Topic 2: Important Characteristics of Wool

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Learning objectives
On completion of this topic you should be able to:
- Describe the properties of wool contributing to a high quality fleece
- Understand how timing of shearing can affect wool quality traits
- Understand how wool quality traits impact on the price received for wool

Introduction
The majority of wool produced in Australia is of Merino origin and is generally produced under grazing production systems. Merino wool tends to be finer and more suited to end-use in fine apparel. Australian wool also has a reputation for being relatively free of dark and medullated fibre contamination due to stringent clip preparation procedures. There are many characteristics of wool that can affect its suitability for particular processing procedures and end uses including fibre diameter, staple length and strength, fleece weight, colour, style and contamination. This topic aims to outline how these characteristics impact on wool quality and their effects on price received for wool.

The influence of time of shearing on these characteristics will also be discussed. Other factors affecting these characteristics will be covered in Topics 3, 4 and 5.

2.1 Average fibre diameter
Average fibre diameter is the major determinant of wool value, accounting for 55–83% of variation in clean price. It is also the most important trait at each stage of processing. It accounts for approximately 75% of the value of the wool top, with value increasing as average diameter declines. Spinning performance (yarn evenness, strength and breakage) and fabric properties (weight, drape and softness) are significantly influenced by average diameter, product performance improving in general as fibre diameter declines. The growing shift towards lightweight garments and next-to-skin wear is also increasing the demand for finer wools, with supply and demand factors being reflected in significant price differentials in favour of finer wools. As will be seen in the following, average fibre diameter also influences wool value indirectly by way of interactions with other wool attributes.

The unit for fibre diameter is the micron, where 1 micron = 1 millionth of a metre (or one thousandth of a millimetre). The mean fibre diameter of wool in a fleece mostly depends on the breed from which it was obtained, and may range from around 16 to over 40 microns. Because of the inherent variability of wool, any sample of fibres will have a range of diameters (perhaps from 10–70 microns for individual fibres). Figure 2.1 shows the typical fibre diameter distributions for Merino and crossbred wools.

![Figure 2.1: Typical fibre diameter distributions for Merino and Romney wools (Wood 2007).](image-url)
About 70% of the wool produced globally is consumed in apparel and this tends to consume the finer wools. The remaining 30%, which comprise mostly coarser wool types, is consumed mainly in carpets, upholstery and blankets. Figure 1.2 shows the fibre diameter requirements for the main products manufactured from wool.

Figure 2.2: The fibre diameter requirements for the main wool products (Wood 2007).

### 2.2 Staple strength

Staple strength is generally the second most important determinant of greasy wool value (5–14%), though this depends on season. It is measured in terms of Newtons per kilotex (N/ktx), the force required to break the staple (in Newtons) being corrected for the amount of fibre material bearing the load (ktx = grams per metre). All else being equal, a reduction in staple strength results in greater fibre breakage and wastage during topmaking, a reduction in top hauter and greater variation in fibre length, which can reduce spinning efficiency. These relationships, though, are not linear, there being certain strength thresholds above which the benefits of increased staple strength are marginal. The threshold determined in the market varies throughout the year and also depends on average fibre diameter. For example, 34 N/ktx for fine (18.6–20.5 µm), 31 N/ktx for medium (20.6–22.5 µm) and 29 N/ktx for broad (22.6–24.5 µm) wools. This is reflected in wool value where price falls rapidly as strength declines below the threshold (i.e. discounts), but increases marginally above the threshold (i.e. premiums) as shown in Figure 2.3. The rate at which discounts and premiums change as staple strength changes also depends on fibre diameter, higher rates being associated with finer wools.

