Alpaca Fiber Quality and Analysis

Chris Lupton

Texas AgriLife Research
The Texas A&M System
San Angelo

Alpaca Information Day

Petersburg, VA       January 17, 2009
I. Background and current research interests.

II. Recent cooperative studies with alpacas.

III. Animal fiber metrology.

IV. Genetic tools that are being used to improve alpaca fiber quality and production.
1. Develop and evaluate near-infrared reflectance spectroscopy and automatic image analysis for more rapid, less expensive, objective evaluation of animal fibers.

2. Use objective measurements to improve fiber and/or meat production, quality, and income to producers through improved selection, nutrition, management, and marketing efficiency.
I. Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Near-infrared reflectance spectroscopy for measuring clean yield and fiber properties of greasy wool and mohair.
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Comparison of Texas Rambouillet with Australian Merino F1 crosses
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Using a portable automatic image analysis instrument (the OFDA2000) to measure fiber characteristics at the farm or ranch
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Rambouillet ram and Angora billy goat central performance tests
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Genetic selection to improve the use of goats to manage juniper
Current projects at the Wool and Mohair Research Lab, Texas AgriLife Research, San Angelo

- Genetic selection to develop a more profitable dual-purpose (fine wool and meat) sheep. The Texas Rambouillet Superior Genetics Cooperative Breeding Program / National Sheep Improvement Program.
II. Recently completed alpaca research projects

- Fiber characteristics of Huacaya alpacas in the United States
  - Angus McColl, Yocom-McColl Testing Laboratories, Denver.
  - Bob Stobart, University of Wyoming, Laramie.
  - Chris Lupton, Texas AgriLife Research, San Angelo.
  - 23 fiber characteristics, BW, n=585
  - Small Ruminant Research, 63, 3:211-224.
Recently completed alpaca research project

- Determine the effects of age, location, nutrition, and season on fiber production, fiber quality, and body weight of intact alpaca males.

- Ruth Elvestad, Olds College, Alberta Canada
- Chris Lupton, Texas AgriLife Research, San Angelo
Location of Research Sites in Canada and USA

- Olds, AB
- San Angelo, TX
Current projects with alpacas

- Gastrointestinal parasite epidemiology and control in alpacas.
- Effects of management practices on alpaca fiber production.
- Stephan Wildeus et al., Virginia State University, Petersburg
Current long-term, low intensity project with alpacas

- Evaluation of alpaca castrates as guard animals for sheep and Angora goats
Another recently funded project with alpacas

- Evaluation of two objective methods (the SAMBA System and NIRS) for measuring luster in Suri alpaca fiber, comparison with subjective assessment, and correlation with other physical properties. A. McColl and C. J. Lupton.
III. Alpaca fiber metrology

“Current technology”
Sampling

• From live animals
• From shorn fleeces
• From accumulations (bags or bales)
Sampling

- Mid side, best single indicator
- Random (core or grid) sample from part of (e.g., saddle) or whole fleece
- Random (core or grab [manual or machine]) sample from packages of fiber
Figure 1. Five (normally) distinct fleece components
Yocom-McColl’s alpaca mid-side diagram
Neck, side, and britch samples for fiber diameter and medullation
Core & grab sampling bales
Core sampling bales
Fleece and fiber characteristics that can be measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, % (AB, LSY, CWFP, SDY)
- Vegetable matter content, % (VMB, VMP)
- Average staple length, SD, mm, and CV, %
- Average staple strength, SD, N/ktex, CV, %, POB (and % tip, middle, and base breaks).
Fleece and fiber characteristics that can be measured or calculated (contd.)

- **Average fiber diameter, SD, microns, CV, %**
- Comfort factor, % fibers ≤ 30 microns
- Spinning fineness, microns
- Average fiber curvature, SD, deg/mm, CV, %
- Resistance to compression, kPa
- Medullated fibers (med, kemp and total medullation, ASTM), or total medullated fibers, flat fibers, and objectionable fibers, % or number / 10,000 (IWTO). Also AFD, SD, and CV of medullated fibers.
Fleece and fiber characteristics that can be measured or calculated (contd.)

- Dark fibers (in white fleeces or vice versa), number / 10,000 or number / unit weight.
- Color, tristimulus values, brightness or yellowness.
- Luster.
- Fibers per unit area of skin.
Relative commercial importance of raw specialty animal fiber traits (McGregor, 2006).

