HIGH QUALITY CONTAMINANT-FREE WOOL

GENERAL INTRODUCTION

K.J. WHITELEY*

The concept of wool quality centres on those characteristics that distinguish a sale lot of wool from other wools and other textile fibres in terms of the demand it creates from the manufacturer at each stage of processing and from the buyer of the final wool garment. Wool can be differentiated from its natural and man-made fibre competitors by a range of mechanical, physical and chemical properties common to virtually all fine wools. Among wools the differences are more subtle and concerned principally with shape factors and variations in levels of contamination. In this paper attention is focussed on these differences among wools and their impact on wool grower strategies.

Fibre characteristics

In terms of fibre parameters average fibre diameter is of overwhelming importance in establishing price with staple length and strength having significant influences on both price and processing pathways. Other fibre characteristics such as crimp and colour are important in particular applications, especially when extreme expressions of such characteristics are encountered (Andrews and Lunney 1982).

The ability to produce lists of wool properties in priority order relating to various stages of processing is based on processing trials initiated in the early 60's (Bastawisy et al. 1961) a decade before the first measurements appeared in sale catalogues. These trials demonstrated that measurement of parameters such as average fibre diameter provided advantages over subjectively appraised quality number or spinning count.

Research is continuing into objective methods to assess trade terms such as style which comprises a number of visual components including staple shape, colour and crimp characteristics. However current processing trials suggest the influence of these components is relatively slight being evidenced mainly by small differences in wastage and in the average fibre length in the top. This, in turn, is probably due to the fact that wools that are considered to be of inferior style may have suffered tip damage. Currently there are no accepted commercial procedures for establishing the properties of the staple tip and the influence they will have on mechanical and chemical processing.

Uniformity of appearance was also regarded as significant but evidence now suggests that the classing of skirted fleece into uniform lines was mainly to facilitate appraisal. It did not increase uniformity in measured parameters to any significant extent. In any case processing experiments have demonstrated that wide levels of variation likely to be encountered for example in both fibre-diameter and length can be accommodated by existing processing equipment (Turpie 1977).

Fibre diameter distribution deserves special mention as current technology does not distinguish between variation among fibres as opposed to variation along individual fibres (Quinnel et al. 1973).

Variation among fibres whilst having little effect upon processing and spinning may, in extreme cases, have some effect on yarn hairiness and influence yarn

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Mechanical properties (Ly 1983) to produce, for example, stitch distortion. These observations have not yet been fully confirmed.

There is strong evidence that coarse fibres protruding from the surface of a fabric are responsible for the sensation of prickle (Hayfield 1987) regarded as a major disadvantage when wool is worn next to the skin. However, it is essential to determine the effect, if any, that sheep selection, wool production, clip preparation, wool marketing and construction of consignments can have on reducing the variability of diameter. Although much research on fibre diameter distribution remains to be done in the fields of metrology, processing and sheep selection it must be kept in perspective as a characteristic of secondary importance to the textile industry.

Secondly, variation in fibre diameter along the length of an individual fibre will obviously affect its mechanical properties. Whilst staple strength indicates the weakest point in a staple and is a very useful predictor in early stage processing, subsequent breakages may occur at other thin points in the fibre. Consequently a complete trace of variations in fibre diameter along the length of the fibre may provide a better understanding of fibre breakage and the resultant effects upon topmaking performance.

**Contaminants**

The question of contaminants is complex; natural contaminants consist of dark fibres, secretions from the sebaceous and the sudoriferous glands, dust and vegetable fault. Pesticides and non-wool fibres originating, for example, from pack materials and bale twine are also a constant source of complaint.

Australian Merino wool has a low incidence of pigmented fibres and careful skirting can contain the level of stained fibres. The two types of fibres are grouped together as “dark fibres” by the processor and even very low levels equivalent to 2 staples per bale of stained fibres can lead to rejection of tops destined for the production of fabrics in light and pastel shades (Foulds 1989). Research to ensure that dark fibre contamination is minimised remains a high priority.

