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Evaluation of mean fiber diameter measurements by FibreLux micron meter and OFDA2000 in Texas and Intermountain west wool

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ABSTRACT

Objective measurements of wool, specifically mean fiber diameter (MFD), plays an important role in the selection of replacement animals and the marketing of greasy wool. The FibreLux (FL) was designed for field use and will be a cost-effective instrument for producers if it compares favorably to the OFDA2000 on U.S. wool samples. The aim of this study was to compare accuracy and precision of the FL to the OFDA2000 for measurement of mean fiber diameter of U.S. wool. We hypothesized that MFD accuracy of the FL vs. OFDA2000 would be within manufacturer recommended 0.8 μm specifications in U.S. wool samples. Wool from animals originating from two distinct regions was used in this study. Side samples from Montana, Wyoming, and South Dakota (n = 998; 21 flocks) and Texas (n = 883; 11 flocks) were measured on the FL and OFDA2000 at the Montana State University Wool Lab (MSU) and the Texas A&M AgriLife Bill Simms Wool and Mohair Research Lab (AgriLife), respectively. The FL and OFDA2000 were strongly correlated ($P < 0.001$) at both MSU ($r = 0.89$) and AgriLife ($r = 0.93$), yet differed ($P < 0.001$) between the two laboratories. At MSU the FL measurements were 0.25 μm greater ($P < 0.001$) than the OFDA2000. The opposite was found at AgriLife, where the FL measurements were 0.21 μm less ($P < 0.001$) than the OFDA2000. At MSU, the slope of the geometric mean regression coefficient did not differ ($P = 0.111$) from unity. In contrast, AgriLife underestimated MFD by 0.9 μm for 15 μm fibers and overestimated MFD by 0.7 μm at 25 μm ($P < 0.001$). Samples coarser than 25 μm indicated that the FL can provide useful measurements above the specified range. Standard error of predictions were 0.94 and 0.67 μm for MSU and AgriLife, respectively. The FL variance components were greater than the OFDA2000, with the greatest source of variation was from multiple staples within the same fleece, and reload error was greater for FL than OFDA2000. We believe the FibreLux will be a useful tool for on farm measuring of MFD in U.S. wools.

1. Introduction

Rapid objective measurement of mean fiber diameter (MFD) or "fineness" of wool is a valuable tool for selection, classing, and marketing purposes (Teasdale and Cottle, 1991). The utility of objective fiber measurements for on-farm use relies on the instrument's accuracy, or how well the observed value agrees with the true value and how well repeated observations agree with one another (precision). Accuracy must be determined by reference to a primary system (Peterson and Gherardi, 2001; Sommerville, 2002). Although instrumentation for determination of MFD has progressed over the last 40 years, instrument cost and logistical challenges still hinder real-time, on-farm fiber analysis. The recently developed FibreLux Micron Meter™ (FL) utilizes light diffraction to measure MFD. This portable, cost-effective unit was developed in South Africa and is currently available in the U.S. and other countries throughout the world. However, the accuracy and precision of the FL compared to reference instruments (OFDA2000) has not been determined on U.S. wools. We hypothesized that the MFD accuracy and precision of the FL would be less than the OFDA2000 but would be within manufacturer recommended 0.8 μm specifications for 15–25 μm wool samples. Accuracy and precision of the FL was compared the OFDA2000 (Baxter, 2001), the only other instrument commonly used for on-farm measurement of MFD. To make this comparison we analyzed wool side samples representative of the two major wool producing regions of the U.S. (i.e, Southern Plains/Southwest, and Intermountain west/Northern plains regions) at their respective land-grant university wool laboratories in San Angelo, TX, and Bozeman, MT.

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2. Materials and methods

Wool samples for this study were obtained from 998 side samples from 21 different Montana, Wyoming, and South Dakota flocks and 883 side samples from 11 different Texas flocks. At the Texas A&M AgriLife Research Bill Sims Wool and Mohair Research Laboratory (San Angelo, TX; AgriLife), side samples were either submitted by the producer or collected from whole fleeces by laboratory staff members. Samples measured at the Montana State University Wool Lab (Bozeman, MT; MSU) were all submitted by producers. At each lab, a staple approximately 6 mm in diameter was removed from each side sample for measurement of MFD.

