BASIC FIBRE TESTING FOR ALPACA BREEDERS

By Cameron Holt ©January 2011

The development of the Alpaca Industry is dependent upon the use of various forms of measurement applied to almost all characteristics of production (e.g. animal and fibre). To increase production of clean fibre per head Alpaca growers need to use measurement so as to select the animals with the desired characteristics, which will give them increases in that particular area. The most accurate method is by using scientific equipment at a testing laboratory.

Most Australian sheep’s wool offered for sale today is tested before sale. Processors demand accuracy and precision in the testing of fibre so that they can correctly batch (match) and blend the fibre to produce a yarn of a given specification. The technique previously used by the wool industry is the airflow method (Laserscan & OFDA now used), whereby a given weight of fibre (2.5 gms) is subjected to a stream of air under carefully controlled conditions, and the fineness calculated as a function of the resistance of the sample to airflow.

This process, whilst economical, measures only mean fibre diameter. It does not measure variation within the fibre. It is less suited to use with alpaca because of the presence of some guard hair fibre in alpaca fleece, also because the lower scale height of alpaca fibres may offer less resistance to airflow than sheep fibres of similar diameter. As well, lightness of alpaca due to the medulla means more fibre is placed in the chamber (2.5gms) creating a greater surface area therefore changing the reading of the micron. Machines used for wool need to be recalibrated for alpaca.

Airflow machine

A number of processors are now paying a premium for wool that has a low CV. These wools have to be measured on testing machines that can calculate SD and CV (Laserscan & OFDA). Wools, which have a CV of lower than 24%, produce a yarn that performs like a finer yarn due to their evenness of fibre diameter through out, (spinning fineness).

Almost all alpaca fibre tests currently performed are called “Guidance Tests”, because the results are not certified. Only those tests performed by a certifying authority (eg. Australian Wool Testing Authority) can be called Certified Tests, and ONLY when the certifying authority itself samples, measures and weighs the fleece or bale. They guarantee the results, but where a third party, unknown to the test house does the sampling, there is no guarantee of the origin or correctness of the sample.

This type of test is used in the wool industry, as well as for the sale of other commercial fibres (including alpaca), when offering baled fibre for sale. The vast majority of alpaca fibre tests that are performed are done on samples taken by the breeder and then submitted for testing, and are hence uncertified “guidance tests.” The testing procedure is, however, essentially the same as that used for certified tests, and the standards by which those machines operate are also the same.
Before looking at sampling and measurement it is important to understand 3 basic concepts which could have a large affect on the outcome of your test results.

1. **PRECISION**
The ability to provide a test result that is repeatable (using the same sampling technique and testing machine would help achieve this).

2. **ACCURACY**
   (a) The ability of the sample to correctly represent the true (correct) value of the fibre to be measured. (a grid sample of the fleece or a coring of the whole fleece would enable the correct value to be assessed from the “Breeders” sample point of view. An “in shed” sampling, scouring and laser machine is currently being used in Australia.

   It cores the whole fleece, washes and calculates micron etc.)

   (b) The ability of the testing machines to correctly interpret and calculate the true values of fibre being measures. (This would include controlled standard laboratory conditions, 20degrees C [+ -2 degrees] and 65% humidity [+ - 2%], as well as correctly controlled sub-sampling of the “Breeder sample” according to IWTO testing procedures).

3. **BIAS**
   Most SITE samples taken for alpaca (animal / fleece) evaluation are biased as per the definitions (see below, sampling methods and techniques).

**FOR A RESULT TO BE ACCURATE IT SHOULD BE PRECISE AND FREE FROM BIAS.**

**REMEMBER**
For practical purposes of comparisons within your alpaca herd it is important to (as mentioned earlier) use the same sampling technique and the same testing machine so as to cut down the variance that can occur between testing results.
SAMPLING

Whenever any testing is carried out, whether for fibre fineness, or yield, or perhaps vegetable matter content, the item requiring measuring (e.g.: bale or fleece) cannot be tested completely. In other words, EVERY fibre in a fleece or a bale cannot be measured, nor can EVERY piece of vegetable matter in the bale be collected. Complete testing of all fibre cannot be carried out because either the test is destructive, the expense is prohibitive if every fibre is measured and or the remaining fibre would be damaged. For this reason a sample is taken from the population and this representative sample is tested.

SAMPLING METHODS & TECHNIQUES

Whether we wish to sample a fleece, a bag, a bale or herd of Alpaca's or any population at all, the sample taken must fulfill 2 basic requirements.

1. Every fibre has a chance of being selected.
2. The method should not be intentionally or unintentionally manipulated in order to obtain a biased sample.

Bias occurs in the following ways:

1. If the property of the lot varies from place to place and the sample drawn from only one or two places, the sample is likely to be biased (technically this applies to "site" sampling).
2. Nearly all methods depending on personal selection of fibres lead to biased samples.

Bias, which contributes to “sampling error”, may give a lower/higher result. Therefore to acquire an accurate result the sample should be free of bias. Site samples are by definition a “Biased sample”.

SAMPLING INDIVIDUAL ANIMALS

The Alpaca does vary for fibre diameter from neck to the britch:

Within each breed of Alpacas there is a variation between sites on the individual breed, but there was no significant variability between the Suri and Huacaya in variability between sites. (Holt/Scott 1998)
This would suggest that the most accurate form of fibre measurement would be by gridding the fleece area. Research (Holt/Stapleton 1993) done on variation of Alpaca Huacaya fleece has shown that animals vary in evenness, that is, some display a more even fleece (fineness) to that of others. Studies on Suri fleece (Holt/Scott 1998) have shown similar results. This variation may cause problems when comparing one animal with another.