Variations in staple strength can arise from variations in the load-bearing material within the staple and variations in the intrinsic strength of the fibres in the staple. There may be an interaction between the two in that changes in the physical dimensions of the fibre may be associated with changes in the structural or chemical components of the fibre. Either way, any factor which influences the load-bearing capacity of wool fibres can impact on the strength of the staple.
2.3 Position or Point of Break

When a staple is extended to breaking point, it usually breaks at the relatively weakest point of the staple, yielding a tip section and a base section. The point or position of break (POB) in the staple is measured via the relative weights of the two sections as a percentage of the staple weight. If the tip section accounts for <33% of the staple weight, then it indicates that the staple broke in the top third of the staple, (i.e. a tip break). Alternatively, if the base section accounts for <33% of the staple weight, then it indicates that the staple broke in the bottom third of the staple, (i.e. a base break). Otherwise, it is a middle break. There are currently no market signals indicating the influence of POB on clean price, however a tip or base break is generally preferable over a mid break from a top-making point of view. However when the proportion of mid breaks is >60% a discount will apply and conversely when the proportion is <40% a premium is applied but the extent of these premiums and discounts depends on micron.

2.4 Staple length

Staple length accounts for 1–7% of clean price variation. It is the major determinant of top hauter which in turn is the second major determinant of top value and spinning performance. It also influences choice as to the processing system. The optimum length determined in the market varies throughout the year and depends on fibre diameter, as do the premiums and discounts applied to sub–optimal lengths.

2.5 Vegetable matter content

Vegetable matter (VM) is regarded as a contaminant of greasy wool and must be removed during processing. VM can be divided into seven types (Table 2.1) which have differing effects on the processing performance of the wool when present. VM removal increases processing costs and results in fibre breakage and wastage. Failure to remove VM can result in either the rejection, downgrading or costly mending of fabrics. Very high levels of VM usually require carbonising, but this is a relatively complex and expensive process which can also damage the fibre if not strictly controlled. VM accounts for 2–5% of price variation, with price discounts increasing as the level of VM increases and as average diameter declines. VM type influences wool value, seed and shive generally attracting a slightly greater discount compared to burr and hardheads due to difficulty of removal. Figure 2.4 shows some of the VM types causing contamination. More examples of these can be found at the following website


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Figure 2.3: Staple strength premiums and discounts, relative to the threshold strength for fine, medium and broad wool types: 2003/2004. Tender wool is 15 to 20 N/ktext, part tender is 20 to 30 N/ktext and sound is higher than 30N/ktext (Woolmark 2003).
### Table 2.1: Types of VM contamination (AWTA 1986)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>B – Burr</td>
<td>Seed pods produced mainly by Medicago species eg Subterranean clover. Generally non-fibrous and relatively easy to remove</td>
</tr>
<tr>
<td>E – Seed</td>
<td>Fine grass seed material eg. Carrot seed (<em>Tragus australicus</em>), Dock (<em>Rumex spp.</em>) and Saffron Thistle (<em>Carthamus lanatus</em>)</td>
</tr>
<tr>
<td>S – Shive</td>
<td>Fibre-like seed material derived from a wide range of plant species often difficult to remove</td>
</tr>
<tr>
<td>F – Bogan Flee</td>
<td>Seed of <em>Calotis hispidula</em> a small, flea-shaped seed with several spreading awns.</td>
</tr>
<tr>
<td>N – Noogoora Burr</td>
<td>A hard, spine covered burr capable of causing damage to processing machinery due to its hardness. Also Ring Burr (<em>Sida platycalyx</em>) included in this category</td>
</tr>
<tr>
<td>T – Bathurst Burr</td>
<td>A hard spine-covered burr, more easily removed during processing compared to Noogoora Burr</td>
</tr>
<tr>
<td>M - Moit</td>
<td>All non-burr, non-seed plant material such as leaves, twigs and bark. Relatively easy to remove during processing.</td>
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</table>

![Figure 2.4](image)

**Figure 2.4.** Vegetable matter types: a) hard heads and twigs (e.g. Noogoora burr) b) burr eg burr medic c) seed and shive (e.g. Barley Grass).