2.1. Texas procedures

At AgriLife, staple fibers were teased apart by hand, producing a loose array of individual fibers. The prepared staple was then placed into an OFDA2000 slide. The entire length of the staple was measured on the OFDA2000. After the sample had been measured on the OFDA2000, the entire sample was removed and combed to align its fibers to fit into a FL slide. Combing resulted in the loss of some fibers from the sample. The base end of the staple was placed on the top end of the slide and excess staple tip was trimmed off. Thus, only the middle portion of the staple was measured. About 3% of samples had results that were obviously incorrect (e.g., ≤13 μm or ≥35 μm) as reported by the FL. When such readings occurred, the sample was redistributed and re-run until a reading within the expected range was reported.

2.2. Montana procedures

At MSU, staple fibers were first combed and placed to fit into the FL slide similar to the procedure at AgriLife. After measurement, the fibers were removed and trimmed such that only the segment of fibers measured on the FL remained. These fibers were then spread on the OFDA2000 slide and measured. No attempt was made to identify and re-measure apparent outliers on either instrument.

Grease correction factor was set at 1.5 μm for both instruments and relative humidity and temperature adjustments were enabled at both labs. Five different operators measured samples during the course of the project at AgriLife and two operators at MSU. At both labs, samples were run concurrently with two operators, one on the OFDA2000 and one on the FL. It was assumed that technician was not a significant source of variation on fiber measurements since all were familiar and proficient with both instruments.

2.3. Load error

To estimate error associated with loading wool on a FL slide, two wool tops, IH-STANDARDS certified as 20.5 and 23.5 μm by the Interwoollabs (Bradford, U.K.), were used to estimate the effect of the amount of wool on MFD at the AgriLife lab. To accomplish this, a slide was first loaded with enough wool top that the instrument gave an error message. The top was then combed to remove fibers until a measurement was obtained. After this, the top continued to be combed to remove more fibers with a measurement taken between each combing. This process was repeated until the instrument gave another error message, indicating there were not enough fibers present on the slide.

2.4. Repeatability

At AgriLife, samples from an additional 4 fleeces were measured multiple times to estimate and compare instrument repeatability. The samples came from fleeces that nominally measured 18, 19, 21 and 23 μm and were selected to more or less encompass the specified range of the FL. Three staples were taken from a side sample of each fleece. First, the staple was spread on the OFDA2000 slide and measured, then turned over on the slide and measured again as an estimate of machine error. Next, the sample was removed from the OFDA2000 slide and formed into a staple, then spread back on the slide and read twice as before as an estimate of loading error. The staple was then placed into the FL slide, measured twice, and then the slide was reversed and read an additional two times. This procedure allowed both true test error and machine error to be estimated. The staple was then removed and reloaded, as with the OFDA2000, and measured as previously described. This procedure allowed the estimation and comparison of instrument precision, loading, and sampling error.

2.5. Statistical analysis

Estimates of MFD by the FL and OFDA2000 were compared following the IWTO-0 (2002) procedure for comparison of methods, where the OFDA2000 was considered the reference method and the FL as the alternative method. Although technically the OFDA2000 is not a primary system it is the only method widely used in the U.S.A. for on farm testing and thus the IWTO-0 (2002) procedures are considered appropriate (sensu Baxter and Marler, 2004). Samples that were outside the 95% confidence limit (1.96× Standard Error of the regression) of the difference versus average regression were removed as outliers before final analysis (IWTO-0, 2002). Two analyses were done using this method: 1) samples that measured greater than 15 μm and less than 25 μm on the FL, which is the operating range specified by the manufacturer; and 2) samples that measured greater than 25 μm. Analyses of fibers within the manufacture's specified range was done separately for each laboratory, while only MSU had sufficient samples to compare instruments for fibers greater than 25 μm.

To compare MFD between the two laboratories, data were analyzed using the GLM procedure of SAS (Version 9.4) where laboratory was fit as a fixed class effect, the sample's MFD measured on the FL was fit as a linear covariate, and the sample's MFD measured on the OFDA2000 was the response variable.

Machine precision for both instruments was estimated at the AgriLife lab using the MIXED procedure of SAS where instrument, fleece, and their interaction were fit as fixed effects and staple (instrument x fleece) and reload (instrument x fleece x staple) were fit as random effects using a heterogeneous variance component model for the effect of instrument. To further examine the variance components for MFD on the FL, the fixed effect of fleece and random effects of staple (fleece), reload (fleece x staple), and side (fleece x staple x reload) were analyzed using the MIXED procedure of SAS.

3. Results

3.1. FibreLux compared to OFDA2000

After removing outliers and samples outside the specified range, 743 and 836 samples from MSU and AgriLife, respectively, were used to compare the FL to the OFDA2000. Eleven of the MSU samples measured on the FL were less than 15 μm and 226 were greater than 25 μm. A total of 10 MSU samples were identified as outliers and removed from the analysis. Only five AgriLife samples were outside the suggested operating range of the FL and 43 were removed as outliers. The greater number of outliers removed from the AgriLife samples was primarily caused by the smaller standard error of the regression lines.