When testing with site measurements for micron and/or yield they should be used only as a guide and/or ranking for that animal within your herd. It also can be used to monitor the fibre change in micron from year to year. The full fleece test takes into account micron variation over the fleece (C or V) and should be read in conjunction with the Histogram print out.

**MIDSIDE SAMPLE**

A sample is drawn from the mid side as shown (a). Such a sample (although scientifically biased) as mentioned early may be a reasonable representative of the total fleece (Holt/Stapleton 1993). Care must be taken on site selection as sampling too high or too low may give a finer or stronger result.

Site sampling can also be carried out using the shoulder pin and hind pin in conjunction with the midside. These will give an indication of variance over the animal. A more accurate measurement would be to send the whole fleece for assessment or grid the fleece. This may only be practical for the top animals.

( a ) Midside

**NOTE** A word of caution. When taking a midside or site sample from an animal, you must cut the sample at skin level. If you vary the level of the plain of the cut between your samples then the cut would represent different growth patterns (nutritional and health as well as possibly age). This would make comparisons amongst animals unreliable.

The sample must be:

(a) Carefully and Accurately Identified

(b) Securely packaged for dispatch to a Testing House.

Mid side sampling can also take place during shearing. Sampling taken at this stage can complement fleece weighing, which is done at this point of time.

The same procedures for testing would apply.

Studies into site variation (Holt/Stapleton 1993) gave impressions that the Shoulder pin-bone and Mid were more reliable than those of the Hind pin-bone for fibre diameter measurements.
A reliable method for obtaining a representative sample from an Alpaca fleece is the grid sampling technique.

This occurs as follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Spread the alpaca fleece evenly on a table.</td>
</tr>
<tr>
<td>(b)</td>
<td>A grid made of a mesh approximately 4&quot; x 4&quot; (100 x 100) is placed over the whole fleece.</td>
</tr>
<tr>
<td>(c)</td>
<td>A sample (eg 1 staple) is taken from each square filled with fibre.</td>
</tr>
<tr>
<td>(d)</td>
<td>All squares more than half-filled with fibre are sampled, those with less rejected.</td>
</tr>
<tr>
<td>(e)</td>
<td>The small sample taken is in turn put together with the others taken from the same fleece to form a composite sample.</td>
</tr>
<tr>
<td>(f)</td>
<td>The sample is carefully and accurately identified.</td>
</tr>
<tr>
<td>(g)</td>
<td>The sample is securely packaged for dispatch to a testing house.</td>
</tr>
</tbody>
</table>

For “grid samples”, advise the Testing Laboratory that they are “grids” as they need to be sub-sampled using the “mini – core machine or similar. The whole sample is cored to avoid bias in the result.

All testing must be put into context. Research by Holt and Stapleton 1993 showed that fleece on a huacaya alpaca indicated an average difference of .77 microns between the grid sample (unskirted fleece) and the midside sample (on animal). The mean magnitude of difference was .92 microns. These indicated a correlation between the two sites of .93.

Later research in 2004 by Davison and Holt on a huacaya fleece, where comparisons were made between a grid sample (skirted fleece) and a midside sample (on animal), showed an average difference of .4 microns with a mean magnitude of difference of .87. This was the equivalent of a correlation of .94. Breeders must remember that on some alpacas, the fleece does vary considerably.

Test results (based on research from Holt / Stapleton 1993) indicated an average variance (over the research huacaya fleece) of 4.8 microns excluding apron and 11 microns including apron. Research in 1997 by Holt / Scott on suris fleece indicated an average range of 3.2 microns (excluding apron ) and 10.1 microns (including apron) over the tested Suri herd.
The following photos demonstrate the need for care when sampling your animal.

The alpaca in photo "1" has a reasonable even fleece all over. Here sampling on the midside may be adequate for your needs.

The animal in photo "2" shows extreme guard hair. This is seen in the hairy appearance. Midside sampling on an animal like this may give you an inaccurate result.

**NOTE** "The midside is likely to be more accurate on this alpaca than any result sampled from other single sites".

**The alpaca should be grid sampled.**

As mentioned earlier grid sampling is a more accurate form of measurement than any form of site measurement.

**FIBRE MEASUREMENT**

**FLEECE WEIGHING**

The selection of animals on your eye assessment for clean fleece weight or yield is not accurate.

The process of fleece weighing is a way to overcome these problems and give a more accurate measurement of fleece weight and in turn yield.

The weighing takes place in conjunction with mid side sampling or grid sampling during the shearing process, or a similar time each year.

Make sure your scales are accurate and weigh in 1.75 oz (50 grams) increments.
The procedure is as follows:

(A) As the mid sides shorn a small sample (50x50mm) is taken - a tag with the animals number is put with the sample.

(B) The fleece is laid on a table and if a grid sample is required, then the sample is taken as previously mentioned.

(C) The total fleece plus sample is weighed together, and weight recorded against the animal’s number in your record book or card.

**NOTE:** Information re fleece colour/type can also be noted at this stage.

(D) The sample is carefully and accurately identified, and placed to one side.

(E) The fleece is then placed in the appropriate fleece type.

(F) When all sampling is complete the individual samples are packaged and sent to a testing house.