Wax, suint, dust and vegetable fault are deficiencies of wool as a textile raw material. The small amounts of residual wool grease and mineral matter, comprising dust and suint salts, remaining after scouring have deleterious effects in processing, especially spinning (Christoe 1986). Vegetable fault contamination is the major determinant of the relative clean price of wool after fibre diameter, as it increases wastage during carding and combing and failure to remove it during processing results in rejection or costly manding of fabrics. There appears to be comparatively little that can be done to reduce levels of natural contaminants the removal of which must remain a task for the textile technologist. With increasing wool prices in recent years rugging of more valuable animals appears to be increasing and would reduce both dust and vegetable fault. However the impact of this process on the clip as a whole would still be slight.

In recent years awareness of pesticide residues in greasy wool have been a cause for concern and the wool clip is now being surveyed to identify clips with high levels of illegal pesticides (Australian Wool Corporation 1988/89). It has been demonstrated that pesticides are removed from wool with the grease during scouring. This however creates further problems such as the disposal of scouring effluents and the possibility of unacceptable levels of pesticides in lanolin to be used in human applications. Techniques to reduce these levels are in an advanced stage of development but in the longer term alternative solutions to the control of external parasites are required.

The implications for management arising from contamination are discussed later in the paper in more detail.
At each stage of processing a portfolio of tests, both objective and subjective, have been developed and these are principally concerned with the operations at a particular processing stage and/or prediction of performance during the next stage. Typical examples are greasy wool specification for prediction of topmaking performance or, at the other end of the processing chain, fabric objective measurement for the prediction of tailorability, appearance retention, comfort and aesthetics.

Individual raw wool characteristics play a role in some or all of the many steps involved in the production of a finished wool garment. Whilst advances in these individual sectors are substantial the development of bridges between them are in their infancy and during this development the relative levels of significance attributed to particular raw wool fibre parameters may change somewhat as our knowledge increases.

Ultimately the aim must be to establish the significance of wool characteristics when viewed against the wool production and wool textile industries as a whole so that the profitability of woolgrowing enterprises are sustainable in the context of production whilst ensuring a supply of raw material that is predictable in both its performance during processing and the quality of the finished garment.

HIGH QUALITY CONTAMINANT-FREE WOOL - THE PROCESSOR'S PERSPECTIVE

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The quality of any wool garment depends very much on the correct application of quality control procedures and adequate supervision of the many stages through which wool passes, from the sheep's back to the retailer's shop. Practices adopted in the growing and harvesting of the clip will enhance or diminish the processing potential of the wool, particularly in its early stages of manufacture. This paper considers the factors that can affect the quality of wool top produced from greasy wool after scouring (to remove impurities), carding (to randomise fibres and remove vegetable fault), and combing (to remove vegetable matter, fibre entanglements, short fibres, noil, and to align the fibres).

Firstly, however, it is useful to discuss the stages involved in topmaking, in order to identify areas where problems are likely to occur.

Stages in early stage processing

Remarks are restricted to WORSTED processing which utilizes combing wool categories of the clip (some 82% of the total clip), however, some comments are applicable to WOOLLEN processing as well.

The steps in topmaking are:

(i) Blending
(ii) Opening the wool
(iii) Scouring
(iv) Drying
(v) Carding
(vi) Preparer gilling
(vii) Combing
(viii) Finisher gilling

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Characteristics of importance in producing a wool top

The topmaker's customer is the spinner who specifies the top he orders in terms of:

(a) quality
(b) mean fibre diameter (and sometimes variation)
(c) mean fibre length (Hauteur), plus other fibre length parameters
(d) whiteness
(e) number of vegetable matter particles
(f) number of neps (small knots)
(g) number of dark fibres
(h) residual grease/oil content
(i) pH extract
(j) evenness of sliver weight.

Of course, the top must also be completely free of foreign fibres. These specifications must be met or the topmaker will face a claim or even rejection of the lot.