Descriptive statistics for wool samples that were between 15 and 25 μm are shown in Table 1. Mean fiber diameter measured on the FL was finer ($P < 0.001$) for AgriLife samples and coarser for the MSU samples ($P < 0.001$) compared to the OFDA2000. Comparison of FL to the OFDA200 in Tables 2, 3, and 5 show statistics for all samples and with outliers removed as recommended by IWTO-0 (2002) but except of the one instance when the inferences differed between the two data sets only results from the data sets with outliers removed will be presented. At MSU there was no level dependent bias as shown by the estimate of

Table 1
Summary statistics for the comparison of mean fiber diameter (MFD) measured on the FibreLux and OFDA2000. Estimates are based on FibreLux readings ≥ 15 μm and ≤ 25 μm with outliers removed as recommended by the IWTO method.

	MSU		AgriLife	
	FibreLux	OFDA2000	FibreLux	OFDA2000
Number of Observations	753	753	836	836
Mean MFD (μm)	21.49	21.25	18.83	19.04
Standard Deviation (μm)	2.02	1.97	1.84	1.58
Standard Error (μm)	0.07	0.07	0.06	0.06
Pr > t $\bar{x}_{FL} = \bar{x}_{OFDA}$		< 0.001		< 0.001

Table 2
Geometric mean regression for FibreLux readings ≥ 15 μm and ≤ 25 μm of OFDA2000 (reference method) to FibreLux (alternative method) using IWTO-0 Appendix B methods for all samples and after removal of samples outside the 95% confidence interval of residuals regressed on average of OFDA2000 and FiberLux measurement.

Statistic		MSU		AgriLife	
		All Samples	Outliers Removed	All Samples	Outliers Removed
N		763	753	879	836
Estimated Slope		0.97	1.03	1.17	1.16
Standard Error of Slope		0.02	0.02	0.02	0.01
Significance of Slope:	t-Value	−1.91	1.59	9.66	11.24
	Significance	0.235	0.111	< 0.001	< 0.001
Significance of Correlation:	*R-Value*	0.74	0.89	0.90	0.93
	t-Value	30.60	54.18	61.48	74.78
	Significance	< 0.001	< 0.001	< 0.001	< 0.001

the geometric mean slope of 1.03 ± 0.02, which did not differ significantly from unity (P = 0.111; Table 2, Fig. 1A). The slope for the regression of instrument differences versus instrument averages was 0.03 ± 0.02, which was not significantly different from zero (P = 0.107; Table 2, Fig. 1C). The only instance where outlier removal changed the results was an increase in the correlation between instrument differences and instrument averages −0.04 (P = 0.880) and 0.06 (P = 0.053) without and with outlier removal, respectively, at MSU (Table 3). A level dependent bias was detected at the AgriLife lab as shown by the estimate of the geometric mean slope of 1.16 ± 0.01, which differed from unity (P < 0.001; Table 2). This suggests that the FL underestimated MFD by 0.9 μm for 15 μm fibers and overestimated MFD by 0.7 μm for 25 μm fibers (Fig. 1B). The estimate of the slope for the regression of the instrument difference versus instrument average was 0.16 ± 0.01 at the AgriLife lab, which differed from 0 (P < 0.001) and agrees with the geometric mean regression between the two instruments. Fig. 1A and B show that outliers from the MSU data resulted because the FL under estimated MFD compared to the OFDA2000, but at the AgriLife lab MFD of outliers were evenly over and under estimated. Fig. 1C and D also show that after outlier removal the confidence interval for the AgriLife data was smaller than for the MSU data ± 2.94 μm versus ± 1.49 μm.

Comparison between the two laboratories of the regression of OFDA2000 on FL showed that the slopes and the intercepts of the lines differed (P < 0.001) between the two labs. Ninety-five percent confidence limits on the predictions were 1.8 and 1.3 μm for MSU and AgriLife predictions, respectively.