<table>
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<tr>
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<td>Staple strength/POB</td>
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<td>CV of fiber length</td>
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<tr>
<td>Dark fibers</td>
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### Relative commercial importance of raw specialty animal fiber traits (McGregor, 2006) contd.

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<tr>
<td>Fiber crimp</td>
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<td>Color</td>
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<td>Style and handle</td>
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</table>

* Some significance
**** Highly significant
Sampling the staple

- Guillotine (2 mm) the base of staple (OFDA 100 or Laserscan).
- Guillotine elsewhere along the staple.
- Measure the whole staple (OFDA2000).
- Minicore the whole staple (2 mm).

- Measuring each type of sub-sample will give you a different result, but all are potentially useful.
Standard methodology

- American Society for Testing and Materials (ASTM)
- International Wool Textile Organisation (IWTO)
Fleece and fiber characteristics that can be measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, %
- Vegetable matter content, %
  - Average staple length, SD, mm, and CV, %
  - Average staple strength, SD, N/ktex, CV, %, POB (tip, mid, base or fraction)
Alpaca fiber base

- Mass of clean, dry fiber with all impurities removed expressed as a % of the original “raw” or “greasy” alpaca fiber mass.
- Usually report the fiber base after adjusting for allowed moisture (12%), residual grease (1.5%) and ash (0.5%).
Vegetable matter base

- Mass of oven-dried scoured burrs, seeds, twigs, leaves, and grasses, free of mineral matter and alcohol-extractable matter expressed as a % of the mass of the sample.
Presale Measurement Procedure

Weights shown in the chart are typical examples of the weights of the samples, subsamples and test specimens which occur in a pre-sale test.
NIRS

• Allows us to quantify broad classes of compounds or individual compounds that contain different chemical bonds.
  
  e.g., protein (in this case keratin), lipids (wool wax), cellulose and lignins (vegetable matter), and water.

• NIRS is also sensitive to particle size (potential for estimating AFD, SDFD, AC).
Near-infrared Reflectance Spectroscopy
NIRS Measurements

• Non-destructive and results available in less than two minutes.
• Currently, only being used commercially to replace one of the gravimetric tests (residual grease).
<table>
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<th>Fleece and fiber characteristics that can be measured or calculated</th>
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<tr>
<td>✓ Clean yield, %</td>
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<td>✓ Vegetable matter content, %</td>
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<tr>
<td>✓ Average staple length, SD, mm, and CV, %</td>
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<tr>
<td>• Average staple strength, SD, N/ktex, CV, %, POB (tip, mid, base or fraction)</td>
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</table>
Length Measurement, contd.

Grid sampling

Average staple length, SD, and CV of staple length
Length & Strength Testing

Staples in a Tray

ATLAS

Measuring Length
Fleece and fiber characteristics that can be measured or calculated

- Weight (raw and clean; whole or components), kg
- Clean yield, %
- Vegetable matter content, %
- Average staple length, SD, mm, and CV, %
- Average staple strength, SD, N/ktex, CV, %, POB (tip, mid, base or fraction)
Staple Strength Measurement

Average staple strength, SD and CV of staple strength, Position of break, and % tip, middle and base breaks
Strength Measurement, contd.

Agritest Staple Breaker 2

ATLAS
Fleece and fiber characteristics that can be measured or calculated (contd.)

- **Average fiber diameter**, SD, microns, CV, %
- Comfort factor, % fibers ≤ 30 microns
- Spinning fineness, microns
- Average fiber curvature, SD, deg/mm, CV, %
- Medullated fibers (white and pastel fibers only), total medullation, flat fibers, and objectionable fibers, % or number / 10,000.
  - Dark and medullated fibers and contaminants (in white fleeces), number / 10,000 or number / unit weight
  - Resistance to compression, kPa
  - Color, tristimulus values, brightness or yellowness
Instruments for measuring average fiber diameter

- Projection microscope (PM)
- Sirolan Laserscan (LS)
- Optical Fiber Diameter Analysers (OFDA 100 and 2000)
- Sirolan Fleecescan
- Airflow
Projection Microscope

Courtesy: Yocom-McColl Testing Labs, Inc.
Microprojection

Courtesy:
Yocom-McColl Testing Labs, Inc.
One Micron Equals...

