4. Wool Colour and Fleece Rot

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Learning Objectives

On completion of this topic you should be able to:

- explain the economic importance of wool colour and measurement of wool discolouration and fleece rot
- articulate and document the processes involved in the development of yellow wool discolouration
- discuss the importance of factors associated with resistance to yellow wool discolouration describe the development of fleece rot and discuss the factors associated with resistance to fleece rot

Key terms and concepts

Wool colour, yellow discolouration, fleece rot, scourable colour, unscourable colour, AWEX-ID wool discolouration appraisal, objective colour measurement, yellowness (Y-Z) units, incubated colour test, fleece rot scoring, phenotypic correlations.

Introduction to the topic

This topic describes greasy colour of fleece wool on the sheep in the context of two types of unscourable discolourations that develop under certain conditions of moisture, temperature and bacterial activity, namely yellow discolouration and fleece rot. The economic impact of unscourable colour on fleece value is presented. The processes involved in the development and the measurement of yellow discolouration and fleece rot are described, with factors associated with resistance to yellow discolouration and fleece rot identified.

4.1 Wool colour

The colour of greasy Merino wool can vary. It varies from near white through to shades of cream and yellow, with intense yellow discolouration in greasy wool known as ‘canary stain’. Yellow discolouration results from chemical reactions occurring within the fleece under the influence of moisture, temperature and bacterial activity. Due to moisture and bacterial activity at skin level inducing fleece rot, other discolourations can often occur. Discolouration can range from red, orange, pink, violet and blue as well as the more usual discolourations of yellow, grey, brown and green. An example of near white wool colour shown in Figure 4.1 contrasts with the wool discoloured by fleece rot shown in Figure 4.2.

Figure 4.1 An example of near white Merino fleece wool. Source: Mortimer, S (2004). Image taken by S. Mortimer, Trangie, N.S.W. D.P.I., (2004).

Figure 4.2 An example of Merino fleece wool discoloured by fleece rot. Source: Mortimer, S (2004). Image taken by S. Mortimer, Trangie, N.S.W. D.P.I., (2004).

Wool colour will influence the price achieved for a sale lot under the auction system. Wool is discounted if it is perceived to have an 'unscourable' colour as the type of products the wool can be used for and dyed is expected to be more limited. Wools that scour 'white' can be dyed any colour, including pastel shades. In contrast, wools with increasing degrees of yellowness after scouring are more difficult to dye pastel shades and therefore have more limited end uses.

Before sale, greasy wool is appraised visually as being either scourable or unscourable, with wools considered unscourable graded for the degree of discolouration present based on the AWEX-ID system. Wool with scourable colour will be creamy-white after scouring (washing to remove impurities). Wool with unscourable colour will be off white or yellow after scouring and subsequently discounted. The AWEX-ID system provides three grades for appraising greasy wool discolouration: H1, light unscourable colour; H2, moderate unscourable colour; and H3, heavy unscourable colour. An additional category, N1 (light water stain) is provided for bacterial discolouration and water stain. Table 4.1 shows the average discounts for the unscourable colour grades in a range of Merino wool types over the last three full wool auction seasons (2000/01 to 2002/2003). As discolouration increases, the level of discount increases. As well, discounts are greater as wool type becomes finer. Greasy wool colour is of greater economic importance to fine wool production as compared to broad wool production.

Table 4.1 Average discounts (% relative to wool that has no unscourable colour) for light (H1), medium (H2) and heavy (H3) unscourable colour in superfine (17-18.5 μm), fine (18.6-20.5 μm), medium (20.6-22.5 μm) and broad (22.6-25.0 μm) Merino fleece wool sold during the full auction seasons 2001/02 to 2003/04. Source: Woolmark (2005).

	Superfine (17.0 – 18.5)	Fine (18.6 – 20.5)	Medium (20.6 – 22.5)	Broad (22.6 – 25.0)
H1, light	-3.1	-2.1	-1.1	-0.8
H2, medium	-5.8	-5.8	-4.1	-3.6
H3, heavy	-8.9	-8.8	-8.4	-8.2

Both greasy and clean scoured wool can be objectively measured and described by the components of brightness (the opposite of dullness or greyness) and yellowness (to provide a scale from white through to intense yellow). Wool colour is determined using a spectrophotometer or a colorimeter. Colour measurement systems allow colours to be represented by a mixture of three defined colours (notionally red, green and blue) expressed by the derived tristimulus values X, Y and Z. In wool colour measurement, the Y value is indicative of brightness and the Y-Z value indicative of yellowness. Brightness of wool increases as Y value increases and its yellowness increases as Y-Z value increases. The colour is best described in yellowness (Y-Z) units, which can range from 7 to 18 units. Most Australian fleece wools have Y-Z values between 7 and 12 units.