Characteristics of greasy wool which affect processing

Many of the above characteristics can now be fully or partially specified by measurements made on the greasy wool:

1. Quantity of top and noil can be predicted from the core test yield.
2. Top fibre diameter equates almost exactly to core test average fibre diameter.
3. Mean fibre length is becoming more predictable through the use of staple length and strength measurements.
4. Colour measurement of greasy wool after test scouring may be helpful in determining top colour.
5. Vegetable matter specifications can be controlled through knowledge of the core test V.M. result.
6. Quantity of neps is very dependent on fineness.
7. Dark wool fibres are still difficult to specify and contamination of greasy wool by foreign fibres is another serious concern.

The influence of other characteristics depends very much on the processing conditions used in the mill.

These areas have been discussed in terms of their economic significance in topmaking and suggestions given as to where changes in the growing and harvesting of the clip could be made, to help produce a better quality product.

HIGH QUALITY CONTAMINANT-FREE WOOL - THE GROWER'S PERSPECTIVE

M. McBride*

The wool grower's primary concern must relate to the economic factors governing his profitability. An appropriate starting point is to determine what the market will pay most for, i.e. what is most attractive and, taking costs of production into account, most successful in the long term.

Prices received for the raw material reflect indirectly factors influencing profitability of all sectors of the wool textile industry up to and including the retailer of finished wool garments.

The availability of test results for determining the major characteristics determining value (core test: yield, average fibre diameter and vegetable fault) and performance (core test plus staple length, staple strength and colour) provides clear signals as to the relative price of individual sale lots. They are equally effective as indicators of the efficacy of clip preparation and interlotting procedures. No section of the industry has yet learnt to exploit this information to its fullest extent and there may be many significant opportunities that can be seized using historical measurement and other information, for predictive purposes. The industry is now very close to total specification by objective methods.

When wool as a raw textile fibre is viewed against the man-made fibre industry, it is clear that we must not hesitate to encourage innovation. Australian agriculture has an outstanding record of invention and the wool industry must continue to engender this spirit. In particular the revolution in information technology now makes it feasible for all sectors of the production and processing industries to manipulate available data to facilitate management strategies.

However the computer revolution and the introduction of total specification of raw wool should not be regarded as a break from the traditional values that have brought the industry world recognition. Rather these developments should be viewed as additional aids that will sharpen our skills and maintain wool at the top of the quality pyramid.

HIGH QUALITY CONTAMINANT-FREE WOOL - NEW MANAGEMENT TECHNOLOGY

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Within the limit set by the genotype, the production of high quality wool depends very largely on the regular supply of adequate high quality nutrients to the wool producing follicles. Inadequate nutrition reduces fleece weight and properties such as fibre diameter and staple length, while variation in nutrition produces variation in diameter along fibres which is related to staple strength (Hansford and Kennedy 1988).

A principal management objective is to optimise pasture quality and pasture intake and to account for changes in requirements owing to physiological events such as pregnancy and lactation.

The technology of pasture improvement is well established in the higher rainfall areas (Wheeler and Freer 1986), however Wheeler (1986) identified many serious limitations to pasture production in southern Australia. Progress in overcoming these limitations will come through new and improved plants, control of weeds, control of competitors such as rabbits and amelioration of acidification and salination of soils. In cereal growing areas it is important to be able to enhance the nutritional value of crop residues while in the lower rainfall areas the control of woody weeds and soil and pasture stability are essential. In all areas economic and practical ways of filling seasonal feed gaps are needed.

Enhancement and modification of rumen function can be achieved with various supplements and exogenous agents such as ionophores and in the longer term we may—see increased efficiency by genetically engineered micro-organisms. The overcoming of mineral deficiencies by slow release technology is another advance.

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The continuing cost-price squeeze, expanding technology and enhanced awareness of consumer requirements make management increasingly complex. Computer simulation models are becoming important aids to decision-making and in the longer term expert systems may be able to be applied in management (Black and Vickery 1986).