3.2. Samples coarser than 25 μm

Descriptive statistics of the MSU wool samples with a MFD greater than 25 μm are shown in Table 4. In contrast to fibers less than 25 μm, FiberLux MFD was coarser than the OFDA2000 (P < 0.001). The correlation coefficient of MFD between the instruments was 0.95 and was highly significant (P < 0.001; Table 5). The estimate of the geometric mean slope for the regression of OFDA2000 MFD on FL MFD (1.27 ± 0.03) differed from unity (P < 0.001) and the slope for the regression of the instrument difference versus instrument average differed from 0 (P < 0.001; Table 4, Fig. 2). Thus, for the MSU samples greater than 25 μm, MFD was underestimated by 0.9 μm at 25 μm and overestimated by 1.4 μm at 34 μm.

3.3. Load error

The effect of amount of fibers on the FL slide is shown in Fig. 3. The measurements greater than 35 μm indicate that it is possible to obtain measurements rather than an error message; however, these erroneous measurements exceeded the manufacturer's specified range for the instrument by more than 10 μm. Regression of measurements less than 30 μm on successively fewer fibers for the 20.5 μm top showed that the slope did not differ from 0 (P = 0.53), thus measurements were not affected by the number of fibers. However, a similar regression for the 23.5 μm top showed the slope differed from 0 (P = 0.016; R^2 = 0.65), indicating that the MFD increased 0.1 μm for each combing.

3.4. Repeatability

Analysis to compare the error associated with repeated measurements on the two instruments showed that MFD was similar on both instruments but differed between fleeces (P < 0.001), although the fleece x instrument interaction was also significant (P < 0.042, Table 6). The significant fleece x instrument interaction was caused by one of the fleeces measuring below the OFDA2000 on the FL and is considered a vagary of sampling and not an important interaction. The FL estimated variance components were greater than the OFDA2000 (Table 6). The estimated sampling error associated with multiple staples from the same fleece was the greatest source of variation and was 4 and 40 times greater than the estimated reload error for the FL and the OFDA2000, respectively. The estimated reload variance component for the FL (0.17 μm^2) was larger than for the OFDA2000 (0.01 μm^2). Analysis of additional sources of variation of the FL were similar to the results for the comparisons between instruments. The estimated variance component for sampling error associated with staple was about 4 times greater than the reload error (Table 7). The estimated reload variance component was about 5 times greater than the variance component for reversing the FL slide, and the latter was similar to the residual variance.

4. Discussion

4.1. FibreLux compared to OFDA2000

Our objectives were to evaluate the accuracy and precision of the FL instrument for on-farm measurement of MFD in U.S. wools. Results indicated that when compared to the OFDA2000 the FL performed within the manufacturer's specified 15–25 μm range as well as for fibers up to 34 μm. Across both labs and datasets, the average difference in mean fiber diameter between the OFDA2000 and the FL was 0.23 μm, and the standard error of prediction of the geometric mean regression for predicting OFDA2000 MFD with FL MFD was 0.71 μm and 0.94 μm for AgrLife and MSU, respectively. The FL manufacturer's specified accuracy is 0.8 μm, but they do not indicate what this represents (e.g., 95% confidence interval or standard error of prediction). Precision, or repeatability when μeasuring the same sample repeatedly, was similar between the two instruments. As expected, variance components due to staple-to-staple variation within a fleece were the greatest source of sampling error for both instruments. Repeatability when the same staple was reloaded was a minor source of error for both instruments, but was estimated to be larger for the FL than the OFDA2000.

Sommerville (2002) defined technical instrument equivalency, especially with emerging technologies, as exhibiting the same overall

