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The Quality of Fibre Grown by Australian Alpacas

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PART 1: THE COMMERCIAL QUALITY ATTRIBUTES AND VALUE OF ALPACA FIBRE

The paper discusses the quality of alpaca fibre with reference to the alpaca trade mark definitions of the International Alpaca Association. The paper then defines the major commercial quality attributes of alpaca fibre (fibre diameter, fibre length, fibre colour, contamination and incidence of medullated fibres) and discusses why the quality of fibre is important. The way the international market place has valued different quality characters of alpaca fibre is described. Preliminary data from a survey of the quality of fibre grown by alpacas in southern Australian are presented and discussed in light of commercial requirements and trade definitions.

INTRODUCTION

How does the International Alpaca Association define alpaca fibre? What do leading processors of luxury fibres regard as the major quality attributes of alpaca fibre and why? How does the international marketplace value the quality attributes of alpaca fibre? What is the current quality of fibre grown by Australian alpacas. What fibre quality attributes does the Australian industry need to improve? These and many more questions can be asked about producing quality alpaca fibre and many are discussed in this paper.

The information on the quality of Australian alpaca fibre is taken from preliminary data collected during surveys at shearing in 1995 and 1996 on alpaca properties in southern Australia and is presented in paper 2. This survey is part of collaborative research being conducted by Primary Industries South Australia and Agriculture Victoria with support from the Rural Industries Research and Development Corporation and collaborating alpaca farms.

1. THE INTERNATIONAL ALPACA ASSOCIATION DEFINITION OF ALPACA

The International Alpaca Association (IAA) is an association of commercial businesses and breeders involved in the production and commercialisation of fibre from alpacas, llamas and other South American camelid species. The IAA have registered Trade Marks for the use by licensees on products which meet certain quality standards (see Anon 1997).

The IAA have decided that to use the Alpaca Mark the following criteria must be adhered to.

- **Gold Alpaca Mark:** 100% alpaca or unbristled llama fibre, with fibres up to a maximum of 28 µm.
- **Silver Alpaca Mark:** More than 50% alpaca or unbristled llama fibre, with fibres up to a maximum of 28 µm.
- **White Alpaca Mark:** At least 10% alpaca or unbristled llama fibre, with fibres up to a maximum of 28 µm.

The IAA have also defined the **Huari Mark**. This mark is to certify content of textile products from South American camelidae fibre. The IAA have defined that the Huari Mark is reserved for the following products subject to the quality control standards determined by the IAA.

- **Huari Mark** products that contain South American camelidae fibres with a mean fibre diameter greater than 30 µm.

If we accept these IAA definitions, only those fleeces which can be classed into lots, which after processing into alpaca textiles, have a mean fibre diameter of less than or equal to 28 µm can be called alpaca fibre. Consequently it is a nonsense to talk about fleeces with a mean fibre diameter greater than 30 µm as alpaca fibre as these are Huari fibre.

2. PROCESSORS' DEFINITION OF IMPORTANT COMMERCIAL ATTRIBUTES OF RAW ALPACA FIBRE

At the First International Symposium on Specialty Fibres, Smith (1988) reported what he regarded as the important commercial parameters of raw fibre for processors of luxury fibres. Some of these raw fibre parameters are of great importance in early and latter (spinning) stage processing while others are only of importance in early stage processing. The data from Smith (1988) has been modified by the addition of new information from a variety of sources and is shown in Table 1.
The difficulty for growers is that they have to produce a fibre which will please all stages of the industry -- from the early stage processor right to the consumer -- and make a profit at the same time. It is important to note that these fibre attributes are usually specified in orders and sometimes characteristics only become significant if upper limits are exceeded. The relative importance of different raw fibre characteristics depends on the defined end use for which the fibre is destined. For example the presence of dark fibres is usually only a problem with white, pastel and fawn shades.

Table 1: The relative commercial importance of greasy raw speciality animal fibre characteristics (adapted from Smith 1988 and other sources).