An important point is that all Alpaca’s should be tagged for identification and that the scales used are calibrated.

**It is advisable to test when the animal has a full year’s production.**

**YIELD**

Fleece obtained from Alpacas contains various impurities, that is, natural and acquired impurities (grease, vegetable matter, dust). The sample taken for micron testing, is used by the testing lab to calculate yield.

Alpaca fibre also contains an undesirable medullated fibre (GUARD HAIR).

Heavy guard hair in Alpaca fibre is not desirable and therefore should be considered in calculating yield.

Yield is expressed as a percentage of the greasy (Raw) sample or fleece.
TESTING FOR FIBRE CHARACTERISTICS

We can measure for many alpaca characteristics such as -
- micron
- c of v
- sd
- fleece weight
- yield
- length
- strength
- crimp
- fibre curvature
- follicle structure
- medullation
- bulk

Micron is considered to be the most important characteristic for measurement. Fibre diameter is the single most important characteristic/property for all fibre. It accounts for 75/80% of value in the processed “Top” (Bell-Ainsworth 1984).

Some areas that can be objectively assessed by breeders and testing labs are:

<table>
<thead>
<tr>
<th>Fleece Sample Taken by Breeder</th>
<th>Responsible for test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fleece Weight</td>
<td>Breeder</td>
<td>Kg</td>
</tr>
<tr>
<td>Yield (Washing)</td>
<td>Test lab</td>
<td>X%</td>
</tr>
<tr>
<td>Diameter of Fibre</td>
<td>Test lab</td>
<td>Micron</td>
</tr>
<tr>
<td>Length of Fibre</td>
<td>Breeder/Test lab</td>
<td>CMS</td>
</tr>
<tr>
<td>Fibre Curvature</td>
<td>Test lab</td>
<td>DEG mm</td>
</tr>
<tr>
<td>Prickle Factor (comfort factor)</td>
<td>Test lab</td>
<td>Num over 5% Num under 95%</td>
</tr>
<tr>
<td>Medullation</td>
<td>Test lab</td>
<td>X %</td>
</tr>
<tr>
<td>Live Weight</td>
<td>Breeder</td>
<td>Kg</td>
</tr>
<tr>
<td>C of V</td>
<td>Test lab</td>
<td>X%</td>
</tr>
<tr>
<td>SD</td>
<td>Test lab</td>
<td>1 St Dev</td>
</tr>
</tbody>
</table>

The above measurements or samples can be taken easily by the breeder, and where necessary tests carried out by a testing house.

Measurements are generally carried out on two machines. The Optical Fibre Diameter Analyser (OFDA) and the Laser scan. Regardless of what method is used, an understanding of some statistical terms is necessary.
TERMS

MODE: The most commonly occurring value. (The highest peak or the micron with the greatest number of fibres recorded against it).

MEAN: The average of those values (MEAN MICRON).

When the mean (average) and mode are similar then the shape of the histogram is said to have a bell shaped curve which indicates an even spread of the population around the mean, however the height and base can vary.

MEAN FIBRE DIAMETER
This is a measure of central tendency and gives mean (average) of the fibre diameter in the sample expressed in microns. One micron is one millionth of a metre.

- STANDARD DEVIATION (SD)
This indicates how the fibre diameter in the sample vary around the mean. The smaller the standard deviation the less the variation around the mean.

One standard deviation (+1, -1 either side of the mean), will represent 68% of the fibres measured

\[ \text{Mean} = 26 \text{ microns} \]
\[ \text{SD} = 6.0 \text{ microns} \]

then 68% of the fibres will occur between 20 and 32

2 SD will represent 95% of the fibres measured

(95% of the fibres will occur between 14 and 38

"The concept of SD assumes that the fibre diameter is normal (bell shaped)"
(Summerville AWTA 2000)

CO EFFICIENT OF VARIATION (COV)
Is the percentage of variation in the measurements and is related to the mean and standard deviation. The C.O.V. enables various populations to be compared to each other.

Both SD and CV measure the degree of variation of micron in the tested sample.

THE FORMULA FOR CV% IS

\[ \frac{\text{SD}}{\text{MICRON}} \times 100 = \text{CV\%} \]
The following table represents 25% CV for each micron. The equivalent SD is next to the listed microns.

<table>
<thead>
<tr>
<th>MICRON</th>
<th>SD</th>
<th>MICRON</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>4.25</td>
<td>24</td>
<td>6.00</td>
</tr>
<tr>
<td>18</td>
<td>4.50</td>
<td>25</td>
<td>6.25</td>
</tr>
<tr>
<td>19</td>
<td>4.75</td>
<td>26</td>
<td>6.50</td>
</tr>
<tr>
<td>20</td>
<td>5.00</td>
<td>27</td>
<td>6.75</td>
</tr>
<tr>
<td>21</td>
<td>5.25</td>
<td>28</td>
<td>7.00</td>
</tr>
<tr>
<td>22</td>
<td>5.50</td>
<td>29</td>
<td>7.25</td>
</tr>
<tr>
<td>23</td>
<td>5.75</td>
<td>30</td>
<td>7.5</td>
</tr>
</tbody>
</table>

There are three basic shapes

All these have an even spread around the mean but No. 1 is very even and would have a low COV e.g. 20%
No. 2 is a normal distribution and would have a COV around 25% and No. 3 would be considered to be a mixed histogram with a COV around 30+%

There are other histogram shapes we may see when testing Alpaca fibre

The fineness of fibre you are breeding in your herd must be considered if you reflect on what the end product that the fibre is to be used for. Breeders should be aware of the average micron of each animal in their herd not only to identify those finer or superior types, but those that are undesirable for the owners breeding goals. The fineness of the micron will determine the final use of
the fibre and in some cases how the fibre is to be processed, that is whether the Alpaca is to be blended with another fibre e.g. wool or processed by on its own.

