Comparison of Three Measuring Techniques for Staple Length and Strength in U.S. Wools[1,2]

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Summary

Twenty-nine consignments of greasy wool in Texas warehouses were used to compare three measuring techniques for staple length (SL) and strength (SS) and to assist the U.S. wool industry in deciding which techniques to adopt for commercial testing. Samples (~10 lb/lot) were obtained using a bale grab sampler and were subsampled at the Texas Agricultural Experiment Station (TAES) Wool and Mohair Research Laboratory (WMRL) to provide three sets of comparable subsamples. One complete set of subsamples (29 subsamples x 65 staples/ subsample = 1,885 staples) was sent to the Australian Wool Testing Authority (AWTA) for measurement using the Automatic Tester for Length and Strength (ATLAS) while another set was sent to SGS Wool Testing Services (SGS) in New Zealand for testing with the Agritest Staple Breaker Model 2. A third set was measured at WMRL using the American Society for Testing and Materials (ASTM) manual method for SL and an Agritest Staple Breaker (manual model) for SS. Each testing lab used the same wool base and vegetable matter base values to convert "greasy" to "clean" SS. Paired t tests and linear regression analyses were conducted to test for differences and calculate r^2 values between test methods. Warehouse personnel provided visual estimates of SL. Mean values of SL determined by AWTA and the visual assessments were not different (3.20 and 3.21 in, respectively, $P > 0.05$; $r^2 = 0.63$). Measurements of SL made by SGS and WMRL were not different (3.07 and 3.12 in, respectively, $P > 0.05$; $r^2 = 0.74$) but were shorter ($P < 0.05$) than the AWTA and visual results. Mean values of variability in staple length (CV) were not different ($P > 0.05$) among the three measuring techniques. The AWTA and SGS means of SS were not different (32.1 and 31.8 N/ktex [a textile measure of strength, newtons per kilotex, literally kilogram-force per unit of staple thickness expressed in ktex, kg per km], respectively, $P > 0.05$; $r^2 = 0.41$). The WMRL mean value, 41.7 N/ktex, for SS was greater ($P < 0.05$) than the other two labs, which strongly suggests that either the manual instrument and/or the WMRL technique produced excessively high values. Further testing incorporating a broader cross-section of U.S. wools is required before an authoritative recommendation can be made to the U.S. wool trade.

Key Words: Staple length, Staple strength, Wool

Introduction

The U.S. wool industry has expressed an interest in having some of its staple wools objectively measured for staple length (SL) and staple strength (SS) before the time of sale of greasy wool to further describe the wool being sold and to achieve maximum price discovery. According to Adams (1997), SS is second only to fiber diameter in determining the value (expressed on a clean basis) of raw wool because it is an important contributor to Hauteur, i.e., average fiber length in the wool top after early stage processing. Qi et al. (1994), reported that SL is the third most important characteristic of wool after scoured yield and fiber diameter. Australian methodology and machinery are currently available for obtaining staple samples for measuring SL and SS but as yet are not easily adapted for most U.S. wool packages (i.e., 6 and 8 ft wool bags). The ATLAS instrument used in Australia for measuring SL and SS is very expensive and, even if it were available, may

1 This article reports research conducted by the Texas Agricultural Experiment Station, The Texas A&M University System.

2 Financial support from the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture under agreement number 99-34148-7417 is gratefully acknowledged.

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not be cost-effective in the U.S. commercial testing laboratory. Fortunately, less expensive instrumentation is available from Agritest for measuring SL, SS, and position of break but it requires further evaluation to establish its equivalency with both the now accepted ATLAS technique and the established ASTM and manual Agritest methods.

Materials and Methods

Twenty-nine commercial lots of sound, staple length wool were identified in member warehouses of the Producers Marketing Coop, Inc. (San Angelo, Texas). An Australian bale grab sampler was used to obtain approximately 10 lb of sample from each lot. Each grab sample was inspected by the warehouse manager and the cooperative manager and a consensus visual staple length was established for each lot. Subsequently, the samples were transported to the Texas Agricultural Experiment Station's Wool and Mohair Research Lab (WMRL) and subsampled to provide three sets of comparable subsamples for each of the 29 lots. One set of subsamples consisted of 65 individual staples each being suitable for measurement of SL and SS. This number (65) of staples representing a single lot has been established as the minimum necessary to produce the desired degree of accuracy when measuring SS and SL.