### 2.6 Greasy wool colour

The scoured colour of wool can range from near-white to yellow and therefore affects the range of colour achievable during dyeing. This is more of a problem for wools destined to be made into white or pastel-shade fabrics. No information on true scoured colour is currently used to set price relativities, the market relying instead on the visual appraisal of greasy wool colour. Discounts are applied for light (H1), medium (H2) and heavy (H3) non-scourable colour and are greater for finer wools. Unfortunately, greasy colour is a poor indicator of scoured colour, such that some H1– and H2– graded (and therefore discounted) wools can often scour to an acceptable colour while some non-discounted wools can discolor during scouring. Greasy colour currently accounts for 1–3% in price variation.
2.7 Style

Style grades are used in the market to distinguish between wools which are expected to have different processing performance and different end-product characteristics beyond that indicated by the measured wool attributes. It is a subjectively-appraised composite trait, incorporating crimp definition, frequency and evenness, dust penetration and colour, tip shape and wool colour. Style grades range from 1 – 7 with 1 being “choice” and 7 “inferior”. The bulk of Australian sale lots fall into style grades 4 (best) and 5 (good), with less than 1% of bales falling into grades 1-3 combined. State differences in style reflect environmental differences as well as Merino type effects. In general, Victoria and Tasmania produce the largest proportions of the highest style grades, with Qld, SA and WA producing a higher proportion of lower style grades, reflecting in part the more arid nature of parts of their wool-growing environments.

Recent processing trials suggest a comparatively small though positive effect of improved style on hau ter and fibre wastage in topmaking. Improvements in crimp traits can also improve spinning performance and fabric quality, especially softness, though the effects are small compared to those of the measured wool attributes. Style accounts for 1–4% of variation in clean price with price differentials between style grades tending to be greater in finer wools as shown in Figure 2.5.

![Figure 2.5: Fibre diameter premiums for Merino fleece style grades 3-6; Northern Region 2003/04 (Woolmark 2003).](image)

2.8 Dark fibre contamination

Naturally-pigmented fibres and urine-stained fibres are a source of dark fibre contamination in supposedly white wool, the latter being the most prevalent form in Australia. For the white and pastel trade, upper limits of 20 dark fibres per 100 grams of top could be specified, equating to around 4 coloured/stained staples per bale. If the level of contamination in the fabric is too high, compensation claims can be made against the spinner who in turn makes claims against the topmaker (from 4–15% of the selling price of the top). Dark fibre contamination is generally not detected until topmaking.

Given the amount of wool blending that occurs, the source of the contaminant cannot be identified, so wool growers at present are not penalised if contamination is present (unless, by bad luck, it appears in the sample on display at the wool store).

Given the increasing proportion of shedding breeds in the Australian sheep flock it is imperative that wool producers are careful to limit dark and medullated fibre contamination in their wool clip.

2.8 Wool faults

These are attributes of the greasy wool which, when present, incur a price penalty due to reduced fibre quality or increased fibre breakage during processing. Examples include cotting, in which the
fibres are entangled, and dermatitis or ‘lumpy wool’, a skin infection resulting in the formation of hardened structures which encompass fibres and even whole staples.

2.9 Fleece weight and yield
The amount of wool produced is also an important consideration for the wool producer as they are paid on a cents per kilogram basis for their wool. Producers generally know the weight of greasy wool they produce but prices are quoted on a clean fleece weight basis so they need to know the yield of their wool. Yield is used to estimate the quantity of usable wool fibre present.

2.10 Shearing management
Timing of shearing (when and how often) is one of the major management decisions for a wool producer. These two choices have a significant impact on the quality and quantity of wool produced by a farm, as well as on sheep health. Time of shearing has been observed to affect staple strength, position of break, fleece weight, yield and fibre diameter.

Staple strength and position of break
Wool shorn at different times of the year, from many locations, has been observed to have different staple strengths (for example, see Butler, Gibson and Head 1994; Oldham 2000). In addition, the hauteur and romaine of tops made from these different shearing time wools varies (Arnold, Charlick & Eley 1984).

Wool growth is amazingly variable, as can be seen in the example of a wool fibre profile from a spring-shorn wether in Western Australia (Figure 2.6). Shearing time affects the shape of a profile because shearing determines where the ends of the wool staple lie along the fibre diameter profile. Where the thinnest part of the fibre, which is usually the position of break (POB), lies along this profile then becomes an important consideration.

Figure 2.6: Monthly wool fibre diameter profile from an unsupplemented spring-shorn wether at Mt. Barker, WA (Doyle and Thompson 1992).
The measured staple strength of wool will be improved if shearing occurs through or near the thinnest part of the fibre diameter profile, which puts the POB near the tip or base of the staple. Machines that measure staple strength clamp up to 15mm of wool at either end of the staple. If clamping includes the POB, the staple will have to break at another, stronger, point and the machine will record a higher breaking force. In this way, a time of shearing that places the POB near the staple's end improves the measured staple strength of wool (Butler, Gibson & Head 1994).

