Small Ruminant Research 159 (2018) 31–37

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

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

J.W. Walker[a,*], W.C. Stewart[b,c], R. Pope[a], S.L. Spear[b], M. Ebert[a,b], T.W. Murphy[b]

[a] Texas A&M AgriLife Research, San Angelo, TX 76901, United States
[b] Montana Wool Lab, Department of Animal and Range Sciences, Montana State University, Bozeman, MT 59717, United States
[c] University of Wyoming, Department of Animal Science, 1000 E. University Ave, Laramie, WY 82071, United States

ARTICLE INFO

Keywords:
Wool
Fiber diameter
FibreLux
OFDA2000

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.

* Corresponding author.
E-mail address: jwalker@ag.tamu.edu (J.W. Walker).

https://doi.org/10.1016/j.smallrumres.2017.12.008
Received 20 March 2017; Received in revised form 29 November 2017; Accepted 11 December 2017
Available online 16 December 2017

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