The normal measurement for micron is usually measured on 12 months fleece or thereabouts. I would advise that testing for micron is done at yearly intervals up to 5 years of age (animal’s micron goes out for 3 to 4 years on average).

**Before deciding** on what type of measurement or sampling procedure ask yourself - **What do I want to know and why?**

In some cases where breeders wish to get an idea of their animals follicle structure they will have carried out what is called "single plain cut (butt cut)" usually 1-2 cm from the butt. This method gives a good indication of a staple make-up but only measures at 1 point in time of growth and gives lower CV and SD. (does not have any environmental influence).

**CANNOT BE COMPARED WITH MEASUREMENTS MENTIONED ABOVE.** Those animals that test well may then have skin histology tests taken depending on the histograms from the “single plain cut.”

**TESTING MACHINES**

**Projection Microscope & General Microscope Method**

These methods involve the measuring of 400-600 images of fibres magnified 500 times on to a screen (projection microscope) or an eye piece (general microscope) where they are individually measured by an observer.

These methods are labour intensive and subject to a number of operator errors.

However, if the standard methods are followed correctly, the results obtained are accurate, and are capable of giving the user a measure of the distribution of diameters within the sample. Strict rules are prescribed about the preparation of slides, and the scanning of those slides to avoid measuring the same fibre twice, or selecting points within the field of view, which may not be random.

**General Microscope**

The test results can be expressed in the form of a Histogram, or a mathematical expression of the distribution such as Mean Fibre Diameter (MFD), the Standard Deviation (SD), and its derivative, the Co-efficient of Variation (CV).
Laser Scan Method

The Laser Scan is an instrument used for the rapid measurement of fibre diameter that also gives a full diameter distribution. This is the main testing machine used to test the Australian wool (sheep) clip.

Prepared snippets of fibre (less than 2mm) in length are dropped into either an isoprepnelol/water mixture or water based (AWTA), where they are dispersed. The dispersed snippets, still in the solution, are then carried past a light beam, and as the fibres intercept the beam, the amount of light scattered is measured. This light scatter is directly related to the diameter of the fibre, and so the machine can calculate the fibre diameter in microns. Mean fibre diameter, standard deviation, co-efficient of variation, fibre curvature etc are calculated and a histogram of the variation is printed.

Optical Fibre Diameter Analyser 100 (OFDA) Method

This optical measuring device was developed in Australia and is widely used in guidance testing wool, Alpaca, Cashmere and Mohair.

The OFDA 100 is an automatic microscope above a moving set of fibres. The analyser captures the magnified images of the individual fibres with a video camera. The diameter of each fibre identified is measured and recorded by means of computer aided image analysis. On completion of a predetermined number of fibres, a histogram print out is produced similar to the Laser Scan.

OFDA100 histogram

The OFDA100 can identify medullated fibres (white only). Fibre curvature can also be calculated on the OFDA.
**OFDA 2000**

OFDA2000 gives a report based on the entire staple, sampling it along its entire length.

The OFDA 2000 produces a graph, which records the average fibre diameter of the staple, measured at different distances along the staple from the skin. Variations in the fibre diameter along the staple may be interpreted as representing variations in the health, pregnancy, nutrition or climate enjoyed by the animal at the time the fleece was grown. The 2000 also prints the standard histogram.

For the 2000 to test for Medullation it needs to have an OFDA100 attachment to the machine. This “100 mode” would allow for measurements of the 2mm snippets' which come from the “mini-core that is used in laboratory sub-sampling. This then also enables the measuring of the grid samples taken by the breeder.

The Laser machine and both OFDA,s produce a histogram, indicating the number of fibre measurements recorded in a sample for every possible fibre diameter value in a range (from zero to 60 or more microns).
USING HISTOGRAMS

Care must be taken when using measured data as a number of variables can fudge the use of the results.

An example of this is when comparing one animal with another. Alpacas do get stronger with a combination of genetics, age and body weight/size. Evidence suggests that for alpacas an approximate 2 micron increase occurs between the first and second year (around 10%) and tends to increase for 5 – 6 years (around 5% a year) before becoming more stable. There are of course exceptions to this. Anecdotal comments from breeders have suggested that a blow out range can be from 2 to 10 microns over this period. Generally on average the finer microns blow out the least in “micron” terms, but are probably similar in “%” terms.