<table>
<thead>
<tr>
<th>GREASY FIBRE CHARACTERISTIC</th>
<th>RELATIVE PROCESSING SIGNIFICANCE</th>
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<tbody>
<tr>
<td></td>
<td>Scoured</td>
</tr>
<tr>
<td>Mean fibre diameter</td>
<td>****</td>
</tr>
<tr>
<td>Washing yield</td>
<td>****</td>
</tr>
<tr>
<td>Vegetable matter contamination (amount and type)</td>
<td>***</td>
</tr>
<tr>
<td>Mean fibre length</td>
<td>**</td>
</tr>
<tr>
<td>Staple strength/position of break</td>
<td>**</td>
</tr>
<tr>
<td>Clean fibre colour</td>
<td>*</td>
</tr>
<tr>
<td>Incidence of dark fibres</td>
<td>*</td>
</tr>
<tr>
<td>Incidence of medullated fibres</td>
<td>**</td>
</tr>
<tr>
<td>Mean fibre diameter variability</td>
<td>**</td>
</tr>
<tr>
<td>Proportion of fibres &gt; 30 µm</td>
<td>*</td>
</tr>
<tr>
<td>Fibre length variability</td>
<td>**</td>
</tr>
<tr>
<td>Resistance to compression (crimp)</td>
<td>*</td>
</tr>
<tr>
<td>Incidence of cotts</td>
<td>**</td>
</tr>
<tr>
<td>Degree of staple tipiness</td>
<td>*</td>
</tr>
<tr>
<td>Style and handle</td>
<td></td>
</tr>
</tbody>
</table>

**** Highly significant * Some significance

Why are these raw fibre attributes of commercial significance?
These raw fibre attributes directly affect some of the following important commercial parameters:
- the speed of processing,
- processing yield and quantity of waste products,
- yarn quality;
- dyeing performance;
- visual attributes;
- handle attributes;
- fabric properties;
- cost of product;
- appeal to customer.

Extensive trials in wool processing mills have shown that mean fibre diameter, staple length, staple strength, position of break, vegetable matter and yield accounted for approximately 80% of the variation in Hauteur (the mean fibre length in the top before spinning) and fibre wastage experienced during top making. The remaining 20% of the variation is explained by variation between processing mills, fibre diameter variation, crimp definition, style and other matters. Most alpaca fibre is processed on equipment designed for and operated by manufacturers in the wool industry (wool meaning fibres from animals). Specialist alpaca processors have adjusted their equipment to optimise their processing efficiency in similar ways to the adjustments made by fine wool processors compared to medium and coarse wool processors. Given the very limited amount of published research on the specifics of alpaca processing (Leeder et al 1992) the comments made are based on the few published alpaca processing studies (eg Swinburn et al 1995) and the much larger body of evidence gained during experiments with wool, mohair and other animal fibres.

Mean fibre diameter and fibre diameter variation
When a constant number of fibres is maintained in the cross section of the yarn, increasing fibre diameter reduces the potential speed during spinning, as yarn breakages increase. Increasing fibre diameter is likely to increase yarn hairiness and irregularity and in fabrics increases the severity of wrinkles and reduce the recovery from wrinkling. Increasing fibre diameter increases the flexural rigidity of fabric and increases the air permeability of fabric. Swinburn et al (1995) found that increasing alpaca fibre diameter significantly increased prickliness, and reduced softness in
alpaca blend knitwear. Some of these fabric characteristics can be modified depending on the yarn construction and finishing process (Leeder et al. 1992). For example, steaming, scouring and tumble drying can reduce the prickliness of alpaca blend knitted fabrics (Swinburn et al. 1995).

Lower levels of fibre diameter variation are associated with fewer yarn breakages during spinning due to the production of a more even yarn. Tops with fibres having a low coefficient of variation of mean fibre diameter CV(D) and tops with fibres which are finer, lead to more uniform yarn with fewer thin spots. A difference of 5% in CV(D) is considered equivalent to a decrease of 1 µm in mean fibre diameter in improved spinning performance.

**Proportion of fibres > 30 µm**

The proportion of fibres greater than 30 µm is important because the prickle sensation felt by some people when they wear garments next to the skin is related to the incidence of more than 5% of fibres greater than 30 µm. The percentage of fibres greater than 30 µm is influenced by both the mean fibre diameter and the fibre diameter variation (CV(D)). This characteristic is of prime importance only if textiles are being designed for wear next to the skin. It is also affected by fabric construction, temperature and humidity conditions. Some people refer to this measure as the prickle factor (PF).

Surveys of consumers in the big six consuming countries of Japan, Germany, Italy, France, Britain and the USA have indicated that the most important negative attribute about wool clothing was prickle discomfort (IWS 1993). The Australian wool industry also regards prickle discomfort as a major impediment to the use of wool, especially in the USA market. Wool lots with over 5% of fibres exceeding 30 µm are classed as prickly. Surprisingly this includes about 35% of wool with a mean fibre diameter of 21 µm and all wool lots with a mean fibre diameter of 24 µm and greater.

