area required to compress a fixed mass of wool to a fixed volume. Units of measurement are kilopascals (kPa). Resistance to compression is related to fiber diameter and the form and frequency of crimp. Differences of two kilopascals result in significant processing differences, thus R to C is a useful measurement from a manufacturers point of view.

As resistance to compression decreases, wool is generally softer and more lustrous. Resistance-to-compression values are useful in assessing suitability for specific end-uses. For example, high R-to-C wools, being more resistant to felting are desirable in high quality worsted fabrics whereas low R-to-C wools can provide soft, lustrous effects in knitwear.

A literature search failed to reveal comprehensive information concerning staple strength and resistance to compression of U.S. wool. This study was designed to partially fill this void in our knowledge by characterizing a broad cross-section of U.S. wools in terms of staple strength and resistance to compression.

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Table 1. States Providing Fleeces For Strength/Resistance-To- Compression Study.

Grade	Contributing States
64s	California
	New Mexico
	Texas
	Wyoming
58s	Colorado
	Montana
	Utah
	Wyoming
54s	Iowa
	Minnesota
	Ohio
	South Dakota

Materials and Methods

Three grades of wool were initially identified for this study: 64s, 58s and 54s. All wool tested in the program was shorn in 1988. Woolgrowers, warehousemen, research and extension personnel in 11 states were contacted and asked to supply the project with fleeces that, in their judgment, were representative of the areas and grades being studied. Fifty fleeces were obtained from each of the top four producing states of the three wool grades studied. The states involved are listed in table 1. The 600 fleeces were assembled and tested at the Wool and Mohair Research Lab, Texas Agricultural Experiment Station, San Angelo. Table 2 lists the objective measurements conducted on each fleece together with appropriate references that describe the techinques used.

Although the study was primarily concerned with staple strength and resistance-to-compression, it was necessary to measure staple length and yield in order to calculate staple strength and to prepare a suitable sample for measurement of resistance to compression. Diameter measurement was essential in order to quantify that which had initially been subjectively assessed.

The lengths of ten randomly selected staples per fleece were measured (to the nearest .25 in) prior to strength determination and weighing (to ± .01grams) of the broken tip and base portions. Weighing the two parts of the broken staple permitted calculation of position of break and staple thickness (ktex), which in turn allowed calculation of greasy staple strength (N/ktex). Yield was required to convert this value to staple strength of clean wool. Yield was determined on a minimum of 32 × 1.3 cm cores removed from random positions in each fleece

Table 2. Wool Characteristics Measured in Strength/Resistance To Compression Study

Objectively measured fleece characteristic	Tests per fleece	No. of tests	Reference
Grease fleece weight	1	600	--------
Diameter	1	600	Lynch and Michie, 1976
Lab scoured yield	2	1,200	ASTM Standard Test Method D584, 1988a
Staple length	10	6,000	ASTM Standard Test Method D1234, 1988b
Staple strength and position of break	10+10	12,000	Manual for the Agritest Staple Breaker System Agritest; 1988a
Resistance to compression	2	1,200	Manual for the Agritest Resistance to Compression System. Agritest 1988b. Australian Standard 3535; SAA, 1988
Total Number of Tests		**21,600**	

(Johnson and Larsen, 1978). All samples were dried at constant temperature (80°C) for a specific length of time (15 h). Subsequently, the clean conditioned cores were randomized and sub-sampled for determination of mean diameter and distribution of diameter using a Peyer Texlab FDA 200 System. The remaining cores were carded by a single passage through a Haigh-Chadwick, Ltd. sample card. Two portions (2.5 g each) of the conditioned (70°F, 65% RH) card web were used to determine resistance to compression. All measurements were made within 30 h after carding under the standard conditions of temperature and humidity.

Results and Discussion

The original intent was to test three groups of fleeces having average grades of 64s, 58s and 54s. The fleeces used in this study were subjectively appraised for grade prior to selection. The actual grades of the three groups tested were 62s, 56s and 48s. Since some of the fleeces in the 62s group were finer than 64s and some of the fleeces in the 48s group were coarser than 46s the study incorporated a broader cross section of wool in terms of fiber diameter than was originally intended. It was never the intent of the study to compare fleece characteristics by state or flock within a state. Thus, the results are presented in terms of "generic" U.S. wool. The distribution of mean fiber diameters for all fleeces tested is shown in figure 1.