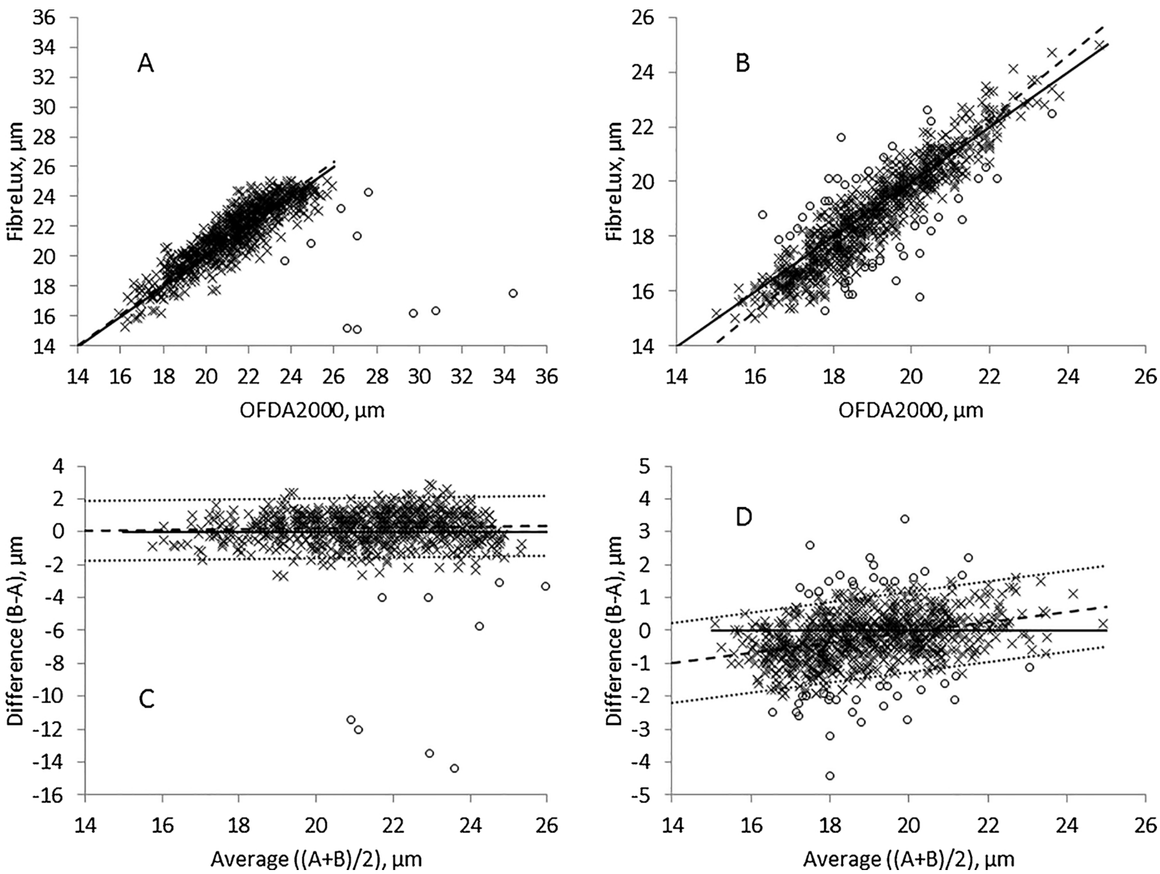

Fig 1. Scatter plot of geometric mean regression of FibreLux on OFDA2000 for MSU A and AgriLife B, the solid line is the 1:1 line and dashed line is the regression line. Difference (alternative method B − reference method A) versus average of both methods regression for FibreLux (B) and OFDA2000 (A) MSU C and AgriLife D, the dashed line is the regression line and the dotted lines are the 95% confidence intervals. Data points represented by "x" were used in the final analysis and those represented by "○" are outliers and not included in the final analysis.

Table 3
Residuals regressed on average of OFDA2000 and FiberLux measurement for FibreLux readings ≥ 15 µm and ≤ 25 µm of OFDA2000 (reference method) to FibreLux (alternative method) using IWTO-0 Appendix B methods for all samples and after removal of samples outside the 95% confidence interval of residuals regressed on average of OFDA2000 and FiberLux measurement.

Statistic		MSU		AgriLife	
		All Samples	Outliers Removed	All Samples	Outliers Removed
N		763	753	879	836
Estimated Slope		−0.03	0.03	0.16	0.16
Standard Error of Slope		0.03	0.02	0.02	0.01
Significance of Slope:	t-Value	−1.17	1.62	10.46	12.15
	Significance	0.241	0.107	< 0.001	< 0.001
Significance of Correlation:	*R-Value*	−0.04	0.06	0.33	0.39
	t-Value	−1.17	1.62	10.46	12.16
	Significance	0.880	0.053	< 0.001	< 0.001

Table 4
Summary statistics for mean fiber diameter (MFD) measured on the FibreLux and OFDA2000. Estimates are based on FibreLux readings ≥ 25 µm taken at the MSU laboratory with outliers removed as recommended by the IWTO method.

	FibreLux	OFDA2000
Number of Observations	209	209
Mean MFD (µm)	27.30	27.54
Standard Deviation (µm)	2.79	2.20
Standard Error (µm)	0.19	0.15
Pr > t $\bar{x}_{FL} = \bar{x}_{OFDA}$		< 0.001

precision (encompassing sampling and measurement), bias, sensitivity, detection limit, selectivity, and operational range. Instrument equivalency was not the objective of the present study, nor is the commercial certification of the FL for MFD measurement its intended use. Rather, the instrument provides real-time capabilities to make assessments of MFD in selection decisions.