One complete set of subsamples (29 subsamples x 65 staples/subsample = 1,885 staples) was sent to the Australian Wool Testing Authority (AWTA) in Guildford, New South Wales for measurement using the Automatic Tester for Length and Strength (ATLAS) instrument. Another set was sent to SGS Wool Testing Services (SGS) in Wellington, New Zealand for testing with the Agritest Staple Breaker Model 2. A third set was measured at the WMRL using a manual method (ASTM, 1999b) to measure SL and an Agritest Staple Breaker (manual model) for measuring SS. Wool and vegetable matter bases were determined for each lot (ASTM, 1999a) by Yocom-McColl Testing Labs, Inc. in Denver. Each testing lab used the same wool base and vegetable matter base values to convert "greasy" to "clean" SS. Paired t tests and linear regression analyses were used to test for differences and calculate r^2 values between test methods (SAS, 1996).

Results and Discussion

The results of testing at the three locations using the different methods are summarized in Table 1. We have assumed that 65 staples/lot were measured by AWTA, as they were by TAES technicians. The SGS lab measured 57-59 staples per lot. Table 2 indicates that overall mean values of staple length determined by AWTA and visual assessments made by warehouse personnel were not different ($P > 0.05$). Similarly, measurements of staple length made by SGS and TAES were not different ($P > 0.05$) but were slightly smaller (~ 0.1 in) than the AWTA and visual results. Mean values of variability in staple length as measured by coefficients of variation were not different among locations. Overall means of SS were not different between AWTA and SGS. The TAES values for SS were considerably higher than the other two labs strongly suggesting that the instrument and/or our technique is producing excessively high values.

Conducting t tests using mean values of each of the 29 lots is only one method of comparing results from the three instruments. Regression analyses were also conducted and our results are summarized in Table 3. Somewhat surprisingly considering the general acceptance of these test procedures by the testing community and elsewhere in the past few yr, SL and SS values obtained using the three different sets of methods were not highly correlated. The r^2 values between labs for SL range from 0.74 to 0.81 ($P = 0.0001$) for the three objectively measured sets of data. Values for visually appraised vs objectively measured SL are lower (0.48 to 0.63, $P = 0.0001$). Coefficients of determination for the SS data are even lower (0.41 to 0.61, $P = 0.0001$ to 0.0002) while those for CV of SL are still smaller (0.11 to 0.39, $P = 0.0003$ to 0.0849). These r^2 values would probably have been higher if unsound, very strong, very short, and very long wools had been included in the study. We chose to use typical, sound, staple-length West Texas wools only. In fact, the AWTA and SGS strength data are remarkably similar for 21 of the 29 lots measured (0 or 1 N/ktex difference between labs). The differences for the other eight lots range from 2-5 N/ktex with no apparent bias.

The relative costs of conducting these tests and the time required to get results from overseas are documented in Table 4. Currency conversion rates effective on 10/21/99 were used in the calculations.

Conclusions

This study indicates that results of testing sound U.S. wool for SS and SL were not highly correlated among the three testing locations (methods). The visual appraisals of SL and measurements using the ATLAS instrument were not different but were greater than (~ 0.1 in) the SL results, obtained using the ASTM standard method and SGS measurements. Mean values of SS were not different between the SGS and AWTA labs but were significantly higher at the TAES lab.

Implications

The U.S. wool industry had anticipated that results from this study would have been close to identical from each of the three labs participating using different methods and instruments. Further investigations and analyses will be required to help us identify reasons for these disagreements.

Table 1. Individual, mean, minimum, maximum, and standard deviation values for the 29 wool lots used in this study.