1/25,400 of one inch

or

1/1,000,000 of one meter
Sirolan LaserScan Sample

Courtesy: Yocom-McColl Testing Labs, Inc.
LaserScan Display

Courtesy: Yocom-McColl Testing Labs, Inc.
OFDA 100
Optical Fibre Diameter Analyser
OFDA slide on stage

Courtesy: Yocom-McColl Testing Labs, Inc.
OFDA2000
Sirolan Fleecescan
Texas Agricultural Experiment Station

Date: 13Feb07
Sample ID: ALPACA
Description: 232
Lot/Client: ALPACA FARMS
Operator: CJL

27.3 u
Mean = 6.6 u
SD = 24.3 %
CV = Sample size = 5509
Spin fineness = 71.3 %
Comfort factor = Curve number = 3045
Curve = 66.8 [43] deg/mm
OPDA030:2.14 Cal: D=5.4121*WH -3.80, wV= 1.4680*WH+ 0.08, DkFlash= 77.5

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<td>60 1</td>
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- Statistical measurement of the variability in a sample
- 68% of the fibers fall within +/- one SD of the mean or average
- Smaller the number, the more uniform the sample
Standard Deviation (SD)

- Example:
  - MFD=20 microns
  - SD=4.0 microns
  - CV=(4.0/20.0)*100=20%

- Assume “normal” distribution then:
  - 68% of all fibers measured are between 16 and 24 microns
  - 95% of all fibers measured are between 12 and 28 microns
Curvature

• Is a measurement of the fiber crimp. Does not indicate the type of staple crimp (i.e., uniform staple crimp (like most fine wools) or crinkle (like cashmere).

• Is correlated with Bulk and Resistance to Compression

• Generally, worsted processors (lean yarns for fine suitings) prefer less crimp, woolen system spinners prefer more crimp (bulkier yarns for knitwear).
Frequency
Amplitude

Angle of curvature, °/mm

Large angle, small crimp

Small angle, bold crimp
Curve Histogram

Date : 13Feb07
Sample ID : ALPACA
Description : 232
Lot/Client : ALPACA FARMS

Diam = 27.3[6.6] μ
Curve = 66.8[43] deg/mm
Sample size = 5509
Curve size = 3045
Fiber crimp

- Fiber crimp (visual or measured as average fiber curvature, AFC) is **not** an accurate indicator of average fiber diameter.
Curvature ranges

- **Low**: < 50 deg/mm, crossbred wool, mohair (~2 crimps per inch). Alpaca 15-55 deg/mm.

- **Medium**: 60-90 deg/mm, 21 micron Merino and Rambouillet wool (~4 crimps per inch)

- **High**: >100 deg/mm, 16-18 micron superfine Merino and Rambouillet wool (~7 crimps per inch)
Spinning fineness

• Used by textile processors, a better indicator of processing performance than MFD alone, particularly in spinning.

  SF=0.881*MFD*(1+5*[CVD%/100]^2)^{1/2}

• For a given MFD, spinnability ↑ as CV ↓
• The number of microns above the MFD that contains the coarsest 5% of fibers
• Another statistic used by textile processors
• Smaller = more uniform
Degrees of medullation
(ASTM nomenclature, med, kemp, medullated fiber)
Microprojection
Dark and medullated fibers and contaminants (especially polypropylene) in white fleeces
Medullation
(IWTO [OFDA100] nomenclature)

- Total medullated fibers
- Flat fibers
- Objectionable fibers
- Units: per 10,000 or %
- AFD, SD of medullated fibers
- White and pastel fibers only
Texas Agricultural Experiment Station

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<td>28.61(5.2) Max 0.90(0.3) Std 0.601(0.31) Lg=0.29(0.71)</td>
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OFDA2000 bonus measurements: staple length and staple profile. But, limited accuracy, since measuring greasy, unconditioned samples.
Staple Profile (OFDA2000 only)

- Fiber diameter measured along the staple
- Left side tip, right side base of staple
- Can see how MFD changes during the growing season.
Figure 7. Histogram and typical staple profile for an alpaca
Figure 8. Histogram and typical staple profile for very uniform alpaca

OFDA 2000 REPORT: SORTED BY TAG
Canada Staples (18 Records)

EarTag: 038L
Micron: 28.3 mic
SD: 4.5 mic
CV: 15.9 %
CF: 71.0 %
SF: 26.5 mic
CRV: 27.8 Dg/mm
SDC: 21.8 Dg/mm

Staple Len: 115.0 mm
Min Mic: 27.5 mic
Max Mic: 29.4 mic
Finest Point From Tip: 5.0 mm
FPFT – Finest Point From Tip
Used to indicate where the MFD is the smallest and most likely to break during processing

MFE – Mean Fiber Ends
MFD at the ends of the staple
Relationship to comfort factor?

