An Inside View of Fiber Testing

By Angus McColl

Alpaca breeders have an active interest in individual animal fiber diameter testing. You might call these results a micron test, a histogram report, or a micron count, but the information available through objective measurement has become a vital part of the animal selection process in the North American alpaca industry.

Fiber statistics can be used in marketing, but without a careful perspective and understanding of the data collected on individual alpacas, the display of "magic numbers" is about as useful as last week's lottery ticket.

The value of objective measurements and record keeping have emerged in sharper focus in the past few years with the interest in Expected Progeny Differences (EPDs). Suddenly, accurate reporting of AFDs, SDs, and CVs has taken on increased significance. Reports that reflect good sampling procedure from adult animals and contain descriptions complete with ARI numbers, fleece color, dates of birth, and dates of sampling are critical to researchers gathering data for calculation of EPDs.

All the power of image analysis and the capability of LaserScan and OFDA100 instruments in measur-

ing wool and animal fiber are of little value without good samples. Test results are only as good as the samples they represent.

An individual alpaca fiber sample should be taken from the midpoint of the side (blanket) area, the most representative and valuable part of the fleece. For measurement using the LaserScan or the OFDA100, the sample should be shorn at skin level from an area not less than two inches square (5 x 5 cm), the approximate width of a shearing head and the staple length should be at least one and one half inches (or 4 cm).

This fiber sample is then retained in the staple configuration that is its natural growth state. It should be identified by name and/or ear tag number, breed, sex, color, date of birth, and date of sampling and placed in a quart-sized Zip-Lok® bag with the identification information facing out, so it is easily read. The fiber sample submitted for testing should not be brushed out, cleaned up, or folded. Flat-bladed shears or clippers are recommended as the safest tools to use in the taking of samples. Shearing time is an ideal time to take individual samples.

There is a practical reason for maintaining the staple formation of the sample submitted to the lab. Unless otherwise requested, the individual sample used for measurement in the LaserScan or OFDA is cut close to the base of the staple to measure fiber that has grown side by side under the same environmental conditions.

If additional samples are taken from other areas, such as the shoulder, back, or hip, this will give you a better idea of the variability in the fleece as a whole. The value of this extra information must be considered in the context of increased testing costs. Ideally, the animal would have more than six months' growth of fiber at the time of sampling.

How old should the alpaca be when you first send in a fiber sample? Hopefully, not six days or six weeks old. There is no proven correlation between the fiber diameter of very young animals and the fiber diameter range of their adult fleece. The age of the animal at the time of testing is one of the three most important factors (age, sex, and level of nutrition) affecting fiber diameter. Always check the date of birth and the date of sampling on an individual animal histogram. If you are given a report showing any descriptive fields filled with a row of X's, it means the lab did not receive that information from the breeder. It could also indicate that keeping complete and accurate records is not a priority for the management of that animal's herd.

The reported Mean Fiber Diameter (MFD) is indicative of what fiber the animal was growing at the time of sampling. Variability stats Standard Deviation and Coefficient of Variation (SD and CV) indicate the genetic variability present in the fiber sample when it is guillotined at the base of the staple.

When samples for measurement are prepared in the same manner (i.e. either guillotined at the base of the staple or minicored, then washed and conditioned under standard testing conditions prior to measurement), the two standard methods of measurement (LaserScan and OFDA100) will give approximately the same result. The Sirolan LaserScan is more of a production instrument and well-suited for measuring a higher sample volume with fewer preparation steps than the OFDA100.

Yocom-McColl did use the OFDA100 instrument in completing an Alpaca Research Foundation study in 2004, entitled "Fiber Characteristics of U.S. Huacaya Alpacas" with co-investigators Dr. Christopher Lupton, Texas A&M University, and Dr. Robert Stobart, University of Wyoming. This study sought to define the ranges of quality attributes of domestically-produced huacaya alpaca fiber, using internationally-accepted methods to objectively measure most of the important fiber characteristics on 606 huacaya alpaca fiber samples. PDFs of the "layman's version" of the study which appeared in *Alpacas Magazine*, Summer 2004, are available from Yocom-McColl via e-mail.

