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The Quality and Processing Performance of Alpaca Fibres

A report for the Rural Industries Research and Development Corporation

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Foreword

Australia has great potential for a viable alpaca fibre industry. The Australian Alpaca Association (AAA) was founded in 1989 to provide co-ordination for a growing national herd of high quality alpacas in Australia and to enable a viable and sustainable animal and fibre industry. The Alpaca Co-operative P/L (Alpaca Co-op) was established in 1995 to market products derived from alpaca fibres. Both organisations promote alpaca fibres and products in Australia as well as overseas. Australia has sound pastures and modern technologies for breeding the best stocks and currently has the largest alpaca herd outside South America. There is also an increasing interest in luxury fibres among fashion houses. The alpaca fibre industry in Australia is still very young and relatively small compared to the wool industry, and there has been strong desire to process alpaca fibres in Australia on the established wool processing systems. Knowledge on luxury fibre processing is often kept secret by international processors who have the know-how. Local industry needs to understand the properties of Australian grown alpaca fibres and their processing performance, so that the industry can market the fibre effectively and export high quality alpaca fibre products.

The overall objective of this research project is to evaluate the properties of Australian alpaca fibres, examine their processing performance, and improve the quality of alpaca products.

This project was funded from industry revenue and funds provided by the Australian Government.

This report is an addition to RIRDC's diverse range of over 1000 research publications, forms part of our Rare Natural Fibres R&D program, which aims to facilitate the development of new and established industries based on rare natural fibres.

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Simon Hearn
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Abbreviations and Their Units

Abbreviation	Meaning	Units
SF	Superfine alpaca fibre	
F	Fine alpaca fibre	
M	Medium alpaca fibre	
S	Strong alpaca fibre	
W	White alpaca fibre	
F	Fawn alpaca fibre	
BR	Light brown alpaca fibre	
DKBR	Dark-Brown alpaca fibre	
BLK	Black alpaca fibre	
RG	Rose grey/Roan alpaca fibre	
G	Grey alpaca fibre	
AAA	Good average length alpaca fibre	
AA	Short length alpaca fibre	
A	Very short alpaca fibre	
OG	Overgrown alpaca fibre	
WY	Washing yield	%
Grease	Grease content	%
Resid. G	Residual grease content	%
SL	Staple length	mm
SLCV	CV of staple length	%
CVH	Coefficient of variation of fibre length	%
MFD	Mean Fibre diameter	μm
CV_D	Coefficient of variation of MFD	%
AE30	Percentage of fibres coarser than 30 μm	%
SPNFine	Spinning fineness	μm
Fe	Effective fineness	μm
CUR	Fibre Curvature	°/mm
%MED	Percentage of medullated fibres	%
M.MED	Mean diameter of medullated fibres	μm
RtC	Resistance to compression	Kpa
SS	Staple strength	N/Ktex
POB	Position of Break	%
VM	Vegetable matter contamination	%
UnBL	Unbleached alpaca tops or yarns	
BL-I	Tops or yarns bleached with Bleach (method) I	
B L-II	Tops or yarns bleached with Bleach (method) II	
CVm	Coefficient of variation of mass	%
H	Hairiness value	
sh	Standard deviation of hairiness	
DR	Deviation rate	%
RH or r.h.	Relative humidity	%
OFDA	Optical Fibre Diameter Analyser	
SIFAN	Single Fibre Analyser	
SEM	Scanning Electron Microscope	
IFC	International Fibre Centre	
AAA	Australian Alpaca Association	
RIRDC	Rural Industries Research and Development Corporation	

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Executive Summary

Introduction

Alpaca fibre is soft, luxurious and has a range of natural colours and good strength. Australia has great potential for a viable alpaca industry with sound pastures and modern technologies for breeding the best genotypes. For the development of Australian alpaca fibre industry, there has been a strong demand for research into fibre properties and processing, as well as product development along the value-adding chain. This is the first major research project, funded by RIRDC, to assist the Australian alpaca industry and fibre processors, to develop better understanding of the fibres and their processing performance.

The key project components and findings are summarised in the following sections.