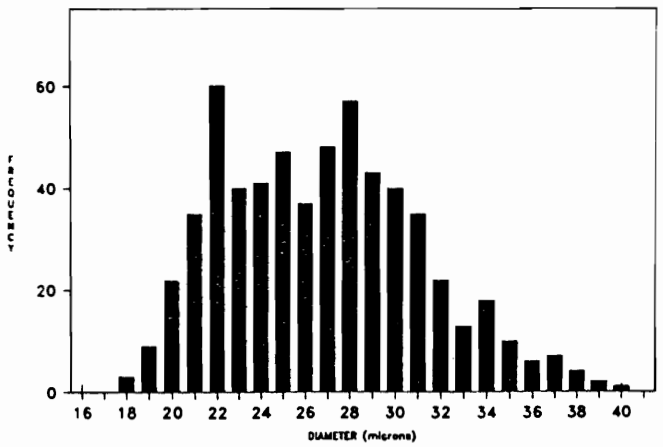

Figure 1. Distribution of fiber diameter.

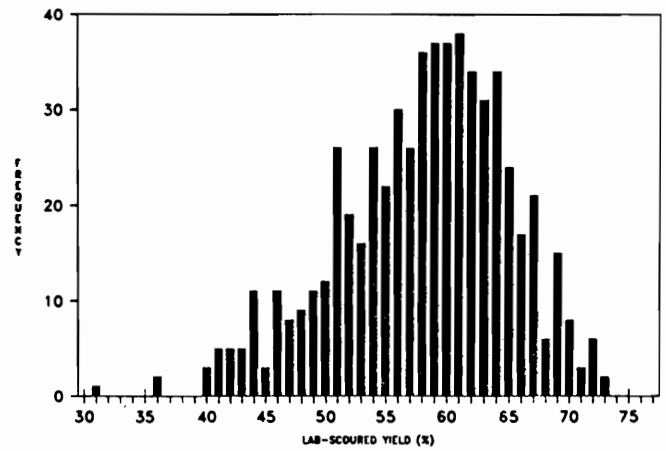

Figure 2. Distribution of lab-scoured yield.

Lab scoured yield (LSY) was measured for each fleece to permit calculation of staple stength based on clean wool. The average LSY for the fine fleeces was 53.9%, for the intermediate fleeces 58.3% and for the coarse fleeces 61.7%. Distribution of LSY is summarized in figure 2. Average staple lengths for the fine, medium and coarse groups were 6.61, 8.29 and 8.62 cm, respectively. Staple length distribution is illustrated in figure 3.

For the purpose of this discussion, ranges of staple strength are described as follows: <10 N/ktex = rotten; 10-20 N/ktex = tender; 21-30 N/ktex = part tender; >30 N/ktex = sound. The average staple strength of the fine wool group was 35.6 N/ktex. For the medium wool group, the average staple strength was 42.5 N/ktex and for the coarse wool group, 36.7 N/ktex. Overall, 72.8% of the 600 fleeces tested were characterized as sound. Distribution of staple strength measured in this study is summarized in figure 4.

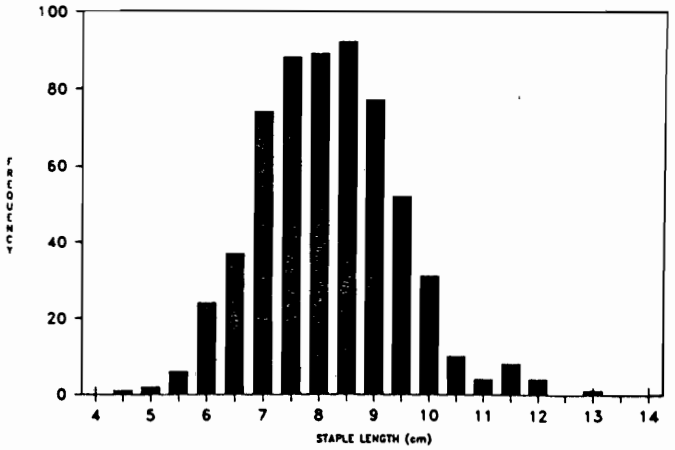

Figure 3. Distribution of staple length.

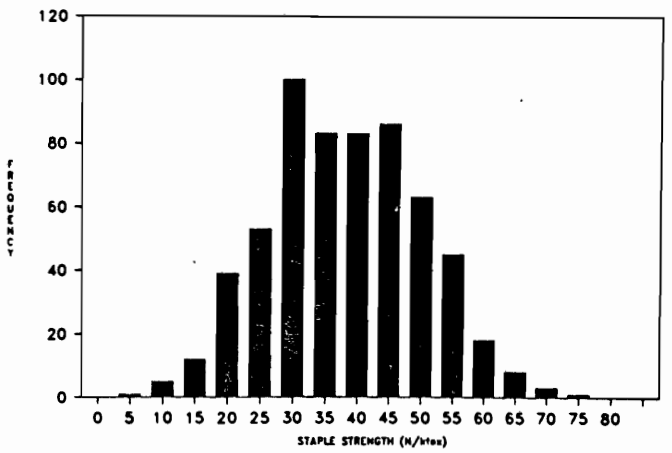

Figure 4. Distribution of staple strength.