Studies of this nature return individual results to the breeders directly, but do not identify any individual breeder's data in the analysis and publication of results. Again, the better the quality of the samples and the information provided by the participating breeders, the better the study.

Good sample selection and information provided to projects of this type will help to answer one of the most frequently asked questions: "how does my animal's fiber diameter test compare to other alpacas of the same age, sex, and or color?"

Fiber test results from an individual animal histogram should be part of careful recordkeeping on all factors that affect the herd's long-range breeding plan. Important factors include – but are not limited to – age, sex, nutrition, parturition, lactation, medical history, environmental stresses, and pedigree information.

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Optical Fiber Diameter Analyser (OFDA100)
Micron Test Report

Computer Bank Data
This is Factual Data
Denver, CO 80216-1823 USA

03/02/09

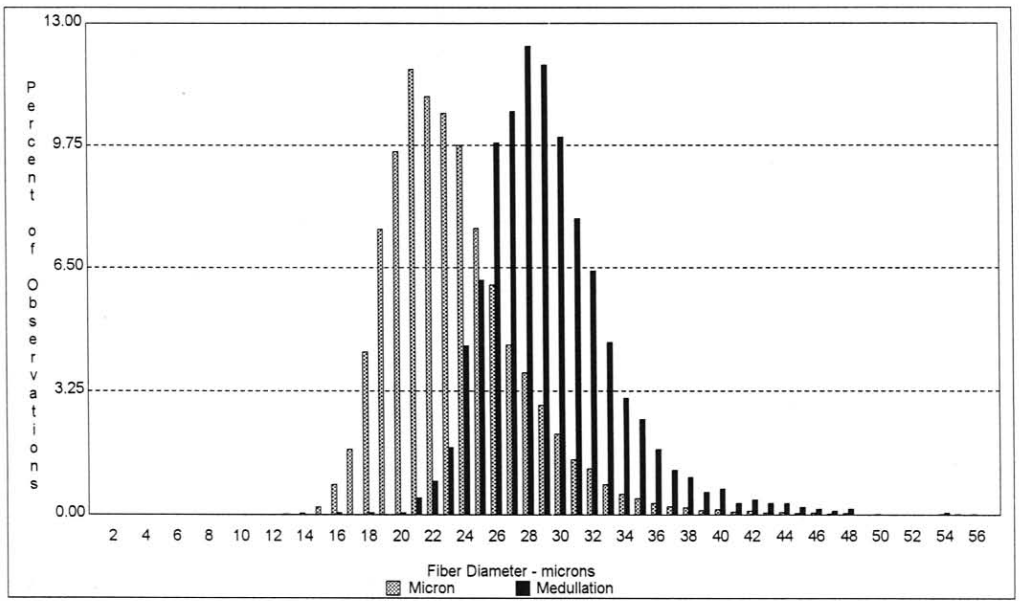
Test No:

Animal and Sample Description

Animal Name:	XXXXX	**Animal ID:**	XXXXX
Breed:	Alpaca(Huacaya)	**Sample Location:**	Side
Sex:	XXXXX	**Sample Date:**	XX/XX/XX
Color:	XXXXX	**Age:**	XX/XX/XX

Laboratory Data

Mean Fiber Diameter:	23.4 microns	**Spin Fineness:**	22.2 microns
Standard Deviation:	4.2 microns	**Mean Curvature (deg/mm):**	38.4
Coefficient of Variation:	17.9 %	**SD Curvature (deg/mm):**	21.5
Fibers Greater Than 30 microns:	5.9 %	**Comfort Factor:**	94.1 %
Medullated Fibers:	16.0 %		



This Test Performed According to I.W.T.O Method 47

This sample micron test report from "Computer Bank Data" contains factual data but all identifiable information has been eliminated.