Systematic instrument bias has been observed between the AirFlow, OFDA, and Laserscan (Baird et al., 1994; Harig, 1995), as each instrument utilizes different geometric definitions of fiber diameter, in addition to calibration wool varying from the actual wool measured (Sommerville, 2002). Comparisons of measurements between OFDA and Laserscan observed a 0.14 µm difference, with no differences in measurements in samples < 15 µm, whereas the Laserscan measured 0.6 µm coarser than the OFDA in samples greater than 20 µm (Knowles, 2000).

Machine differences between the two labs were likely caused by differing protocols on the FL and the OFDA2000. The whole staple was analyzed at AgriLife, while the FL slide window was cut out in MSU samples. The geometric mean regression line for MSU data showed that when the same portion of the staple was run on both instruments, they gave similar readings. The lower between-instrument correlation at MSU compared to AgriLife (r = 0.89 vs. r = 0.93, respectively) might result from more variation of wool fiber diameter and the geographically distinct breed makeup. It is also possible that these differences are the result of the presentation and order in which samples were placed on instruments, although this is less likely as standardized experimental methods were employed by both laboratories.

For the AgriLife samples and the MSU samples greater than 25 µm slopes were greater than 1 for the geometric mean regression line and

Table 5
Residuals regressed on average of OFDA2000 and FiberLux measurement for FibreLux readings ≥ 15 μm and ≤ 25 μm of OFDA2000 (reference method) to FibreLux (alternative method) using IWTO-0 Appendix B methods for all samples and after removal of samples outside the 95% confidence interval of residuals regressed on average of OFDA2000 and FiberLux measurement.

Statistic		Geometric Regression		Residuals Regressed on Average	
		All Samples	Outliers Removed	All Samples	Outliers Removed
N		226	209	226	209
Estimated Slope		1.25	1.27	0.23	0.24
Standard Error of Slope		0.03	0.03	0.03	0.02
Significance of Slope:	t-Value	7.83	9.53	8.82	10.81
	Significance	< 0.001	< 0.001	< 0.001	< 0.001
Significance of Correlation:	*R-Value*	0.92	0.95	0.51	0.60
	t-Value	35.75	42.79	8.84	10.83
	Significance	< 0.001	< 0.001	< 0.001	< 0.001

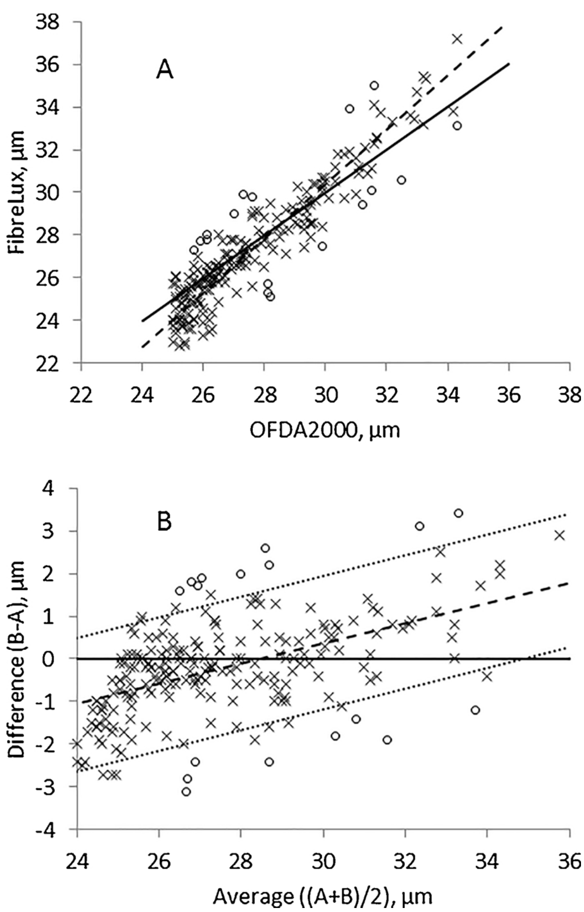

Fig. 2. Scatter plot of geometric mean regression of FibreLux on OFDA2000 for MSU samples greater than 25 μm A the solid line is the 1:1 line and dashed line is the regression line. Difference (alternative method B − reference method A) versus average of both methods regression for FibreLux (B) and OFDA2000 (A) B., the dashed line is the regression line and the dotted lines are the 95% confidence intervals. Data points represented by “x” were used in the final analysis and those represented by “○” are outliers and not included in the final analysis.

