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CHANGES IN FIBRE CURVATURE DURING THE PROCESSING OF WOOL AND ALPACA FIBRES AND THEIR BLENDS

Lijing Wang, Xin Liu and Xungai Wang

ABSTRACT

This paper studied the wool and alpaca fibre curvature and its variation during the fibre processing. It revealed the effect of wool fibre crimp on the cohesion properties of alpaca and wool blended slivers. Different wool and alpaca tops were blended via a number of gillings, and the role of wool fibre curvature in alpaca/wool blend processing has also been investigated. During the wool fibre processing, fibre curvature tended to diminish gradually from scoured fibre to top. Blending wool with alpaca fibres improved the cohesion properties of the blended sliver, compared with pure alpaca slivers. For a high ratio of alpaca component in the blend, a high-crimp wool should be used to achieve good sliver cohesion.

KEYWORDS
Curvature, Topmaking, Alpaca, Wool, Blend, Crimp

1. INTRODUCTION

The world alpaca fibre production is around 5,000 tonnes per annum, of which, the current annual alpaca fibre production in Australia is estimated at 75 tonnes in greasy weight [5]. With the limited quantity of Australian alpaca fibre production, alpaca blends with other fibres such as wool become important. Blending is also expected to enhance the alpaca fibre processiblity and promote the fibre in a wide range of market places. However, there is a lack of published data on how to select the wool fibre properties for the blend, especially the selection of wool fibre crimp.

There has been debate on the importance of fibre crimp in the wool textile industry. It is believed that low-crimp wool is generally better than high-crimp wool [3,4, 7,8,9]. Wool staple crimp can be expressed by crimp definition and crimp frequency. Crimp definition may be simply described as a degree of alignment of the crimp. Wools where the fibre crimp is not well aligned are poorly defined. Crimp frequency is defined as the number of crimp wavelengths per centimetre. Crimp frequency and crimp definition, together with greasy colour, tip length, dust and weathering represent the wool style, which is very important in determining the processing performance, marketing practice and quality of final wool products. Wool crimp, expressed as fibre curvature, can be measured using commercial instruments such as OFDA (IWTO-47-98) and LaserScan (IWTO-12-95). There is a direct relationship between fibre crimp and fibre curvature [1,11,12]. The fibre curvature measured was highly positively correlated with staple crimp frequency, compressed wool height and the bulk/diameter ratio of the wool.

Many studies have been devoted to evaluating the effect of staple crimp on processing performance and quality of wool products. Hansford [7] reported that wool with low crimp frequency and high crimp definition generally gave longer Hauteur in tops. Poor crimp definition may lead to increased fibre entanglement during scouring. If wool was highly entangled after scouring, more fibre breakage would occur during carding, and the combing yield would be lower. For superfine wools, a lower fibre crimp frequency resulted in a higher yarn evenness and lower ends-down in spinning [3]. Fibre curvature has therefore become an input parameter in predicting the spinning performance and yarn quality of wool fibre in the YarnSpec software package [4].

Madeley [9] studied the physical properties and processing performance of fine merino lamb's wool systematically. He claimed that fibre crimp appeared to be as important as fibre diameter in determining the stiffness of fine to superfine merino wool fibres and the softness of the fabric produced from them. He also found that worsted fabric made from superfine, low crimp merino lamb's wool had exceptional *numeri* (or sleekness) and an excellent Total Hand Value (THV). Wool fibre crimp changes down the fibre processing pipeline [10,11]. A loss of wool fibre crimp occurs due to imposed strains during worsted processing, especially in high speed carding and spinning, and the crimp loss is largely irreversible.

This paper aims to understand the effect of alpaca and wool fibre crimp on the properties of alpaca/wool blends. The outcomes are expected to assist alpaca fibre industry in using the appropriate type of wool for the alpaca/wool blend in order to produce premium quality products that contain Australian alpaca fibre component.