So what are good results? Is finer fiber diameter always a good thing? These questions are best answered with even more questions: How old is the alpaca? What was his nutritional level at the time of the test? Does that low micron indicate he was too thin? And of course, what do these numbers mean on my histogram report?

After the ARF huacaya study, OFDA100 histograms were distributed to breeders. We soon saw an increase in demand for additional fiber quality data and included curvature measurement and percentage of medullation on white or light-colored samples. This "Computer Bank Data" micron test report *(above)* contains factual data but all identifiable data has been eliminated on the histogram to protect confidentiality of the breeder and the animal. However, we can tell you the alpaca was a white female huacaya and she was 2.8 years old at the time the sample for this test was submitted to the laboratory.

Normal Distribution

The graph of a normal distribution, the normal curve, is a bell-shaped curve. Many biological phenomena including animal fiber diameter distributions for single-coated animals, result in data distributed in a close approximation to normal. Statistics applicable to normally-distributed populations (mean, standard deviation, and coefficient of variation) are used to define these fiber diameter distributions. The normal curve is symmetric about a vertical centerline. This centerline passes through the value (the high point of the bell) that is the mean, median, and the mode of the distribution. A normal distribution is completely determined when its mean and standard deviation are known.

Mean Fiber Diameter (MFD) 23.4 microns

Fiber diameter is measured in microns. One micron is equal to one millionth of a meter or 1/25,400th of one inch. Mean Fiber Diameter (MFD) is in common use internationally and it is the most important measurement in the commercial wool and fiber industry.

Standard Deviation (SD) 4.2 microns

SD characterizes dispersion of individual measurements around the mean and is an important measure of variability. In a normal population, 68% of the individual values lie within one SD of the mean, 95% within two SD's, and more than 99.5% within three SD's. Since SD tends to increase with increasing MFD, some people prefer to use CV (=SD*100/MFD) as a method of comparing variability about different sized means.

Coefficient of Variation (CV) 17.9%

A measure of variability derived from dividing the Standard Deviation (SD) by the Mean Fiber Diameter (MFD) and used to compare uniformity between different populations. It is useful in ranking uniformity of individual animal fleeces, regardless of mean fiber diameter.

Fibers Greater Than 30 Microns: 5.9%

The percentage of the fibers measured over 30 microns, also known as the Prickle Factor or the coarse edge. It will increase as the Mean Fiber Diameter and Standard Deviation increase. This information is useful to processors of commercial lots of wool or fiber when attempting to predict the comfort of fabrics made from this fiber when worn next to the skin.

Medullated Fibers: 16.0%

The histogram showing medullation on this OFDA100 report is displayed on the same scale as the mean fiber diameter for ease of viewing, but it actually represents only 16.0% of the fibers measured in this particular sample.

Medullation measurement can be performed using either a projection microscope or the OFDA100. Using IWTO nomenclature, a kemp fiber is classified as an "objectionable fiber" when measured on the OFDA100. The OFDA100 measures opacity, and therefore only white or light colored fibers can be measured. A reasonable assumption is that colored fibers have similar levels of medullated fibers as their white and very light counterparts. A medullated fiber is an animal fiber that in its original state includes a medulla. A medulla in mammalian hair fibers is the more or less continuous cellular marrow inside the cortical layer in most medium and coarse alpaca fibers. By definition (ASTM), a kemp fiber is a medullated fiber in which the diameter of the medulla is 60% or more of the diameter of the fiber.

Spin Fineness: 22.2 microns

This provides an estimate of the performance of the wool or fiber when it is spun into yarn. This information is intended for mills that have tested, and will subsequently process large commercial lots and is included on these individual animal reports because the data is generated by the OFDA100 software. It was not originally intended for individual animal selection, although some breeders are apparently using it. The original theory comes from Martindale, but the formula used comes from Butler and Dolling and normalizes the equation so that the Spinning Fineness is the same as the MFD when the CV is 24%. The value of 24% was chosen because this is a typical CV value for an Australian Merino wool sale lot or consignment. The CV of most alpaca side samples would typically be much lower than this.