Illhealth caused by parasites, blowflies and foot diseases is another major effect on production and quality. The technology of preventing disease is likely to be based on vaccines which will be developed using molecular biology techniques. These vaccines will reduce reliance on chemicals, thus removing a current source of contamination of wool.

The important contaminants at present are vegetable matter, dark fibres and fragments of wool packs and baling twine. The last is easily preventable by good management but the others are more difficult to prevent. Research is identifying the relative importance of different types of vegetable matter (Bow et al. 1989) thus enabling management strategies to be better targeted. Nonetheless this will remain a serious problem. Another approach is to better specify the types of contamination (Atkinson 1989) so that processing can be adjusted to minimise contamination in tops.

Urine-stained fibres are the main dark fibre contaminant. Understanding how fibres are stained by urine could lead to prevention through vaccination against the causative organisms (MacDiarmid 1988) while timing of crutching and modified shearing may be used to reduce the risk of contamination (Foulds, 1989). The extent to which wool pack material contaminates wool is a vexed question but less contaminating material is under development. The indications are that these packs will be substantially more expensive than those currently available, which may limit their adoption.

Skin pieces removed during shearing are another contaminant while second cuts reduce the quality of wool. Both could be eliminated with new methods of removing the fleece such as automated mechanical shearing and biological defleecing.

Production of high quality wool implies that we can specify the properties which consumers require and can provide feedback to growers. Knowledge of the processing consequences of various wool characteristics has become an important feature of the industry in recent years. An enlarged range of specifications is becoming possible through the application of image analysis (Winston 1989) while computer-aided decision support systems are being developed for valuation of wool (Charlton et al. 1989). These will provide improved efficiency in the selling system as well as allowing a flow of better information to growers.

HIGH QUALITY CONTAMINANT-FREE WOOL - BREEDING FOR IMPROVED WOOL QUALITY

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In the strictest sense, those characteristics of raw wool which influence the quality and value of final wool products (fabric, carpet etc.) and the costs of producing those products should be considered as possible breeding objectives by sheep breeders. Such consideration will primarily be influenced by the relationship between variation in raw wool quality characteristics and the price received by the wool producer (the relative economic importance of each characteristic). Other factors to influence this consideration include the capacity of the breeder to accurately identify variation in wool quality

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between sheep prior to making selection and breeding decisions, and a knowledge of the relative contribution of genetic and non-genetic factors to that variation.

**Relative economic importance of wool quality characteristics**

The incorporation of pre-sale measurement of a range of wool quality characteristics into wool marketing systems is discussed elsewhere in this contract. What are the implications for sheep breeding decisions of raw wool price differentials associated with these marketing systems? Table 1 summarises the impact on raw, greasy wool prices of unit variation in a range of wool quality characteristics that are measured or scored prior to auction selling in Australia.

Table 1 Variation in price per kilogram of greasy wool according to a one unit increase in each of seven wool quality characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Unit</th>
<th>Change in price* per kg (cents/unit)</th>
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<tbody>
<tr>
<td>Yield</td>
<td>% (of greasy wool weight)</td>
<td>10</td>
</tr>
<tr>
<td>Average fibre diameter</td>
<td>Micron (μ)</td>
<td>-200 (for μ&lt;21)</td>
</tr>
<tr>
<td>Vegetable matter content</td>
<td>% (of clean wool weight)</td>
<td>-75 (for μ&gt;21)</td>
</tr>
<tr>
<td>Staple length</td>
<td>Millimetre</td>
<td>-12</td>
</tr>
<tr>
<td>Staple strength</td>
<td>Newtons/kilometre</td>
<td>3</td>
</tr>
<tr>
<td>Scoured colour</td>
<td>Subjective score**</td>
<td>6 (for N/ktex&lt;35)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.3 (for N/ktex&gt;35)</td>
</tr>
<tr>
<td>Style</td>
<td>Subjective score***</td>
<td>-25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
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* Prices based on AWC Minimum Reserve Price Schedule 1989-90
** Scoured colour score: 1-nil, 2-light unscourable colour
  3-medium unsavourable colour, 4-heavy unsavourable colour.
*** Style score: 1-inferior topmaking, 2-average topmaking,
  3-good topmaking, 4-best topmaking, 5-spinners.