Fibre grown by alpacas, with mean fibre diameters ranging up to 45 µm also has a high CV(D). Peruvian alpaca fibre has an average CV(D) of about 28% (data based on 4500 samples studied by Pumayalla and Levva 1987). Thus almost all raw fibre grown by alpacas, except the very finest, has a considerable proportion of fibres greater than 30 µm. As mean fibre diameter increases to 24 µm the proportion of fibres above 30 µm increases to about 20%. Increasing CV(D) from about 30% to about 40% increases the proportion of fibres above 30 µm by about 4%.

**Washing yield**

Clean washing yield represents the amount of clean fibre present in the greasy fleece, usually expressed as a percentage of the greasy fibre weight. This value is important only for scouring as, from this point forward in the processing chain, the fibre has been cleaned of impurities such as grease and soil. Soil contamination is common as alpacas are in the habit of dust bathing. Heavy soil and grease content requires longer scouring and increases costs per unit of clean fibre.

**Vegetable matter contamination**

Vegetable matter (VM) is acceptable up to certain limits depending on processing sequence and ultimate end use. Clearly VM is not fibre and is not wanted by processors as it reduces the yield of clean fibre. If VM exceeds 5%, the fibre has to undergo an additional processing step of carbonising. Carbonising reduces the lustre and handle and affects the colour of fibre. White fibre is most affected because heavy scouring and carbonising produces creamy yellow fibre which requires bleaching to restore its white colour. These treatments restrict the use of contaminated fibre to lower priced end uses and increase the processing costs. Low amounts of VM can be removed during combing provided the VM is not primarily burrs. VM in yarns and cloths can distract from the finished product appearance and handle and affects uniformity of dyeing.

**Fibre length and length variation**

Fibre length affects yarn construction. Worsted length alpaca, with raw fibre lengths greater than 75 mm and hauteur of at least approximately 65 mm, increases the potential methods of processing the fibre and so increases the potential purchasers of the fibre. During worsted processing the spinners use combing to select the longer fibres to enable them to spin finer and stronger yarns for weaving. Increasing the length of alpaca fibre increases the spinning potential and reduces the number of potential yarn breaks. Scoured fibre which has a large proportion of short fibres will be less value for worsted spinning as the cost of removing the large proportion of short fibres during combing becomes prohibitive. Such fibre is more economically processed by woollen spinning where much shorter fibres are used.

**Fibre strength and position of break**

Weak fibres break during the first stages of processing, called carding. When fibres break they produce two shorter fibres and some of these short fibres may
not be wanted for some end uses (see fibre length). Some fibres have a weak point about half way along their length and these fibres will break and form two short fibres of similar length. The position of the weak point is called the position of break (POB). The POB is important as, in the midpoint area, it reduces the value of the fibre more than POB close to the tip or base of the staples.

**Cotts and tipiness**

Cotts are entangled clumps of fibre in the shorn fleece. Cotts result in excessive fibre breaking during opening and carding of the fleece thus reducing the mean length of the processed fibre. Ultra violet light from the sun damages the tips of the growing fibres. Such damaged tips can break during processing reducing the length of fibres and reducing the ultimate commercial yield of fibre.

**Medullated fibres**

Medullated fibres are fibres which have a central canal containing residual cells and air pockets. These fibres are a feature of alpaca fleeces and they tend to be the coarser fibres in the fleece. Medullated fibres can be a problem if they differ in appearance from the rest of the fibres which are not medullated. A high proportion of short medullated fibres (kemp) can reduce processing yields during carding and combing. Short kempy fibres are found around the edge of the shorn alpaca fleece and should be skirted off into the pieces lines. Kempy fibres have a higher mean fibre diameter than the rest of the fleece and so are stiffer and bend less than finer fibres. Kemp fibres therefore affect handle and can cause prickle sensations on the skin. Medullated fibres often have a lighter appearance following dyeing as they refract light differently to solid fibres (Hunter 1993).

Medullated fibres tend to be harder to twist and to project from the surface of yarns and fabrics. Consequently they impart special visual effects but tend to prickle more. While this visual effect may be valuable in woollen knitwear, it can be detrimental in worsted suiting. To minimise any potential prickle problem many alpaca woollen textiles are specially finished by brushing. The brushing increases the length of fibres and increases the chances of the fibres bending before they prickle.