WHITE Huacaya BY AGE (1618 alpacas)

<table>
<thead>
<tr>
<th>AGE</th>
<th>NUMBER</th>
<th>AVERAGE MICRON</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>473</td>
<td>22.28</td>
</tr>
<tr>
<td>2</td>
<td>406</td>
<td>24.26</td>
</tr>
<tr>
<td>3</td>
<td>263</td>
<td>25.78</td>
</tr>
<tr>
<td>4</td>
<td>182</td>
<td>27.02</td>
</tr>
<tr>
<td>5</td>
<td>106</td>
<td>28.07</td>
</tr>
<tr>
<td>6</td>
<td>62</td>
<td>28.70</td>
</tr>
<tr>
<td>7</td>
<td>36</td>
<td>29.43</td>
</tr>
<tr>
<td>8</td>
<td>33</td>
<td>27.96</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>28.27</td>
</tr>
<tr>
<td>10/12</td>
<td>21</td>
<td>27.83</td>
</tr>
</tbody>
</table>

The genetic make up of the Alpacas will be the determining factor on how extreme the variance will be. Genotype is the genetic blue print of the animal and it is stamped at birth. This normally cannot be altered. **Phenotype is a combination of genotype and environmental effects** (nutrition, husbandry practices, and health). Phenotype describes those characteristics or traits that we can see or measure i.e. physical appearance, fibre diameter etc and is controlled by the genetic make and those areas mentioned above (pasture etc).
It has been well documented in the goat and sheep industries that animals grazing on pasture, that has a higher nutritional level will produce longer fibre, greater fleece weights and a coarser micron than those grazed on lesser pastures (assuming no other influences such as pregnancy, illness etc). Supplementary feeding of a high protein diet can also produce the same effect. A demonstration of this can be seen where animals in the "Cereal producing Zone" (given no other influence e.g. age) can produce a 25 micron fleece and when transferred to a property with better pasture in a "High Rainfall Zone" will have the micron increase. It is not unusual to have variances as close as a few kilometres (or miles) due to the change in the soil values (minerals)

COMPARING RESULTS

When comparing animal test results on your property you need to consider the following points between each individual animal

- Feed intake
- Age / Body weight
- Health during the year
- Pregnancy

When comparing results from various breeders you must be aware of the pastoral district characteristics (nutritional) as well as the other factors mentioned above.

You should check any previous tested data on the animals that you are looking at paying particular attention to the date of testing and age of animal.

<table>
<thead>
<tr>
<th>Date</th>
<th>14Mar03</th>
<th>Date of test</th>
<th>Mean</th>
<th>25.29 u</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample ID</td>
<td>QR 018</td>
<td>SD</td>
<td>5.94 u</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>OL V55</td>
<td>CV</td>
<td>23.5 %</td>
<td></td>
</tr>
<tr>
<td>Lot/Client</td>
<td>AUST ALPACA ASSOC</td>
<td>Sample size</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>Operator</td>
<td>JW &amp; VE PARK RFTS</td>
<td>Spin fineness</td>
<td>25.2 u</td>
<td></td>
</tr>
<tr>
<td>5% of fibres</td>
<td>10.6 u above mean.</td>
<td>Comfort factor</td>
<td>86.3 %</td>
<td></td>
</tr>
<tr>
<td>Curve</td>
<td>35.4[20] deg/mm</td>
<td>Curve number</td>
<td>1143</td>
<td></td>
</tr>
<tr>
<td>OFDA102:2.12 Cal: D=4.8997*WH -2.39, DkFlash= 56.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You should check how the animal's test results compare to other animals on that breeder's farm. In the early days of measurement in the sheep industry some tests were carried out on yearling animals and results were used when the animals were sold at 2 to 3 years of age, this also happened with the alpaca industry (in my opinion there is an ethical question over this practice).

We do have some knowledge of the expected increase in micron over that time span for sheep but at this stage there is still not enough data for us to accurately predict the projected microns for the older alpaca, although patterns are forming.

BREEDER SAMPLING EFFECT

Grid samples, as mentioned, can have a higher COV if the animal varies over the body. A single site in general, should be more even (mid side) therefore having a lower COV than the grid. The laboratory test method of single cut per staple, butt-cut (as frequently used in USA), gives an average around 2% lower CoV than the single site as used in Australia and New Zealand laboratories.
The Co Efficient of Variation is seen to be independent of fibre diameter (Holt / Stapleton 1993). That is fibre diameter was not seen to have any effect / influence on the C of V, except for the variation of fibre diameter spread in the individual staples.

It is noticeable in the histograms of sample T43 that the grid has a finer micron. The same machine was used for the test and the laboratory sub sampling method was the mini core. Difference of approximately 1 micron could be due to variance over the alpaca which is recognized with a full grid sample compared to that of a single site (mid side). The grid sample encompasses the entire skirted fleece whereas the single site only represents one small portion of the fleece.

It should be noted that in both tests, 4000 snippets of fibre were measured as compared to 1000 which are quite often used in guidance tests. Previous research by the writer indicated that the higher number of fibres measured gave a more consistent result (with 4000 being the optimum number).

Another reason for the difference could be sampling error.

**VARIATIONS IN RESULTS**

When measuring fibre there can be small differences between results, brought about by

- Variation between Grower samples
- Variation between Laboratory sub sampling of Grower samples
- Variation between machine types
- Variation between machines of the same type

The following histograms are 4 grids from the same alpaca (U9).
You can see the variance in the scale used as well as the difference in the micron and COV etc. **This is a good reason to use the same laboratory and machine to help reduce “Bias” and at the same time improve precision in your measurements.**

**NOTE:** The breeder sample (grid) was taken by the writer. The technique was the same for all grids except for the RWT which had the total fleece core tested. The laboratory sub sampling was not the same procedure in all cases. The test 32847 and the AWTA both used a mini core sample procedure. The RWT test used a “in shed sample Laser tester” which cores the whole fleece, therefore being similar to a “grid and mini-core” result. The final histogram had 1 staple tested from the “breeder’s grid sample” which was open to bias in its result because of this technique on a grid sample. This does not have the same effect on a “single site sample” as site samples are all considered a “biased sample”.