The formula is: $SF=0.881MFD\sqrt{[1+5(CV\%/100)\ 2]}$

Mean Curvature (deg/mm): 38.4

Fiber curvature is related to crimp. The greater the number of degrees per millimeter, the higher the crimp frequency, the tighter the crimp. Mean Curvature (MC) is determined by the measurement of two millimeter (2mm) snippets in degrees per millimeter

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Histogram display on computer screen of fiber measurements recorded by Sirolan LaserScan.

Sample cups of fiber snippets for individual animal fiber diameter testing by Sirolan LaserScan instrument.

Fiber sample for LaserScan test is dropped in a solution of isopropanol and water. This fluid transports the fibers through a glass cell where each one intersects a laser beam.

Laboratory Methods for Measuring Microns

Both Sirolan LaserScan and OFDA100 fiber testing methods provide the wool and textile industry with high-volume testing applications, but they utilize different technology. The LaserScan instrument scans fiber diameter with laser technology as its name suggests. The OFDA100 does not. OFDA instruments utilize LED (light emitting diode) technology and a digital video camera to capture fiber images for analysis.

These instruments were developed in Australia and are calibrated using Interwoollabs wool tops, the only recognized supplier of calibration tops to the worldwide textile industry. A diagnostic and calibration check is performed each day on both instruments. Testing methods are approved by the International Wool Testing Organisation (IWTO) and the American Society for Testing and Materials (ASTM) and are performed in laboratories under standard conditions for testing textiles, 70º F, and 65% relative humidity (+2% RH).

Sirolan LaserScan

The LaserScan instrument measures fibers by dispersing individual snippets (two millimeter lengths of fiber) in a solution of isopropanol and water and this fluid transports the fibers through a glass cell where each one intersects a laser beam. The LaserScan measures the change in the signal generated when the shadow cast by the fiber snippets falls on a light detector. The signals, which are directly proportional to the fiber diameter, are recorded almost instantaneously by the computer.

Optical Fibre Diameter Analyser (OFDA100)

OFDA100 was approved as an IWTO standard in 1995. Mark Brims and his company, BSC Electronics, designed the instrument. It uses a video camera to produce electronic images of magnified fibers that are distributed over a horizontal glass slide. Software analyzes the fiber images and derives measurement of diameter of a large number of longitudinal fiber sections. OFDA100 also measures and calculates the distribution of fibers (Standard Deviation or SD and Coefficient of Variation or CV), and average or mean fiber diameter. It also measures curvature and on white or light colored fiber, percentage of medullation.

This is how the OFDA100 analyzes your alpaca fiber for an individual animal fiber test:

1. Individual fiber edges are detected and followed.
2. If the followed length is long enough, then the fiber diameter along the fiber is checked and if the sides are parallel, it is accepted as a fiber.
3. The fiber is checked along its length to find a point where both sides of the fiber are clear of other fibers or dirt spots.
4. The fiber is measured for its sharpness of focus. If it is not in sharp focus, then it is not measured and if too many fibers are out of focus, the measurement stops and an error message alerts the operator.
5. Accurate sub-pixel measurements of the diameter are taken at these clear points.
6. The diameter is rounded to 1μ (micron) and added to a histogram.
7. After the whole slide has been measured, the mean and standard deviation of diameter are calculated from the mean fiber diameter histogram.

On the OFDA100 monitor, the white lines show the actual measurement points. The lines run in horizontal or vertical axes to allow the most accurate measurement. The diameter is corrected using the angle of the fiber at the measurement points. This method eliminates the potential for measuring hairs adjacent to each other and then identifying them as one wide snippet. *(See OFDA photo to the right.)*

The OFDA100 uses a monochrome digital video camera, a 4X microscope objective and an ultra-bright, red light emitting diode (LED). The image is digitized to a resolution of 256x256 pixels. The pixels are rectangular with the horizontal pixel width about 1.4X the vertical size.