greater than zero for the instrument differences versus instrument averages but not for the MSU samples less than 25 μm. Differences in procedures whereby at AgriLife the entire staple was measured on the OFDA2000 but only part of the staple was measured on the FL while at MSU the same portion of the staple was measured on both instruments may explain the differences for samples less than 25 μm. Thus, portions of the staple analyzed on the OFDA2000 would be excluded on the FL slide and would not be quantified. This could be further explained by the fact that wool growth in finer wool sheep (AgriLife samples) is more responsive to changes in nutrition than coarser wool sheep (MSU samples) (Olivier and Olivier, 2005). Future research comparing the FL and OFDA2000 using tender wool samples might clarify this speculation. The AgriLife data set is representative of a more homogenous dataset composed of Texas fine-wool sheep, whereas the MSU wool samples represent both fine-wool and dual-purpose breeds (i.e., Rambouillet, Rambouillet x Merino, Targhee, Columbia, and South African Meat Merino). Differences in MFD observed between the Airflow, OFDA and Laserscan instruments indicated breed-specific effects for South African wool with strongest instrument correlation observed in finer Merino type wools (Van Zyl, 2000).

The MSU data set was included to evaluate a broader range of wool MFD, potentially more representative of the field use of the instrument across different wool types. The manufacturer’s specified range of 15–25 μm was intentionally exceeded because there is a large population of dual-purpose breeds utilized in the Intermountain and Northern Plains regions of the U.S. that generally have coarser wool. The 95% confidence limits for prediction of OFDA2000 measurements from the FL measurements between 15 and 25 μm were ± 1.3 μm and ± 1.8 μm for AgriLife and MSU, respectively. Correlations coefficients between the instruments 0.93 and 0.89 for AgriLife and MSU, respectively, were greater than reported by Peterson and Gherardi (2001) r = 0.83 and similar to Bhrendt et al. (2002) r = 0.94 comparing the OFDA2000 to the OFDA100. Analysis of samples coarser than 25 μm indicated that the FL could provide useful, yet less accurate, measurements above the specified range, especially in instances where flock outliers are to be identified.

Broadly speaking, precision refers to how well repeated observations agree with one another. The inherent heterogeneity of wool fibers will result in different MFD measurements in a sample run in duplicate regardless of the instrument employed (Sommerville, 2002). The 95% confidence limit of a single staple for estimating mid-side on the OFDA2000 (± 1.3 μm) was similar to previously reported values for this metric (Baxter, 2001; Peterson and Gherardi 2001). However, for the FL this metric was somewhat larger (± 1.6 μm). The analysis of the effect of reloading slides on measured MFD indicated that the FL was fairly insensitive to loading. It should be noted that about 3% of the readings were outside the range of the instrument, usually below 13 or above 35 μm, without an error message being displayed on the instrument. Therefore, it is recommended that when FL readings are outside the specified range, samples should be reloaded and reread. Because staple-to-staple error is greater than either the FL within-instrument error or differences between the FL and the OFDA2000, greater accuracy can be obtained by measuring multiple staples on each fleece than by using an instrument with higher precision and accuracy.

4.2. Applications of FibreLux

One potential application of the FL would be for on farm selection purposes in fine-wool or dual-purpose sheep. Fiber diameter is one of the most heritable fleece traits (Safari et al., 2005). Therefore, an animal’s MFD phenotype serves as a fairly accurate predictor of its genetic merit for MFD in comparison to other economically important sheep traits with low to moderate heritability (*e.g.*, litter size, mothering ability, growth rates, etc.). Consequently, selecting replacement animals on their MFD phenotype can result in appreciable genetic gains. The FL may help producers make more timely assessments of breeding stock at a reduced cost. Real-time on-farm fiber diameter information can facilitate sifting and sorting animals compared to the time required for submission of samples to testing laboratories. Although the FL does not provide the additional fiber measurements of the OFDA2000 (i.e., fiber diameter distribution, diameter variability, curvature, comfort factor), it’s questionable whether this additional information is utilized