Other raw wool characteristics of some (variable) significance in quality considerations such as coloured fibres, resistance to compression, fibre diameter variation, staple length variation, medullation, cotts, staple tip, character and handle are currently not formally assessed prior to wool sale and cannot therefore be objectively analysed in terms of relative economic importance to sheep breeders.

However for those listed in Table 1 it is possible to calculate, using techniques described by Ponzoni 1988, the relative economic values that might be ascribed to these characters in designing a sheep breeding program.

Using this approach, reduced average fibre diameter will have the highest relative economic value amongst greasy wool quality characteristics. On these grounds it is hard currently to justify significant attention to raw wool.
quality characteristics other than average fibre diameter in the breeding objectives for Merino sheep.

Assessment and utilisation of variation between sheep in wool quality characteristics

In the context of selective breeding to improve wool quality by genetic means, there are two sources of genetic variation which are exploitable by breeders.

Firstly, genetic variation exists among individual rams and ewes within flocks. The potential exists to measure or assess the relative merit of individual young rams or ewes with respect to any economically important wool quality characteristic prior to selection for breeding. The Australian national performance recording scheme for non-pedigreed wool sheep, WOOLPLAN, currently provides breeders with the methodology to objectively rank young sheep on two wool quality traits, yield and average fibre diameter (Ponzoni 1988). By inference there is insufficient evidence of the relative economic importance of other wool quality characteristics and/or a lack of information on the extent of genetic variation and covariation in these characteristics between animals within Merino flocks, to justify their current inclusion in WOOLPLAN. A recent review of the available genetic parameters for wool quality traits (Rogan 1989) highlighted the need for more precise parameters for many of the newer aspects of wool quality. Another issue receiving current research and industry attention is the magnitude of correlations between measurements of wool quality and production characteristics at a young (~12 months) age when selection decisions are made, and expression of those traits at older ages.

It appears (Atkins et al. 1998) that using rankings based on measurements of the average fibre diameter of fleeces from young rams (10-12 months old) to estimate their relative breeding values for lifetime fibre diameter performance may be quite accurate. However, the same report suggests that rankings based on measurements of fleece weight at the same age may be less accurate as selection criteria for lifetime fleece weight performance and in estimating breeding values for that trait.

The second source of genetic variation in wool quality traits is that found between flocks and particularly between some of the distinct family groups (strains and bloodlines) within the Australian Merino population. Based on the results of research comparisons and wether trials, some family groups are known to differ significantly in average fibre diameter, yield and staple length (Rogan 1984; Hygate and Atkins 1989) and possibly in fibre diameter variability and staple strength (Rogan unpub.) when the production of representatives of those family groups is compared under a common environment. The ability of sheep breeders to utilise this source of genetic variation to improve wool quality characteristics is severely restricted by their lack of access to non-confounded objective information on the relative merit of rams from different flocks. On-farm contemporary progeny testing of rams from different flocks is probably the most efficient means of identifying “flock improvers” at this stage.

CONCLUDING REMARKS

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There is now a substantial body of knowledge concerning the essential aspects of wool quality. Although a number of areas require further study there is available both technical and commercial information to guide the woolgrowers' planning activities. There is still much to be achieved in the development of information systems to facilitate this process.
With regard to contaminants, very substantial progress is being made in terms of reducing levels to conform with stringent international requirements relative to processing efficiency and, more significantly, to perceptions of community welfare. The grower can contribute much through appropriate sheep husbandry practices but, again, efficient dissemination of information is an urgent prerequisite.

Overall, the industry can look forward to steadily increasing standards of wool quality and reduced levels of contamination provided current levels of research and development are matched by adequate extension programs.

REFERENCES