2. EXPERIMENTAL PROCEDURES

2.1 Fibre Materials

Table I shows the information on fibre materials used in this investigation. Test samples were collected from the initial form of the fibres or their processed materials.

Table I A list of Wool and Alpaca Samples.

Material	Form of Fibre	Purpose
Low crimp wool (21µm, 65.7°/mm)	Scoured wool	Topmaking
Superfine low (17.8µm, 62.7°/mm) & high (17.9µm, 79.0°/mm) crimp wools, Superwashed (21µm, 56.8°/mm) wool tops	Commercial tops	Alpaca/wool blends
Range of alpaca staples	Greasy/Scoured fibres	Curvature and diameter measurement.
Fine (21.6µm, 37.6°/mm) and strong (31.7µm, 30.7°/mm) alpaca fibres	Greasy alpaca	Topmaking and alpaca/wool blends

2.2 Alpaca and Wool Topmaking and Top Blending

Two lots of alpaca fibres, fine (21.4µm) and strong (31.7µm), were scoured and processed to tops using modern worsted wool processing line at a low production speed. The tops were blended with three types of wool tops: 30% fine alpaca and 70% superfine low-crimp wool blend, 30% fine alpaca and 70% superfine high-crimp wool blend, and 50% strong alpaca and 50% superwash wool blend.

2.3 Curvature and Cohesion Force Measurements

An Optical Fibre Diameter Analyser (OFDA100) was used to measure the fibre diameter and curvature of wool, alpaca and their blends. The breaking strength of slivers was measured using a Lloyd material testing instrument at a gauge length of 50 cm and a jaw separation speed of 500 mm/min. The sliver cohesion force was expressed by the sliver breaking length in Equation 1. Each sliver breaking length presented in the Results and Discussion section represents its mean and 95% confidence level.

$$\text{Breaking length (m)} = \frac{\text{Sliver breaking strength (g)}}{\text{Sliver linear density (g/m)}} \qquad (1)$$

All measurements were conducted in the testing laboratory where temperature was controlled at 20±2°C and relative humidity was maintained at 65±5%.

3. RESULTS AND DISCUSSION

3.1 Fibre Diameter and Curvature

To understand the role of wool fibre crimp in the fibre processing stage of alpaca/wool blends, we firstly need to know the crimp difference between the two fibre types. Figure 1 shows that the curvature of alpaca fibre is much lower than the wool fibre. For fibres in the diameter range of 15 – 40 µm, their curvature ranges are 50 – 15 °/mm for alpaca fibre and 125 – 58 °/mm for wool. Another report by Fish et al [2] also confirmed that the fibre curvature of wool is in the similar range for 213 sale lots of Australian wool. The apparent curvature difference suggests that blending alpaca fibre with wool can achieve an overall fibre curvature of the blend being less than the wool fibre curvature. It can also be seen from Figure 1 that there appears to be a good relationship between MFD and fibre curvature for both alpaca and wool fibres. Fibre curvature decreases as the MFD increases.