Alpaca Fibre Properties and the Benefit of Improved Classing Practice

Australian alpaca fibre was traditionally classed into broad micron and length ranges due to the small quantity of fibres available. A range of properties of the alpaca fibres, grouped according to colour, length, and fineness were examined objectively to demonstrate the benefit of improved classing practice. The results in this study have shown that the traditional broad classing leads to large variations in fibre properties such as fibre diameter and staple length within the classing lines. The Australia alpaca fibre industry has started to adopt a new classing practice with tighter micron ranges and more clearly defined length groups during the course of this research program.

Australian white alpacas have less medullated fibres than overseas alpacas. The staple strength of Australian alpaca fibres is significantly higher than that of wool staples and the strength of single alpaca fibres is also marginally higher than that of wool fibres of similar diameter. The within fibre diameter variation in alpaca fibres is lower than that in wool fibres.

Alpaca Fibre Scouring

Scouring is one of the key issues for the alpaca industry. Several alpaca scouring trials have been conducted to identify an efficient alpaca fibre scouring method. Results of solvent extractions, ash contents and fibre yield indicate that there is no significant difference between the scouring regimes in terms of scouring performance. All scouring methods examined can achieve satisfactory removal of grease. However, no methods can achieve an ash content below 1%. The high ash content may affect the processing performance of alpaca fibres. Dedusting greasy alpaca fibres can remove about 2% dust, reduce the dust level around the scouring machine and improve scouring efficiency slightly. Scanning Electron Microscope (SEM) study revealed that fine dust particles may be bound with the fibre surface, making them difficult to remove. Alpaca fibre has a higher scouring yield (around 90%) than greasy wool.

Conventional wool scouring regime or the wool scouring regime with a low level of detergent application can be used for alpaca fibre scouring.

Processing Performance of Alpaca Fibres

Three trials have been conducted to examine the performance of alpaca fibre processing. For all trials, the production rates of carding and combing alpaca fibres were well below the wool production rate. This was necessary to minimise fibre damage and reduce processing problems.

Both carded and combed alpaca slivers lack fibre cohesion. This creates problems for the sliver transfer and delivery. Two approaches have been attempted, strengthening the sliver cohesion by adding twists and shortening the distance the sliver has to travel. Single alpaca rovings also lack strength. The rovings should be coarser than 600 tex to prevent roving breakage during spinning. Blending alpaca fibre with wool adds the value of wool fibre and enhances the processibility of alpaca fibre. The wool component is beneficial to the strength of the blend due to the much higher crimp of wool in the blend.

The mean fibre diameter (MFD) increases by about 0.5-1µm as the processing of alpaca fibre proceeds from carding to top stages. The combing noils are 1-3µm finer than the alpaca tops. This makes tops coarser than the pre-combing slivers.

A high ash content on the scoured fibre and high moisture content for reducing the static problem can cause significant residual build-up on the gilling machine front rollers. As such, problems were encountered with sliver periodically jamming in the coiler during each gilling passage. Achieving low ash content is a major task for alpaca fibre scouring.

Static build-up results in frequent machine stoppages and a high mass variations in slivers, rovings and yarns. Maintaining the correct processing conditions is also very important for the quality of alpaca slivers and yarns. The relative humidity in the processing mill should be maintained at a level higher than 80% to minimise the static problems.

Quality Comparison of Alpaca Yarns from Different Sources
The quality of alpaca tops and yarns was assessed. Test samples were commercial products manufactured overseas and by local fibre processors, plus experimental samples. The test results could assist with the benchmarking of product quality for Australian alpaca fibre industry.

The fibre diameter in an alpaca/wool blend is usually coarser than the wool fibre diameter. In an overseas alpaca/wool blend, the MFD of wool fibre is up to 3µm finer than the alpaca fibre. Australian alpaca fibre processors use wool fibre 7µm finer than the alpaca fibre in an alpaca/wool blend. A sliver linear density of approximately 25 ktex is commonly used for alpaca tops. Fine alpaca fibre can produce more even tops than coarse alpaca fibre.

The twist factor of single alpaca yarns affects the yarn strength and fabric handle. As the twist factor increases, yarn strength increases (up to a limit), but fabric handle gets worse. Low twist yarns break easily during spinning and knitting. In addition, when using yarns with the same twist factor, knitted alpaca fabrics shed more fibres than wool fabrics. An overseas yarn manufacturer used a twist factor of around 100 (Metric) for single yarns. However, local fibre processors use a twist factor less than 90 for all singles yarns. For all folded yarns, the twist factor is less than 70. The selection of alpaca yarn twist factor should therefore depend on the application of the yarns. Unlike knitting wool yarns that have a twist factor of less than 80, it is suggested that knitting alpaca yarns have a minimum twist factor of 80, in order to maintain an acceptable strength for knitting.