Minimum and Maximum MFD along staple
Excellent for selection purposes

% fibers < 15 microns
Staple profile (contd.)

- Drastic changes in diameter can cause a weakness in the staple strength and can impact processing ability (breaks).

- Use the information to make management decisions to grow sound fiber
  - Shearing in relationship to parturition, lactation, etc.
  - Supplemental feeding strategies
Airflow (WIRA)

- Measures flow of air through fiber sample.
- Indirect measurement of AFD.
- Does not measure SD, CV, curvature, or medullation.
- Very few, if any, calibrated for alpaca.
- Medullation affects accuracy of measurement.
Resistance to Compression
Colorimeter

Tristimulus values
Whiteness
Yellowness
Brightness
Luster

- Goniophotometer. Single fibers, slow, expensive.
- Opacity (OFDA 100) and NIRS.
- SAMBA Hair System. Very promising.
Of great interest to breeders (but not the textile industry)

- Body weight
- Fleece weight
- Fiber density (fibers per unit area of skin)
Fibers per unit area

- Traditionally determined using histological / staining methods. Not particularly accurate and requires removal of multiple skin samples using a trephane.
- However, skin sections capable of revealing additional information.
flg (a)  
Primary follicles (blue)  
Secondary follicles  

SRS®  

Flat Skin  
Heavy tight skin  

flg (b)  
Fibres  
Fibre Bundles visible in fleece - thin and fine crimping  
Fibre Bundles entangle to form thick staples  

Skin Surface  
Wool follicles  
Secondary follicles  

Thin  
SRS®  
Flat Skin  
Heavy Tight Skin  

Thick  

(Reproduced with permission from the SRS company)
Fibers per unit area

- Alternatively, and less invasively, a known area can be shorn from the mid-side.
- Knowing staple length, clean weight, average fiber diameter, and density of alpaca fibers, can calculate fibers/unit area.
Accuracy of objective measurements

• Don’t get carried away with the second number after the decimal place!!

95% confidence limits
• Fiber base (clean yield): 1 to 2%
• VM Base: 0.1 to 2%
• MFD: 0.2 (15 micron) to 0.9 (40 micron)
• Staple length: 5 mm
• Staple strength: 6 N/ktex
IV. Genetic Evaluation of Fiber Traits in Alpaca
Genetic improvement of alpaca

Is usually geared towards:

• Increased production (per animal or per unit of BW).
• Increased production (per unit of land base).
• Improved quality (decreased fiber diameter and medullation, for example, so that a unit amount of fiber is worth more).
Genetic improvement of fiber production

- Conventional
  - Define breeding objectives
  - Select measurable, heritable trait(s) that exhibits variation among individual animals.
  - Apply maximum selection pressure (mainly from male side).
  - Reduce generation interval
Genetic improvement per year =

\[
\text{Heritability (h}^2\text{)} \times \text{Selection differential} \div \text{Generation interval}
\]
Genetic tools available in the U.S. for improvement of fiber production

- **A National Alpaca Improvement Program**, The Ideal Alpaca Community, Mike Safley (OR) and Dave Notter (VA).
- **Genetic Alpaca Improvement Network (GAIN)**, Wayne Jarvis, Holley, New York.
The most active program for genetic evaluation of U.S. sheep is:

- National Sheep Improvement Program.
- ASI Program
- Genetic Evaluation Center at Virginia Tech
### NSIP Clients

<table>
<thead>
<tr>
<th>Breed</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targhee (TA)</td>
<td>Suffolk (SU)</td>
</tr>
<tr>
<td>Polypay (PP)</td>
<td>Katahdin (KT)</td>
</tr>
<tr>
<td>Dorset (DO)</td>
<td>Columbia (CL)</td>
</tr>
<tr>
<td>Hampshire (HA)</td>
<td>Boer Goat (BO)</td>
</tr>
<tr>
<td></td>
<td>Romney group (Romney, Dorper, White Dorper, Coopworth)</td>
</tr>
<tr>
<td></td>
<td>Texas Rambouillet Nucleus Flock</td>
</tr>
<tr>
<td>In 2008</td>
<td></td>
</tr>
<tr>
<td>Kiko Goat (KI)</td>
<td></td>
</tr>
<tr>
<td>Ideal Alpaca Community</td>
<td></td>
</tr>
</tbody>
</table>
Genetic Trends in Targhee Sheep