The microscope stage holds the fiber snippets between two hinged glass slides and automatically moves the slide under the objective lens. The LED strobes for 40-80 microseconds to freeze the image of the moving fibers onto the CCD camera. The camera captures 50 images per second and each image is analyzed in less than 20 milliseconds. *(A millisecond equals one-thousandth of a second; a microsecond equals one-millionth of a second.)*

OFDA100 software analyzes fiber images and derives AFD, SD, and CV measurement of 2000 to 4000 longitudinal fiber sections. OFDA100 also measures curvature and medullation.

OFDA100 software analyzes fiber images and derives measurement of diameter of a large number of longitudinal fiber sections.

A "CCD" is a charge-coupled device, a silicon chip whose surface is divided into light-sensitive pixels. When a photon (light particle) hits a pixel, it registers a tiny electrical charge that can be counted. With large pixel arrays and high sensitivity, CCDs can create high-resolution images under a variety of light conditions. A CCD camera incorporates a CCD to take such pictures.

(deg/mm). For wool, low curvature is described as less than 50 deg/mm, medium curvature as the range of 60-90 deg/mm, and high curvature as greater than 100 deg/mm. Finer fiber diameter is often associated with a higher mean curvature.

SD Curvature (deg/mm): 21.5

Curvature (and crimp) is variable in alpaca fiber. The value of Standard Deviation of Curvature data available from OFDA100 analysis has not been agreed on by researchers but it is definitely secondary to Mean Curvature when used for assessment or selection of individual animals.

Comfort Factor: 94.1%

Comfort factor is the percentage of fibers over 30 microns subtracted from 100 percent. Ten percent of fibers over 30 microns corresponds to a comfort factor of 90 percent. This term was derived as a marketing decision to place a "positive spin" on the old Prickle Factor, which you will remember is the percentage of fibers over 30 microns. It is included on these individual animal fiber diameter reports on breeder request, but it is not new information, it is just more comfortable terminology. On this report, the Fibers Greater Than 30 microns equal 5.9% and when you add this Comfort Factor of 94.1%, the total will be 100%.

Angus McColl owns and operates Yocom-McColl Testing Laboratories in Denver. He emigrated to Wyoming from Scotland, where he was involved in his family farming business and graduated from the University of Wyoming. In 1964, McColl began operating Yocom-McColl as an independent commercial wool testing laboratory in partnership with Ira Yocom. The lab uses ASTM (American Society of Testing and Materials) and IWTO (International Wool Textile Organisation) procedures and methods in testing fibers. He is a member of the ASTM D13.13 wool committee and has represented the U.S. wool industry at annual technical meetings of IWTO. He has been actively involved in developing equipment for sampling and scouring wool in a commercial testing lab environment and has promoted correlation testing in the textile industry. He served as technical advisor to the Alpaca Registry screening committee for fiber standards of animals imported to the U.S. and worked with the North American alpaca community in the development of its first commercial fiber co-op.

Yocom-McColl in cooperation with Dr. Chris Lupton and Dr. Bob Stobart wrote the Standard Test Methods for Sirolan LaserScan Fiber Diameter Analyser, (LS) D-6466-99, and Optical Fiber Diameter Analyser (OFDA100) D-6500-00 for American Standards for Testing and Materials (ASTM) approval. In 2005, Angus McColl, Dr. Chris Lupton of Texas A&M, and Dr. Bob Stobart of the University of Wyoming, completed a study on U.S. huacaya alpaca fiber characteristics for the Alpaca Research Foundation. Currently, Angus McColl and Dr. Lupton are working on an ARF grant with the Suri Network to study the objective analysis of luster in suri alpaca fiber. Since 2007, Yocom-McColl has been working with researchers to provide fiber testing data for Expected Progeny Differences (EPDs) for North American alpacas.