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**Sampled & tested in shed**

- **Client:** C/o- Cameron Holt
- **Spin Fineness:** 21.65
- **Curvature:** 55.09
- **GFW:** 0

**OFDA 2000 REPORT : SORTED BY TAG**

- **EarTag:** U-9LS
- **Mean FD:** 22.74
- **SD:** 4.17
- **CV:** 18.5
- **Comfort Factor:** 96.00
- **Sire:**

**GRID**

- **Micron:** 25.0 mic
- **MsiDev:** 0.7 mic
- **SD:** 4.1 mic
- **CVD:** 16.3 %
- **CEM:** 7.8 mic
- **<15:** 5 %
- **CF:** 91.0 %
- **SF:** 23.5 mic
- **CRV:** 33.5 Dg/fmm
- **SDC:** 24.4 Dg/fmm

**Histgram:**

- **% of Fibres:**
  - 0% - 10%
  - 10% - 20%
  - 20% - 30%
  - 30% - 40%
  - 40% - 50%
  - 50% - 60%

- **Fibre Diameter (microns):**
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60

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  - 20
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  - 40
  - 50
  - 60
“Butt-cutt” sample has not been used in any histogram shown above.
OFDA 2000 GRAPH

As mentioned earlier the “2000” measures the changes along the shaft of the fibre. This reflects, stress, age/bodyweight, pregnancy, sickness, genetics and nutritional changes, to mention a few.

In an alpaca herd of a similar age, run together under the same environmental conditions, you would expect to see a similar pattern between this herd (subject to stress, genetics etc).

In a herd of 2 yr alpacas I have selected 3 graphs to demonstrate a pitfall that may happen.

No 1 & no 2, similar in micron, show a similar growth pattern. No 3 however shows a reverse pattern.

“WHY IS IT SO”

- No 3 may be a wrong sample as its pattern is indicative of a 1 yr old, but the micron is high.

If a wrong sample, this can be a breeder or laboratory mistake.

- The other possibility is the laboratory placed the staple upside down on the measuring plate.

The “2000” measures from the butt to the tip of the staple. Therefore it is incumbent on the testing operator to follow operational procedures in this matter.

DO not forget to cut sample at skin level for consistency of results.
The Laser and OFDA 100 used in the laboratory have IWTO accreditation and are approved for certified measurements.

BREEDERS
It should be noted by alpaca breeders that,

1. Any sample being sent for testing, at any test house and by any method, should clearly identify whether it is a mid or grid sample.

2. Most Grid samples (at this stage) are not being core tested when using the OFDA 2000 method (unless they have an OFDA 100 adaption).

3. If measuring and recording curvatures, breeders should select and stick with one or other of the OFDA or laser format due to the variances in recording by these machines. Current trials are being carried out to get uniform results.

4. Testing operators do not always use the same “lab sub-sampling” procedures, hence adding to the possibility of “sampling error” and variances’ in results.

SPINNING FINENESS
This is a measurement (using micron and CV %) to estimate the performance of fibre when it is spun into yarn. It has been shown in the sheep industry that if you can reduce your COV by around 5% then you achieve a yarn that performs like a yarn one micron finer (spinning fineness). The reverse also applies.

e.g. 22 micron - COV 24% = spinning fineness approx. 22u
     22 micron - COV 19% = spinning fineness approx. 21u
     22 micron - COV 29% = spinning fineness approx. 23u

Those with a high COV may not only indicate fibre that varies greatly from the mean but may also indicate a larger number of coarse fibres (which may or may not be guard hair) throughout the staple or fleece. This is usually identified by the histogram shape.

Spinning fineness is a good measurement to compare alpacas within your herd because it combines micron and COV into one measurement.
The following histograms can give you an indication of the influence of C of V on spinning fineness.

**CURVATURE**
Fibre curvature is the measure of the fibre crimp frequency and amplitude.

**FACT** Curvature is affected by
- Crimp frequency
- Micron
- Character of the crimp (definition/amplitude/alignment)

There is a good correlation between fibre curvature and staple crimp frequency (sheep’s wool).

The curvature value is expressed in degrees per mm fibre length.

As the frequency of the crimp increases the curvature value is increased, and conversely the lower the curvature value the lower the staple crimp frequency. Fibre curvature can be measured at all stages of processing e.g. greasy to fabric. The curvature of the fibre influences how the fibre will process, particularly during top making and spinning.
Curvature (OFDA) values in Suris have tended to give a range from 15 to 35 (some as low as 10) with the Huacaya showing a range from around 25 to 60. It was noted that the coarser the micron, generally the lower the curvature value. Also when the C of V was more variable (higher) the curvature value also tended to be lower.

**NOTE:** Since the tests for this comparison were taken, the AWTA has altered their solution to a “water base”. This has altered how their current laser views the curvature. The data in this study was from a LASER SCAN using a 92% isopropanol – 8% water formula as its liquid medium. Other laboratories using a Laserscan are most likely to still be using the isopropanol/water formula, as it is believed the AWTA is the only laboratory at this stage to have gone to this water based solution.

The comparisons between the OFDA and laser for curvature indicated an average difference of 17.4 deg mm (100 huacayas measured in this trial by both machines).

The significance of difference in curvature measurements between machines suggests that meaningful comparisons of fibre curvature between different fleeces can only be made if measured by the same techniques.

**NOTE**
Currently there are no International standards for the measurement of curvature. Work to calibrate machines to a similar standard is currently taking place.