Lot number	Visually assessed staple length, in	AWTA			SGS			TAES		
		Staple length, in	CV of staple length, %	Staple strength, N/ktex	Staple length, in	CV of staple length, %	Staple strength, N/ktex	Staple length, in	CV of staple length, %	Staple strength, N/ktex
1	3.1	3.0	22	29	3.0	17	29	3.1	16	37
2	3.1	3.4	13	31	3.1	11	32	3.3	10	45
3	3.2	3.3	14	31	3.1	13	30	3.3	16	44
4	3.3	3.4	13	32	2.8	15	30	3.3	9	39
5	3.2	3.0	18	31	2.8	15	30	3.0	17	42
6	3.0	2.8	15	29	2.7	12	28	2.7	12	37
7	3.1	2.7	12	28	2.6	15	29	2.2	14	32
8	3.3	3.4	12	31	3.2	13	30	3.2	15	40
9	3.3	3.3	11	29	3.1	11	30	2.8	15	35
10	3.4	3.3	12	33	3.3	13	29	3.3	13	40
11	3.6	3.7	16	30	3.5	17	31	3.5	15	37
12	3.2	3.3	13	36	3.2	15	35	3.3	11	46
13	3.2	3.3	12	34	3.1	11	32	3.2	11	37
14	2.8	2.7	11	32	2.8	14	32	2.6	15	37
15	3.3	3.3	11	33	3.3	12	33	3.1	15	42
16	3.2	3.1	18	29	3.0	24	29	2.8	19	36
17	3.2	3.0	17	35	2.9	15	30	3.0	12	42
18	3.0	3.0	13	31	3.0	11	34	2.9	12	47
19	3.1	2.7	13	34	2.6	11	33	2.5	13	45
20	3.3	3.2	17	33	3.1	14	32	3.1	13	47
21	3.4	3.6	12	37	3.5	14	37	3.6	14	50
22	3.3	3.1	12	35	3.1	11	36	3.1	15	44
23	3.3	3.5	16	32	3.4	16	32	3.7	15	41
24	3.4	3.4	11	36	3.3	13	36	3.4	13	48
25	3.3	3.3	17	30	3.1	16	29	3.2	14	41
26	3.2	3.5	13	33	3.3	13	30	3.3	19	40
27	3.3	3.3	18	34	3.2	16	39	3.5	16	53
28	3.4	3.3	14	35	3.3	11	31	3.5	12	44
29	3.0	2.8	16	28	2.7	14	33	2.7	16	40
Mean	3.21	2.30	14.2	32.1	3.07	13.9	31.8	3.12	14.0	41.7
SD	0.16	0.26	2.7	2.5	0.25	2.7	2.7	0.35	2.4	4.7
Min	2.8	2.7	11	28	2.6	11	28	2.2	9	32
Max	3.6	3.7	22	37	3.5	24	39	3.7	19	53

Table 2. Mean values for the 29 wool lots.				
	AWTA	SGS	TAES	(Visual)
Staple length, in	3.20[a]	3.07[b]	3.12[b]	3.21[a]
CV of staple length, %	14.2	13.9	14.0	–
Staple strength, N/ktex	32.1[b]	31.8[b]	41.7[a]	–

[a,b]Within a row, means without a common superscript differ ($P < 0.05$).

Table 3. Coefficients of determination (r^2 values with P in parenthesis) for the indicated relationships.

Staple length	AWTA	SGS	TAES
Visual	.63 (0.0001)	.53 (0.0001)	.48 (0.0001)
AWTA	–	.81 (0.0001)	.81 (0.0001)
SGS	–	–	.74 (0.0001)
Coefficient of variation of staple length			
		SGS	TAES
AWTA		.39 (0.0003)	.11 (0.0849)
SGS		–	.21 (0.0128)
Staple strength			
		SGS	TAES
AWTA		.41 (0.0002)	.46 (0.0001)
SGS		–	.61 (0.0001)

Table 4. Financial and time considerations.		
	AWTA	SGS
Samples sent via Federal Express	5/17/99	5/17/99
Cost of Fed-Ex shipping, US $ (~ 20 lb)	223.25	213.05
Results received by airmail	6/3/99	6/8/99
Cost of length/strength test, US $ / sample	25.15	22.24
MAF clearance and fumigation (29 samples)	–	30.17

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