**Fleece Weight, lbs**

![Graph showing fleece weight trends from 1986 to 2004.](image)

**Fiber Diameter, microns**

![Graph showing fiber diameter trends from 1986 to 2004.](image)
Genetic tools for improvement of fiber production

- Estimated breeding values, EBV (or estimated progeny difference, EPD)

- An EBV can be calculated for each measurable trait of an individual animal.

- The trait is adjusted for DOB, sex, BW, type of birth, etc. and expressed as a deviation from the mean for contemporary animals.
Genetic tools for improvement of fiber production

- Estimated breeding values, EBV (or estimated progeny difference, EPD)

- EBV is calculated as a function of the adjusted trait deviation, heritability of the trait, correlation between measured traits, and records of relatives.

- Within- and across-flock EBV’s are calculated (the latter when sufficient genetic connections are present among flocks).
To design an effective alpaca breeding program and to be able to accurately predict progress, we must have:

• Accurate estimates of **heritability, genetic and phenotypic correlations** among traits, and **phenotypic variation** within traits.

• It is also important to have **relative economic values** for each trait (preferably long-term averages unless specific knowledge is available on what the future holds).
Heritability values

- $h^2 > 0.40$, high
- $h^2 = 0.20$-$0.40$, moderate
- $h^2 < 0.20$, low

Most alpaca fiber traits are moderate to highly heritable.
Heritability estimates for alpacas (Chavez, 1991; Ponzoni et al., 1999; and Wuliji et al., 2000)

<table>
<thead>
<tr>
<th>Trait</th>
<th>h²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease fleece weight</td>
<td>0.21 - 0.83</td>
</tr>
<tr>
<td>Clean yield</td>
<td>0.37 - 0.67</td>
</tr>
<tr>
<td>Clean fleece weight</td>
<td>0.68 - 0.79</td>
</tr>
<tr>
<td>Mean fiber diameter</td>
<td>0.67 - 0.73</td>
</tr>
<tr>
<td>CV fiber diameter</td>
<td>0.90</td>
</tr>
<tr>
<td>Mean staple length</td>
<td>0.43 - 0.63</td>
</tr>
<tr>
<td>Live weight</td>
<td>0.27 - 0.69</td>
</tr>
<tr>
<td>Staple strength</td>
<td>0.16</td>
</tr>
<tr>
<td>Resistance to compression</td>
<td>0.69</td>
</tr>
</tbody>
</table>
If concurrent selection for more than one trait is desired then several approaches may be considered.

1. **Index selection** in which each trait is weighted by its heritability and economic value.

2. **Independent culling levels.** Threshold level for each trait.

3. **Combination** of 1 and 2.
<table>
<thead>
<tr>
<th></th>
<th>Genetic correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Favorable</strong></td>
<td>Fleece weight and staple length.</td>
</tr>
<tr>
<td><strong>Neutral</strong></td>
<td>Clean yield and staple length; fiber diameter and staple length.</td>
</tr>
<tr>
<td><strong>Antagonistic</strong></td>
<td>Fleece weight and fiber diameter.</td>
</tr>
</tbody>
</table>
Molecular biology for alpaca improvement

- The tools are likely to prove very useful for:
  - Identifying traits in young animals that cannot normally be measured until the animal matures e.g., a cria’s genetic potential to remain fine.
  - Detecting carriers of deleterious physical defects in animals that do not themselves exhibit the problem (e.g., Spider lambs).
The tools could prove very useful for:

- Identifying animals with resistance to internal and external parasites, or potential for improved growth, for example.
- Other traits that are difficult to measure directly.
Molecular biology for alpaca improvement

• The tools have already proven to be very useful in other species for identifying:
  ❖ Beef cattle bulls whose offspring will produce more tender meat.
  ❖ Dairy cattle bulls whose offspring will produce more milk.
  ❖ To name just a couple.
But, as an animal fiber metrologist, I feel obliged to point out to breeders that if a fiber trait is measurable, highly heritable, and economically important, then keep measuring it.

The fiber test is likely to be much less expensive than the DNA test.
Questions?