**MEDULLATION   (GUARD HAIR)**

The medullated fibres called “guard hair” are not desirable in the finished product. They are stiff and hollow with pointed tips. They reflect light differently to solid fibres and are hard to control when spinning. Medullation (guard hair and continuous medulla) is also considered a disadvantage because of fibre breakage. Partial fragmented medulla has little affect on fibre tenacity.

Medullation (guard hair) also creates non-uniformity of colour levels in the dyed fibre. A large number of these fibres are removed during the carding/combing process but a number still remain and these are a contributor to the coarse edge, which gives the “prickle factor” (now known as the “comfort factor”) in garments. Being stiff they will protrude from the yarn. A Harris Tweed would welcome this effect.

Breeders can measure the numbers of medullated fibres including those partially medullated, using an O.F.D.A. 100 (white only). This is a useful tool to identify any alpaca (white) which may be more prone to high levels of medulla cells.

Does not identify guard hair separately.
Distribution of Medullation Across a Fleece  (C Holt & I Stapleton)

The above data compares two fleece types (micron). No 5 and 18 (around 22 microns) and No 6 and 15 (around 28 microns). Nos 15 and 18 both exhibit less medullation over the fleece than their counterpart.

Normally alpaca fibre up to around approximately 20 microns (18/22) is solid in structure. The medulla Cells on average tend to occur from 20/22 microns onwards, although in some animals some cells may change at a lower micron and increase with broader microns.

Medullation (except for the last classification) is inherent in alpaca fibre and is not guard hair (Research by Holt/ Stapleton 1993, Tumen Wuliji et.al 1993 and J. Villarroel 1958 confirm these observations).

The diagram below shows the standard classifications of Medullation with the guard hair on the end.
Types of medulla and typical cross-section shape in white Alpaca fibres.

(1) Non medullated fibres, 15-20 micron diameter  
(2) Fragmented, 20-30 micron diameter  
(3) Interrupted, 30-40 micron diameter  
(4) Unbroken medium wide, 40-60 micron diameter  
(5) Unbroken very wide (near to lattice type), 60 or more micron diameter

Group "5" is undesirable in Alpaca fleece.

Dr Werner Von Bergen (1963) states that these fibres can occupy up to as much as 90% of the fibre, which is often dumbbell shaped in the cross section (as below right). It is suggested that around 80% medulla constitutes a guard hair type. Wildman (1954) identifies medulla in various grades of fineness from the finer fibres to the very coarse. These alpaca photos correspond to some that he identified. If you accept Von Bergen’s assessment of kemp then you would have to consider the coarser fibre as guard hair.

In the very coarse 60+ micron various expressions of medulla are identified. The shape of the fibre (elliptical/cylindrical) may affect the medulla formation.

In alpaca, guard hair can be seen at levels of fineness (even 20 microns) and it is a mistake to believe that guard hair is only coarse. It would be interesting to see cross sections of these 20 micron guard hairs to see if they have 80% + medulla in them.

This magnified photo is an 18 micron fleece showing guard hair of 27 microns, not as expected in the previous diagram of standard classifications.
Dr Jim Watts (2009) suggests that if an alpaca has low primary fibre diameter it will have less guard hair and believes that if primary and secondary fibres are around 17 microns there will be no guard hair or medullation in most alpacas.

He suggests that guard-hair is at the end of a continuing medullation development.

A Histogram of medullated fibres is superimposed over the solid fibres and records the various diameters and spread. Dark coloured fibre is more difficult to calculate and results for these colours are not as reliable.

**MEDULLATION RESULTS**

A visual assessment can be made on the coarse guard hair fibres and the fleeces are rated as

- Free or nearly free
- Light
- Medium
- Heavy

The shape of the staple will be a help in identifying content of the coarse medullated fibres. These fibres will usually protrude from the tip of the staple and will have the appearance of a spiky tip.
It should be noted that medullation in Suri appears lower than that of similar microns for Huacayas. (Holt/Scott 1998). It was noted that as the fibre became stronger in micron there was an increase in medullation.

<table>
<thead>
<tr>
<th>Micron</th>
<th>Huacaya</th>
<th>Suri</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>12.9%</td>
<td>4.7%</td>
</tr>
<tr>
<td>26</td>
<td>36%</td>
<td>16%</td>
</tr>
<tr>
<td>36</td>
<td>60%</td>
<td>42.4%</td>
</tr>
</tbody>
</table>

If you look at the photos below you can see the difference between huacaya, suri and guard hair. You will notice the number of scales along the shaft of the fibre. Guard hair is completely different to alpaca fibre.

Tillman © 2006)

To summarise, simply, guard hair is a different fibre to alpaca.

**PRICKLE FACTOR (%AE30)**

“Comfort factor”

This is a term given to the perceived sensations from contact of clothing with the skin. The main sensation is the itch or prickle that some (few) people identify as giving discomfort. Research suggests that the itch is not an allergy but a response from the pain nerve receptors in the skin to the coarse fibres (over 30 micron) protruding from yarn in the fabric.

The coarse fibres being the high load supporting fibres that protrude from the fabric exert a force of 100mg or greater. This indents the skin subsequently activating the pain receptors in the dermis.
The finer more flexible fibres do not create the same problem. It is a prickle or itch that is perceived and not a pain.

The offending fibres (Natural or Synthetic) are usually over 30 microns in diameter in particular are those over 40 microns.

Yarn with a high content of coarse medullated fibre will produce a much greater discomfort to the wearer.