Alpaca Yarns with Improved Softness
Spinning results indicated that low twist factor yarns, which are softer than high twist factor yarns, could be engineered. However, reducing yarn twist level increases ends-down during spinning. Results of alpaca fabric handle subjective assessment showed that reduced twist factor did improve fabric softness, but low twist yarns broke easily during knitting. It is therefore expected that fibre processors would experience difficulties for low twist factor yarns and knitters would prefer relatively high twist yarns.

Sirofil was employed to produce low twist factor yarns using alpaca/wool blends twisted with a nylon filament in a single operation during yarn spinning. The Sirofil yarns of alpaca/wool/nylon are stronger and have larger extensibility and rupture energy than their corresponding normal ring spun yarns. More importantly, the Sirofil yarns have a low initial modulus, and hence the yarns are softer than normal ring spun yarns.

Blending alpaca fibre with high-crimp superfine wool fibre can enhance fibre processibility of a blend and the comfort of yarns.

Understanding of the Softness Attributes of Alpaca Fibres

To achieve objective measurement of alpaca fibre softness, the usefulness of testing method (Resistance to Compression) for wool was evaluated. This study has demonstrated the profound difference between wool and alpaca fibres in their resistance to compression (RtC) behaviour, which is surprising, considering both are animal fibres. The RtC value of scoured alpaca fibre (in the range of 25-30μm) is about 5kpa on average, which is much smaller than that of most fine and super fine wool fibres (17-20μm). The resistance to compression is highly co-related with the curvature of wool fibres, but this co-relation is not as apparent for alpaca fibres. In comparison to wool, alpaca fibres have much lower curvature and scale protrusion, which reduce the bulk of the fibre mass and its frictional resistance under compression, both leading to reduced resistance to compression. This study suggests that the results from the current resistance to compression test method are not suitable for low-curvature alpaca fibres, and it is not a good softness indicator for fibres of varying diameters. Many factors should be considered together for softness assessment, such as fibre surface properties and mechanical properties.

A new testing method for evaluating fibre softness was introduced and a testing rig for the softness measurement of fibre bundles was developed in this study. The new softness testing method can achieve good discrimination between fibres of varying levels of softness, such as alpaca and wool, based on the measured specific forces of pulling a fibre bundle through a series of pins. The specific pulling force reflects the combined effect of fibre surface properties, fibre diameter and fibre rigidity. Fibres with finer microns, lower bending modulus and smoother surface have a lower specific pulling force and are softer, and the effect of fibre crimp or curvature on the specific pulling force or fibre softness is small. Preliminary results also showed that alpaca fibre could have the same softness as wool fibre that is up to 12μm finer. Further research is warranted in this area.

Alpaca Fabrics Softness and Pilling

The softness of fabrics is affected by many factors such as yarns and fabric structures. Fabrics were knitted using yarns of different twist factors and types and their handle was assessed subjectively. For the yarns with the same twist level, alpaca fabrics are softer than wool fabrics, even when the mean fibre diameter of alpaca fibre is coarser than that of wool. Fabrics knitted with low twist alpaca yarns or yarns engineered with finer alpaca fibres have softer handle than high twist or coarser fibre yarns. Alpaca fabrics are softer than alpaca/wool blends of the similar specifications.

Knitted alpaca fabrics have less propensity to pill, but their surface is fuzzier than wool fabric. Pilling performance of alpaca fabrics improves when the yarn twist is increased.