**Resistance to compression (crimp, handle)**

Resistance to compression (RtoC) is the force required to compress a standard mass of fibre into a fixed volume and is affected by mean fibre diameter and crimp frequency. RtoC is related to handle and the bulk of the fibre. Highly crimped wools are more resistant to compression than low crimped wools of similar mean fibre diameter. Recent studies have shown that low crimp wools have a softer handle which transfers though processing to produce softer, smoother and leaner fabrics (Madeley 1994, Stevens 1994). However, in the woollen processing system, higher bulk yarns are required and so it may be desirable to breed higher crimped fibre for this end use. Reducing staple crimp frequency and increasing crimp definition while maintaining other wool characteristics has the potential to increase hauteur and reduce waste during carding and combing (Stevens and Crowe 1994).

Peter Gibson of Mossley Spinning, Lancashire believes that soft handle is one of the two exploitable virtues of alpaca fibre (Anon 1996). The two virtues are: (a) increases in raw alpaca prices can be easily absorbed because alpaca makes up only a small percentage of blends (10 to 20%); and (b) by improving the handle of alpaca, enhancement of the perceived value of blends.

Luxury animal fibres and fibres without crimp are more difficult to process, particularly during drafting (gilling and spinning). However, some of these difficulties arise because these fibres have less prominent and less frequent fibre scales compared to wool and so have lower between fibre friction. Some fibres are therefore artificially crimped during combing to improve drafting efficiency.

A number of other issues are associated with the crimp frequency of animal fibres. In the past, the Bradford system of visual wool sorting relied on the frequency of crimps (crimps per unit length) as a guide to the mean fibre diameter of the fibre. Crimp frequency, unfortunately, accounts for only about 60% of the variation in mean fibre diameter and so it is not a very reliable indicator of the most important physical characteristic of animal fibres.

**Why do the Peruvians use handle to sort alpaca fibre prior to marketing and processing?**

The system of alpaca fibre sorting which occurs in South America uses handle as a major determinant to sort alpaca fibre into commercial quality categories (Weatherall 1995) because handle is highly correlated to number of very important physical characteristics. The Peruvians use handle because it is cheaper than testing all the random fleeces which arrive at the warehouses and it is based on long experience and feedback from processors in exactly the same way that wool sorting was introduced into Australia. The sys-
tem works well because only five main lines or quality categories have been established and sorters are skilled enough to maintain these standards. Table 2 indicates the correlations between important physical and visual characteristics of alpaca fibre and the three main quality categories.

The development of the main quality categories is not surprising as they are used for different textile end points. It is also not surprising that the IAA have defined their Alpaca and Huarizo Trade Marks to ensure that the traditional sorting quality categories are enshrined into the commercial trading system (that is, they are protecting their investment).

Table 2: The correlated physical characteristics of alpaca fibre which result from the sorters of the alpaca clip in Peru using handle as the primary method of discrimination between the basic quality categories of alpaca fibre prior to marketing.

<table>
<thead>
<tr>
<th>Physical fibre characteristic</th>
<th>Handle</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Mean fibre diameter</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Resistance to compression</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Incidence of medullated fibres</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Crimp definition</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>

Quality perceptions differ between processors and consumers

When producers discuss the quality of fibre grown by alpacas they need to appreciate that quality has many dimensions. Growers need to include the following dimensions of quality:

- **Performance** relative to desired or required characteristics
- **Conformity** within specifications of product standards
- **Aesthetics** how a product looks, feels
- **Perception** intangible element of how a product quality is perceived

When processors buy raw fibre they are more interested in the performance relative to required characteristics and conformity to specified standards. Spinners have different levels of performance and conformity to those of top makers. However consumers may only be focussed on aesthetics and perceptions.

3. MARKET PLACE VALUATION OF ALPACA FIBRE ATTRIBUTES

Alpaca fibre diameter

Maximum prices are paid for fine 'baby' alpaca up to mean fibre diameters of 22 µm. In 1995 I reported (McGregor 1995) the relative prices received for alpaca fibre based on values reported by Vinella (1993). Since this time Robert Weatherall from Alpha Tops (UK) has provided price data from 1981 to 1994 for white tops and web for four grades of fibre (Weatherall 1995). The quality categories and mean fibre diameters are shown in Table 3.

Table 3: The basic quality categories under which alpaca fibre is sorted, sold and marketed (from Weatherall 1995).