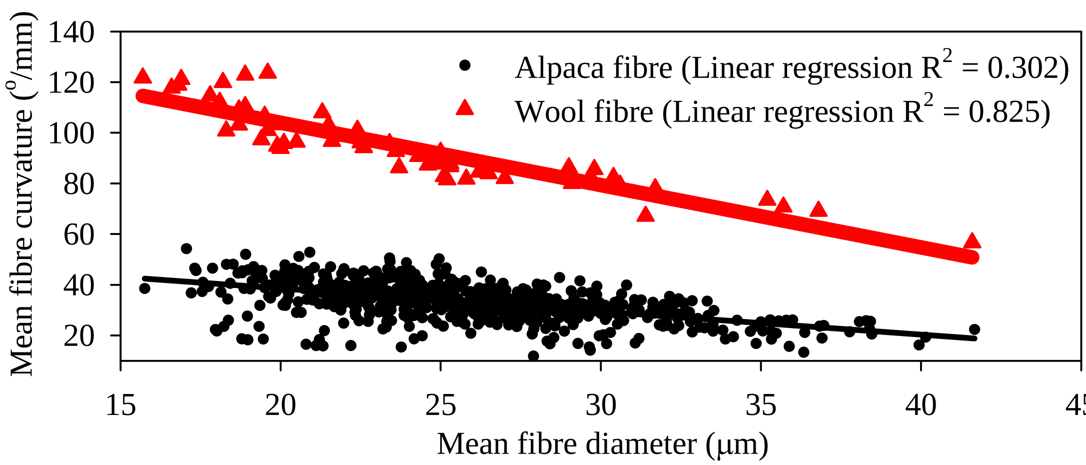

Figure 1 Relationship between MFD and Fibre Curvature for Australian Wool and Alpaca Fibres [data source of wool fibre: Cored Sale Lot in Fish et al 2000]

3.2 Fibre Crimp in Blend Tops

Alpaca and wool were blended through top gillings. As expected, results in Table II show that the curvature in the blends is less than the curvature of their corresponding wool component, but higher than the curvature of their corresponding alpaca component. It can thus be assumed that as the ratio of alpaca component increases, the overall curvature in the alpaca/wool blend reduces.

Table II Fibre properties of blended slivers and tops for the blends

Sliver Sample	MFD (μm)	Curvature (°/mm)
Low crimp wool top	17.8	62.7
High crimp wool top	17.9	79.0
Fine alpaca top	21.6	36.5
Superwashed wool top	21.0	56.8
Strong DB alpaca top	32.4	24.6
Fine alpaca/low crimp wool (30/70)	18.6	58.0
Fine alpaca/high crimp wool (30/70)	18.3	76.7
Strong alpaca/Superwashed wool (50/50)	24.9	49.3

Compare the fibre curvature in top (Table II) with that in scoured fibre (Table I), it can be seen that alpaca fibre curvature has been reduced during the topmaking process. The curvature in wool tops is much higher than that in the alpaca tops. This suggests that any wool fibre blending with alpaca fibre should result in a higher overall curvature of the end product compared to the fibre curvature in the alpaca component.

3.3 Effect of Fibre Crimp on Sliver Cohesion Force

Figure 2 shows that the breaking length of alpaca tops is significantly shorter than that of wool tops. This is simply because alpaca staple has less crimp but bulkier and fluffier structure than wool fibre [6]. In addition, the surface of alpaca fibre, with the mean scale height of approximately 0.4μm, is smoother than that of wool fibre, which has a mean scale height of approximately 1.0μm [6], hence reducing the inter-fibre cohesion of alpaca slivers. This leads to a low sliver breaking length, which is evident by comparing the 21.4μ alpaca top with the 21.5μ wool top. In these tops, the two types of fibres have the similar microns, but the wool curvature (67.3°/mm) is almost double the alpaca fibre curvature (36.5°/mm). Comparing the low and high crimp wool tops in Figure 2, the trend is obvious: low-crimp fibre top has a shorter breaking length than high-crimp fibre top. Therefore, for a better sliver cohesion, high-crimp fibre has an advantage.

Cohesion force of slivers of alpaca/wool blends tends to decrease as the blending passages increase, as shown in Figure 3. This may be due to a further reduction of fibre curvature through gillings and the alpaca fibre surface, which separates wool fibres of rough surfaces and creates a smooth media between wool fibres to reduce the wool fibre frictional force. It is noted that the breaking length of the first gilled sliver is approximately the sum of the products of individual top and its blend ratio, because at this stage, the effect of alpaca fibres separating wool fibres is not significant. Therefore, evenly blended sliver should have a minimum sliver breaking length. By comparing Figure 3 to Figure 2, it can be seen that the blended slivers have a longer breaking length than the alpaca slivers. Blending wool with alpaca fibre hence improves the alpaca fibre processibility. Similarly, if alpaca and wool fibres are blended before carding, to increase the cohesion force of sliver, especially carded sliver, high-crimp fibres should be used.