In the current context, R-to-C values below 8.0 kPa are designated as low; 8.0-10.9 kPa as medium; and 11-18 kPa as high. As a group, the fine wools fell into the low end of the high R-to-C category with a mean of 11.88 kPa. Overall, the medium wools were not as bulky as the fine wools, with a mean R-to-C value of 10.82 kPa. However, the coarse wools were also categorized as high R to C having a mean value of 12.38 kPa. Of the 600 fleeces tested, 358 were classified as having high resistance to compression, 236 medium and six as low. Thus, based on this sample from one production year, a high proportion of U.S. wool is likely to be high R-to-C wool. Overall distribution of R to C measured in this study is shown in figure 5.

Simple linear regression analysis was used to establish mathematical relationships and the degree of correlation between the various characteristics measured in this

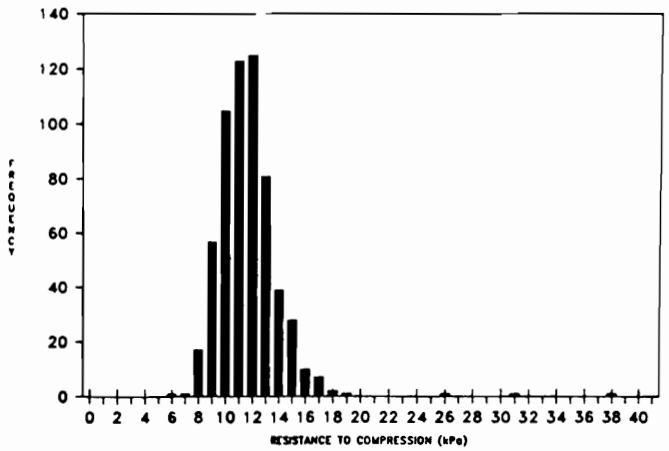

Figure 5. Distribution of resistance to compression.

Table 3. Correlation Coefficients (r Values) Between Fleece Characteristics (Pooled Data)

	Staple length	Lab scoured yield	Staple strength	R to C
Diameter	.21*	.35*	.03	.25*
Staple length	—	.30*	.00	−.15*
Lab scoured yield	—	—	−.11*	.00
Staple strength	—	—	—	−.24*

*Significant correlation (P<.01)

study. The results of the analyses of pooled data are presented in table 3.

Small but significant (P<.01) positive correlations exist between fiber diameter and lab scoured yield and resistance to compression (r = .35 and .25, respectively). Other small correlation coefficients were noted for diameter versus staple length (r = .21), staple length versus yield (r = .30) and staple strength versus resistance to compression (r = −.24).

Conclusions

Data from one production year obtained from a selected sample of U.S. wool permits the following conclusions.
1. A high proportion (72.7%) of the fleeces tested were sound (>30 N/ktex).
2. The majority (59.7%) of the fleeces tested were classified as having a high resistance to compression (>11.0 kPa). Based on this sampling, a high proportion of U.S. wool is likely to have high resistance to compression. This characteristic (unlike strength) is not expected to change significantly from one year to the other.

Literature Cited

Agritest Pty. Ltd. 1988a. Manual for the Agritest Staple Breaker System. 14 pp.

Agritest Pty. Ltd. 1988b. Manual for the Agritest Resistance to Compression System. 9 pp.

American Society for Testing and Materials. 1989a. Annual Book of ASTM Standards. Designation: D584-77. Standard test method for wool content of raw wool — laboratory scale. Sec. 7. Vol. 07.02:144. ASTM, Philadelphia.

American Society for Testing and Materials. 1989b. Annual Book of ASTM Standards. Designation: D1234-89. Standard method of sampling and testing staple length of grease wool. Sec. 7. Vol. 07.02:194. ASTM, Philadelphia.

Johnson, C.L. and S.A. Larsen. 1978. Clean wool determination of individual fleeces. J. Anim. Sci. 47, 1:41.

Lynch, L.J. and N.A. Michie. 1976. An instrument for the rapid automatic measurement of fiber fineness distribution. Text. Res. J. 46, 9:653.

Standards Association of Australia. 1988. Australian Standard 3535. Wool — Method for the measurement of resistance to compression. 8 pp.

Teasdale, D. 1985. Why test for length and strength? Wool Techn. Sheep Breed. June/July:64.