<table>
<thead>
<tr>
<th>Quality (alternative names)</th>
<th>Mean fibre diameter (µm)</th>
<th>Peruvian production(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby</td>
<td>21 - 23</td>
<td>7</td>
</tr>
<tr>
<td>Fleece (first fleece,</td>
<td>24 - 26</td>
<td>47</td>
</tr>
<tr>
<td>or Arequipa fleece)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse (Adult)</td>
<td>31 - 34</td>
<td>31</td>
</tr>
<tr>
<td>Mixed pieces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(short fibre, and skirtings</td>
<td>25 - 32</td>
<td>7</td>
</tr>
<tr>
<td>of 50 to 75 mm length)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The price data provided by Weatherall clearly shows the price of alpaca fibre follows cycles, with maximum prices occurring during late 1985 to early 1986, during late 1987 until 1988 and in late 1994 with price troughs occurring in between. I have chosen two cycles to calculate for each grade: a 10 year mean value for the years 1986 to 1994. The data set used was Italian lire prices, the effective price for alpaca processors who use most of the traded alpaca tops. The price fluctuation in US dollars and German DM showed similar cycles with only slightly different peaks and troughs. The relative mean prices for these basic alpaca quality categories are shown in Figure 1.

Figure 1: The effect of alpaca fibre diameter on the relative price of white alpaca tops over the 10 year period 1985 to 1994 and during the price cycle troughs in 1993.

During the 10 year period, maximum prices were always paid for the finest quality category and prices declined rapidly above 22 µm, with the data indicating...
an average decline in price of 11% per 1 μm increase in fibre diameter up to 26 μm. Above 26 μm, the average decline in price was 5% per 1 μm increase in fibre diameter. Fibre of 32 μm was valued at only 27% of the value obtained for the finest fibre. Suri fibre at 27 μm has received premiums of 10 to 25% above the prices paid for standard adult white alpaca (Vinella 1993). Suri fibre comprises about 7% of the Peruvian alpaca fibre production.

Alpaca fibre colour
Generally, white fibre brings the highest prices as it can be dyed to any shade especially pastel colours. Pastel dyeing can be undertaken at lower temperatures, resulting in less damage to the fibre thus maintaining better ‘handle’ or softness. Japan mainly buys white fibre (Morales et al 1995). Dyeing is avoided if natural shades are used. The fawns are very popular when ‘camel’ is fashionable and when vicuna is in demand, with prices 15% greater than white Vinella (1993). Black is often preferred for worsted processing if the woven fabric is intended for dark suiting (Ross 1988) and has sold at a 15% premium over white fibre. Over the past 30 years, in the Puno district of Peru, the effect of price has resulted in the number of coloured alpacas falling from 60% to 30% (Renieri 1994).

Alpaca fibre diameter and prices at the bottom of the price cycle
I have also calculated the relative prices for alpaca tops during the depths of the price cycle troughs for the three years 1986, 1991 and 1992. These trough values are shown with the 10 year averages in Figure 1. In the troughs, prices decline even more rapidly above 22 μm, with the data indicating an average decline in price of 13% per 1 μm increase in fibre diameter up to 26 μm. Above 26 μm, the average decline in price was 4% per 1 μm increase in fibre diameter. Fibre of 32 μm was valued at only 26% of the value obtained for the finest fibre.

According to Laycock International, Bradford, alpaca demand is now depressed and prices are way down on the relative boom seen in the 18 months from June 1993 to February 1995 (Anon 1996).

Alpaca fibre length
Alpaca from Peru has traditionally been classed into lengths of > 7.5 cm for worsted processing, with shorter fibre being sold for the woollen processing system and marketed in the quality category ‘mixed pieces’. The data from Weatherall suggests that the pieces which are sold have a mean fibre diameter of about 29 μm and the price received over the 10 year period relative to baby alpaca was only 17%. However, relative to other 29 μm fibre, which would have received a price of approximately 41% of the maximum, the additional discount for the shorter fibre was approximately 24% of the maximum price or, in relative terms, a further discount of 60% (24/41). In the price troughs, the shorter pieces received only 12% of the maximum price received for baby alpaca and the additional discount, compared to other 29 μm fibre, was 25% of the maximum price or, in relative terms, a further discount of 67% (25/37).

Contamination and grease and medullated fibres
Vegetable matter (grass seed and burrs), urine and dung stains in alpaca fibre incur serious price penalties of 50% or greater. No specific market information has been sighted on the effect of different levels of medulation on the price of alpaca fibre.