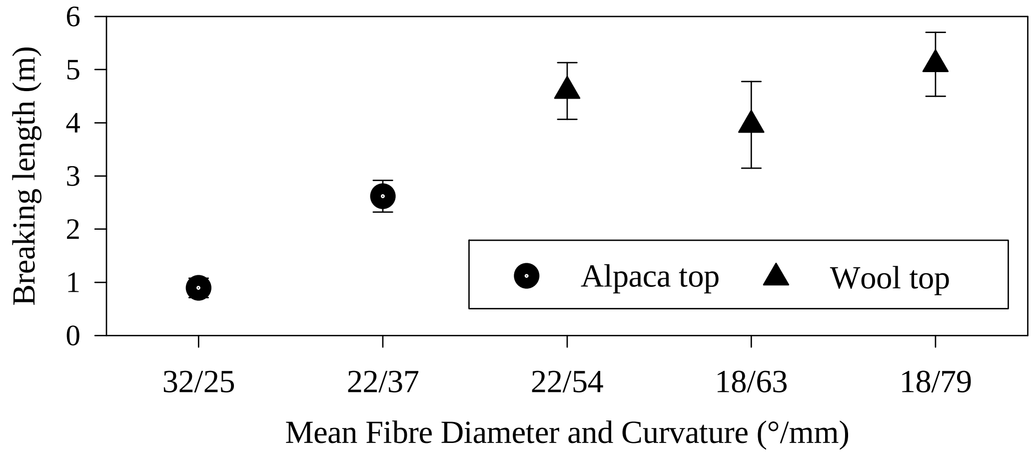

Figure 2 Breaking Length of Tops Processed from Different Fibres

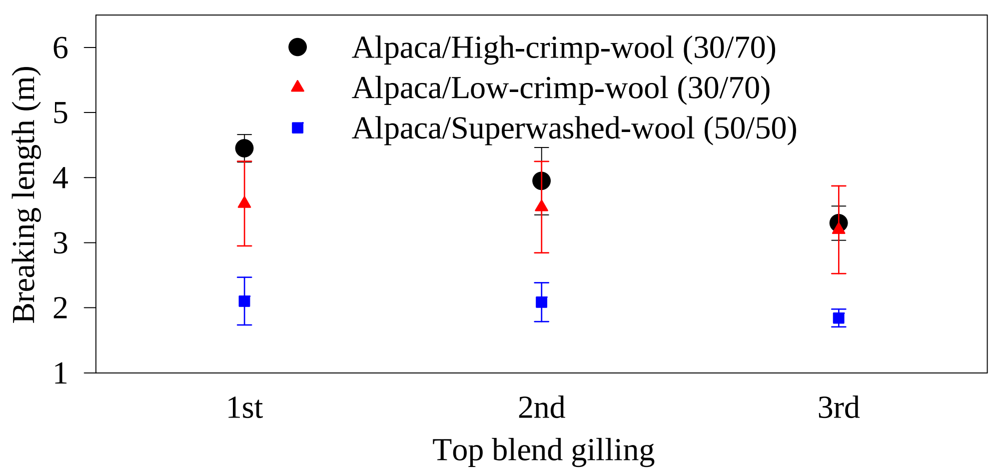

Figure 3 Breaking Length of Alpaca/wool Slivers at Different Blending Passages

4. CONCLUSIONS

The curvature of scoured alpaca fibre is normally much less than half the curvature of scoured wool fibre. Like wool fibre, the curvature of alpaca fibre decreases as the mean fibre diameter increases. During the topmaking process, curvature tends to gradually diminish from clean fibre to top finishing because of the strains introduced in the fibres during processing.

Alpaca fibre has less crimp and a smoother fibre surface than wool. This makes the alpaca fibre difficult to process due to lack of fibre cohesion. Blending alpaca fibre with wool improves the cohesion properties of the blend sliver. Fibre curvature in the alpaca/wool blend is smaller than that in wool component. For a high ratio of alpaca component in the blend, high-crimp wool can be used to improve the sliver cohesion.

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