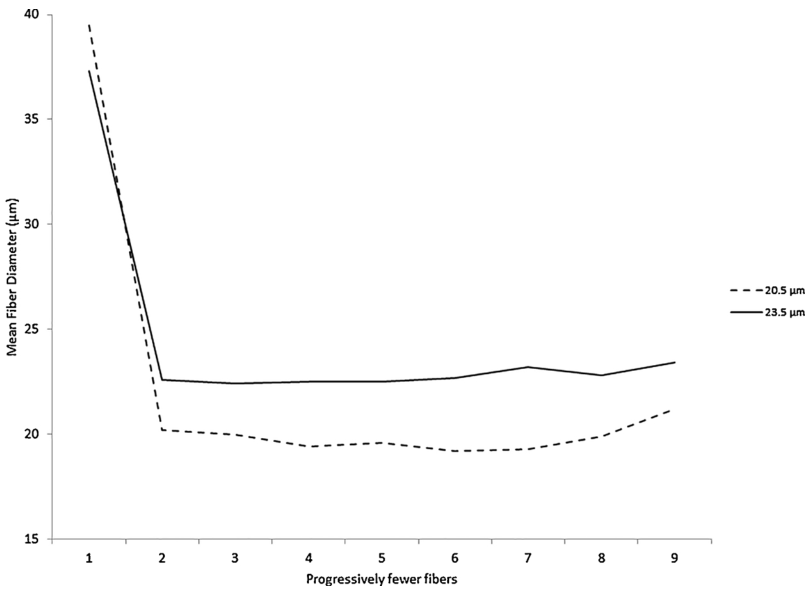

Fig. 3. Plot of FibreLux readings as effected by combing certified top to remove fibers between each reading until the FibreLux had an error message to estimate the error associated with differences in slide preparation.

Table 6
Estimates of sources of error associated with multiple measurements of mean fiber diameter on the FibreLux and the OFDA2000.

	Variance Component ± SE	
Source	FibreLux	OFDA2000
Staple (I × F)	0.69 ± 0.39	0.43 ± 0.22
Reload (I × F × S)	0.17 ± 0.08	0.01 ± 0.02
Residual	0.05 ± 0.01	0.05 ± 0.01

I = Instrument; F = Fleece; S = Staple.

Table 7
Estimates of sources of error associated with multiple measurements of mean fiber diameter on the FibreLux.

Source	Variance Component ± SE
Staple (F)	0.72 ± 0.41
Reload (F × S)	0.19 ± 0.09
Side (F × S × R)	0.03 ± 0.02
Residual	0.05 ± 0.01

F = Fleece; S = Staple; R = Reload.

in current U.S. selection and marketing of breeding stock. Technical evaluation of fleece characteristics reported in central performance tests, quantitative genetic selection programs (e.g. the National Sheep Improvement Program of the U.S.), and ram sales are best conducted on certified instrumentation (e.g., Laserscan, OFDA2000). However, the cost, availability, and timeliness of commercial testing are factors to consider when utilizing FL for selection purposes.

The utility of the FL for on farm fleece classing purposes will depend on multiple factors tied to the economic incentive for accurately classed wool and the cost-benefit of instrumentation to measure MFD. A disadvantage of sorting based on a single side staple is the inability to separate fleeces that are highly variable in fiber diameter. Field use of the OFDA2000 for wool classing into ≤19 µm or ≤20 µm showed a systematic coarse bias that resulted in fewer fleeces allocated to ≤19 µm wool lines (Hansford et al., 2002). However, Kott et al. (2010) observed an opposite bias with the OFDA2000 in Montana fine-wool sheep. Because the variation of different staples from the same side sample was 4 times greater than instrument error the FL should perform similar to the OFDA2000 when used in the field for individual animal selection and classing of fleeces. Thus, following recommendations for the OFDA2000 the FL would be best utilized for making selection decisions on a large proportion of a flock (e.g., retain upper 65%) rather than identifying a few superior animals (Hansford et al., 2002). Economic return for employing the FL will be greatest when there is a significant premium for fine wool fleeces (Lupton et al., 1989) in a wool clip with a high proportion of ≤19 µm wool (Kelly et al., 2007).

5. Conclusion

The FL is a compact, lightweight, seemingly durable instrument that operates on 110 V or battery. As reported here, there is a small technician, or loading, error that indicates that training on the use of this machine is rapid. Experience in the field allows for quick setup in a matter of minutes. Due to the wool sample configuration in the testing slide and its insertion into the instrument itself, sample preparation is simpler for the FL and its readings may be less prone to error due to wind or sunlight than the OFDA2000. Furthermore, the FL is easily stored for transport and is less prone to alignment problems since it has no moving parts. The FL has limited ability to store and retrieve data, but this can be enhanced by connection to a laptop computer.

Simplistically, the relative difference in price of instrumentation FL = $2500 USD; OFDA = $75,000 USD is indicative of the intended end-point uses. The FL is designed for on-farm testing and is not a replacement for commercial testing instruments, the improved accuracy would be lost in application. This research was conducted in the laboratory under ideal conditions. We believe that the FL is a potentially useful tool for on-farm measuring MFD in U.S. wools but further testing with laboratory validation of fleeces or bale lots is warranted.

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