It therefore is wise to be aware of the measurement on the histogram indicating the percentage of fibres over 30 microns (Greater than 5%). Little difference between Huacaya and Suri fibre could be found for this characteristic. ([Holt/Scott 1998](#))

<table>
<thead>
<tr>
<th>Micron</th>
<th>Huacaya %AE30</th>
<th>Suri %AE30</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>5.16</td>
<td>6.03</td>
</tr>
<tr>
<td>25</td>
<td>19.57</td>
<td>20.06</td>
</tr>
<tr>
<td>30</td>
<td>53.76</td>
<td>51.30</td>
</tr>
</tbody>
</table>

Prickle factor is now being quoted as "comfort factor" and is shown in reverse to that of prickle factor, EG PF 5.16, would now read CF 94.84. Some of the research being quoted in this article was done when the term "prickle factor" was in use.

Studies have shown that a wool of a mean diameter of 21 microns and a low C.O.V. having less than 5% of fibre over 30 microns should not be perceived as having a prickle (itch) problem.

General data alpaca research ([Holt 2005](#)) for "%>30" has shown that an alpaca with a mean diameter of 21 / 22 microns should have 5% or less of fibre over 30 microns and like sheep’s wool should not have a prickle problem.

(Holt 2005)

So when using the measured data in selection you should take note of % number of fibres over 30 microns, as well as C.O.V. Of course as the micron gets stronger so the % over 30 microns will become greater in number, but if you keep your eye on the C.O.V. you can keep it at its lowest level.
In conclusion remember why you are testing. Are you testing to get a result to sell the animal or are you testing to compare the animals on your farm to see which ones match your breeding objectives.
- Test for up to 5 years to see which animals are subject to micron blowout.
- Try to test all the herd at the same time each year.
- Use the second year results to rank your animals.

Remember if sampling is not consistent then the ability to compare between animals is impaired.
- A mid side sample although biased will suffice for herd rankings.
- Always cut the breeder sample at skin level.
- A full grid sample is more accurate than a single site sample.
- A “Three site position” will give a good indication of overall evenness across the fleece. Use shoulder and hind pin bones as well as midside for consistency.

From a laboratory point of view,
- a breeder grid sample should always be mini cored in the laboratory
- Select a testing machine that suits your purpose for testing and stick with it for greater precision of results.

REFERENCES

Andrews, M. Downes, J. (etal)  
Objective Measurement of Wool in Australia  
A.W.C. (1973)

Davison, I & Holt, C.  
Study into comparative Differences of Scientific Testing  
Machines, used in Alpaca Fibre Testing  
AAA July 2004

Dawes, K.  
Objective Measurement of Wool  
N.S.W. University Press Ltd. (1975)

Dolling, M  
Fibre curvature has a direct impact on wool processing performance.  
Australian FARM journal Dec 2002

Dolling, M.(etal)  
Knitted fabric made coarser--  
Wool Tech & Sheep Breeding  1992  
Textile Institute, U.K. 1990

Garnsworthy, R.(etal)  
Understanding the causes of prickle and itch from skin contact with fabrics.1988.C.S.I.R.O. Geelong

Harmsworth, T. & Day, G.  
Wool and Mohair, Inkata Press 1979

Holt, C. & Stapleton I.  
A survey of ALPACA FLEECE CHARACTERISTICS, 1993 for AAA.  
Report Melbourne College of Textiles & LaTrobe University.

Holt, C.  
A Survey of the Relationships of Crimp frequency, Micron, Character & fibre Curvature.  
Australian Alpaca Ass, 2006
Holt, C. & Scott, S.,
A Survey of Suri Fleece Characteristics,
Report for Suri Breeders Network AAA (MIT 1998)

Kennedy, J. Teasdale, D.
Wool Preparation, Measurement and Marketing
University of N.S.W. (1987)

McColl, A., Lupton, C., Stobart, B.
“Fiber Characteristics of US Huacaya Alpacas”, Alpaca Magazine –
Summer 2004

Pettigrove, G.
Graphic Support

Scott, S.

Summerville, Dr P, J. AWTA Fact sheet 2000

Swan, Dr P
Private correspondence (wool data 1995)

Tillman, A
SURFACE SCANING ELECTRON MICROSCOPY OF SURI ALPACA FIBER Alpacas Magazine USA 2006

Tillman, A
Private correspondence, (2008 & 9)

Teasdale, D.
The Wool Handbook 1995
Fast Books

Tumen Wuliji et.al
NZ Agriculture dept 1993

Villarroel, J.,
A Study of Alpaca Fibre,
Msc Thesis, University of NSW (1959)

Von Bergen, W.
WOOL HAND BOOK 1963

Watts, Dr J.
“GETTING RID OF GUARD HAIR”
World of Alpacas (2009)

Watts, Dr J.
Private correspondence (1995-2007)

Wildman, A.
The Microscopy of Animal Textile Fibres,
Wool Industries Research Ass. Leeds (1954)
Cameron has had some 45 years in the fibre industry, namely as a wool broker, sheep classer, judge, and educator.

Cameron, a leading alpaca fibre expert, continues to travel globally, judging for various alpaca groups. He also, along with judging, is currently training Judges for a number of International Alpaca Associations.

Cameron still continues his educational clinics and lectures throughout the world. In his semi retirement of grandchildren, golf, fishing and community support, still manages to find time to continue with publications and research into alpaca fibre characteristics and allied areas.