Bleaching of Pigmented Alpaca Fibres and Dyeing of Bleached Fibres

Progress has been made in bleaching of coloured alpaca fibres and dyeing of the bleached fibres. Two bleaching methods for dark coloured alpaca fibres are evaluated in this report. The bleach method-I (BL-I) uses half the concentration of H_2O_2 used in bleaching method-II (BL-II). A trial has been conducted to bleach dark brown (DKBR) alpaca tops/yarns and dye the bleached product. Both bleached and dyed tops were then engineered into yarns. Bleached dark alpaca fibres provide a good base for dyeing the fibres into a more attractive medium or deep shades. These shades will enhance the value of dark coloured alpaca. The bleaching method-I leads to a good finished top that retains the strength of the untreated brown alpaca fibres. This method causes less fibre damage and should be used where retaining the properties of the alpaca fibre is important. Fibre bleached with method-I has a reduced lightness and better chromaticity than that with method-II. Fibre bleached with bleaching method-II exhausts less dye than BL-I. The wash fastness of the finished products from BL-II is on average 1 grey scale unit poorer than BL-I, and the dyed top does not maintain the depth or clarity of the colour after laundering.

Bleaching and dyeing of the alpaca fibre causes a reduction in yarn tenacity and elongation. When colour reduction in pigmented fibres becomes more important than fibre damage, moderate losses in strength can be offset by the advantages offered by bleaching.

Bleaching method-II leads to about 2.3μm reduction in mean fibre diameter. This increases the number of fibres in the cross section of the BL-II yarns of a given count. This results in an improvement in yarn evenness and strength. But yarn hairiness also increases. The increased fibre damage recorded for BL-II may have contributed to the higher level of hairiness of the bleached and bleached/top dyed yarns.

Fibre surface modification and scale removal due to bleaching affect the speed of fibre moisture absorption. Bleached alpaca fibre is quicker to absorb water from the air in the first few hours after it is removed from drying.

It is recommended from this study that a lower concentration of hydrogen peroxide (such as that used in BL-I) can be used to minimize fibre damage but still achieve a light colour base for dyeing pigmented alpaca fibre. The process of top bleaching then yarn dyeing is recommended to reduce yarn strength and evenness problems associated with the top bleached/top dyed fibre.

Fibre Curvature and Alpaca/Wool Blend

Fibre curvature has become an important fibre attribute to the fibre processing performance and its end-product quality. This report studied the fibre curvature of wool and alpaca fibres and their changes during the early stage of fibre processing. The performance of alpaca/wool blend yarns and fabrics has also been investigated. 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 early stages of alpaca fibre processing, alpaca fibre has less curvature reduction compared to wool. Curvature reduction in alpaca tops is about half as much as that in wool fibre. Fibre/pin interactions or edge crimping may generate excessive curvature, such as during carding. Alpaca top relaxation in warm water could remove the generated curvature, particularly in tops manufactured from medium and strong alpaca lines.

Alpaca fibre has low crimp and its surface is smooth. This makes the alpaca fibre difficult to process, particularly during fibre/sliver transfer. Blending alpaca fibre with wool improves the cohesion of the blend sliver, especially when alpaca is blended with high-crimp wools. For a high ratio of alpaca component in the blend, high-crimp wool should be used to improve sliver cohesion.

Fibre curvature in the alpaca/wool blend is smaller than that in wool component. After relaxing the blend tops in warm water, the curvature in the blend is still smaller than the relaxed wool.

There is no significant difference in yarn count and yarn evenness between alpaca/low-crimp-wool blend and alpaca/high-crimp-wool blend yarns when they were processed the same way.

Surprisingly, the knitted fabric made from alpaca/high-crimp-wool blend is softer than that made from alpaca/low-crimp-wool blend. This may be explained by the test results that the initial modulus of alpaca/high-crimp-wool blend yarn is lower than that of alpaca/low-crimp-wool blend yarns.

It is recommended that the selection of wool fibre curvature for alpaca/wool blend should depend on the blend ratio and end-uses. Generally, wool fibre crimp is not critical to the quality of the blends. However, for alpaca and superfine wool blends, high-crimp-wool may be preferred if the ratio of alpaca fibre component is high and low-crimp-wool may be preferred if the ratio of alpaca component is low in the blend.

Calculating MFD and CVD of Alpaca/Wool Blend

A model for computing the MFD and CV_D in a mixture of multiple fibre components has been developed. Validation results show that this model can accurately calculate the MFD and CV_D of a blend from the parameters of the individual components. The developed model has a wide range of applications, including determining the minimum yarn count or number of fibres in a blend yarn cross-section, and choosing the right blend ratio and fibre properties for a blend. Examples of alpaca/wool blends are given to demonstrate such applications. A table is created for alpaca/wool blend, which provides good reference data for the alpaca processors.