Vegetable matter (VM)
The availability of seeds, burrs and other vegetable matter (VM) contaminants that develop in the pastures in spring and summer varies throughout the year. VM accumulates in longer wool, so sheep destined to be shorn in autumn are particularly at risk of accumulating VM in their fleece. Vegetable matter lowers wool quality and can threaten animal health (McDonald 1981) and is especially a problem in regions dominated by annual pastures, whose seeds cause substantial VM problems. One survey of different regions in NSW did not find a change in overall VM due to different shearing times (Warr, Gilmour & Wilson 1979). This is because, over a whole region, changing shearing time might have reduced one vegetable contaminant but another took its place. This study's results contrast with the data presented in Figure 2.8. Even Warr et al.'s work still has implications for individual farms, however. If only one or two species cause vegetable fault, then shearing before those seeds mature may considerably reduce VM contamination. A small study in Victoria showed this, where the later in the year the clips were shorn, the lower the VM percentage (Court 1991; Court & Lawless 1995).
**Greasy fleece weight and fibre diameter**

Shearing time affects other wool quality factors besides staple strength and VM. In several experiments, autumn-shorn sheep cut more wool of broader micron than spring-shorn sheep (Lightfoot 1967; Ralph 1971; Arnold, Charlick & Eley 1984). Shearing removes a sheep's insulation and extra heat must be produced to maintain body temperature. In the weeks following shearing, this heat energy will either come from increased feed intake, diverting extra feed energy into heat production (if intake is already near maximum) or mobilising body energy stores (Bottomley & Hudson 1976). In spring, sheep are in good body condition with high feed availability. They are already eating near their maximum intake and can divert some of this energy into extra heat production. In autumn, however, sheep are in poorer body condition. This means they can increase their feed intake more in response to shearing (Arnold, Charlick & Eley 1984). This greater feed intake after autumn shearing, compared to after spring shearing, results in greater greasy wool growth and autumn-shorn sheep cut heavier fleeces. Because it grows at a faster rate, the ‘extra’ autumn wool is also of higher fibre diameter. Autumn-shorn clips can be up to 0.7µm broader (Arnold, Charlick & Eley 1984) than similar spring-shorn clips.

**Yield and clean fleece weight**

Although greasy fleece weight is increased, autumn-shorn wool has lower yields. Dust accumulates over summer and autumn prior to shearing in the longer wool (Lightfoot 1967). The increased wool growth stimulated by autumn shearing also stimulates extra wax and suint production, further decreasing yield. In trials, the yield was not reduced enough to offset the gain in greasy fleece weight, and the clean weight of autumn-shorn fleeces is often higher than those shorn in spring (Lightfoot 1967; Arnold Charlick & Eley 1984).

**Table 2.2** Comparison of greasy fleece weight, yield and clean fleece weight for Tasmanian shearings (Lightfoot 1967).

<table>
<thead>
<tr>
<th></th>
<th>October</th>
<th>April</th>
</tr>
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<tbody>
<tr>
<td>Greasy fleece weight (kg)</td>
<td>5.1</td>
<td>5.9</td>
</tr>
<tr>
<td>Yield (%)</td>
<td>X 70.9</td>
<td>X 66.0</td>
</tr>
<tr>
<td>Clean fleece weight (kg)</td>
<td>3.6</td>
<td>3.9</td>
</tr>
</tbody>
</table>

**Readings**

There are no readings provided for this topic. Chapter 25 of the International Sheep and Wool Handbook provides further details on some of these characteristics.

**Revision Questions**

1. What are the characteristics that can affect the price received for wool and what is their affect on price?

2. How can time of shearing be managed to optimise these wool quality characteristics?

**References**


AWEX, data from the 2000/01, 2001/02 and 2002/03 seasons, Australian Wool Exchange.


Court, J. 1991, Sheep industry crisis - meeting the challenge Department of Agriculture, Victoria, p. 16.11.
Notes – Topic 2 – Important characteristics of wool