Greasy wool colour has been shown to be a poor predictor of clean wool colour following scouring. Measured clean colour is related weakly to both measured greasy colour (Figure 4.3) and visually assessed greasy colour (Table 4.2). This indicates that discounts applied on the basis of a visual appraisal of greasy colour may not always be justified, as some wool perceived as being discoloured could often produce clean white wool after scouring. Where greasy wool colour is appraised as unscourable for a sale lot, measurement of clean wool colour could be useful in reducing the size of price discounts applied to that wool. While greasy sale lots can be measured for clean wool colour, much less than 10% of fleece wool sale lots are measured currently for this trait.

Figure 4.3 Phenotypic relationships between an index of greasy wool yellowness and an index of clean wool yellowness for fleece lines with and without discounts for greasy colour. Source: Pattinson and Whiteley (1984).

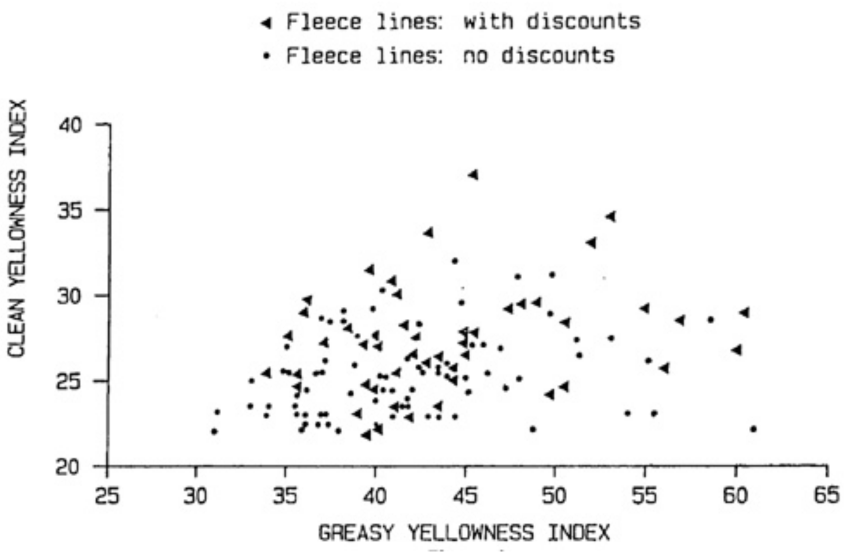

Table 4.2 Phenotypic relationship between assessed greasy colour (greasy score) and measured greasy and clean wool yellowness (Y-Z) in fine, medium and broad wool Merino sheep (mid-side samples). A higher greasy colour score reflects greater yellow discolouration. Source: Compiled from Swan et al. (1997); Raadsma and Wilkinson (1990); James et al. (1990).

	Fine	Medium	Broad
Greasy score versus Y-Z greasy	0.50	0.43	0.55
Greasy score versus Y-Z clean	-	-	0.33
Y-Z greasy versus Y-Z clean	-	-	0.30

4.2 Development of yellow discolouration in wool

Yellow discolouration in wool can occur irrespective of whether wool is on the sheep in the paddock or in shorn greasy, semi-processed or final fabric form. Yellow discolouration can develop due to decomposition of the fibre protein as a result of exposure to ultra-violet light, sustained high temperature and alkaline conditions. However, the natural yellow discolouration that can be seen in some fleeces in the paddock is generally the result of a series of chemical reactions among non-fibre components occurring within the fleece under the effects of certain environmental conditions (moisture and temperature) and bacterial activity.

One of the reactions involved in wool discolouration is the Maillard Reaction, a 'browning' effect that results from the interaction of reactive carbohydrates and proteins within the fleece. This was demonstrated by Hoare and Stewart (1971) when white Merino wool was induced to discolour after being placed into solutions of the reactive carbohydrates, glyceraldehyde or glycolaldehyde.

Within the normal fleece environment, a Maillard reaction involving non-fibre proteins within the fleece occurs following the generation of reactive carbohydrates as a result of the metabolism of suint components by bacterial populations within the fleece. Suint consists mainly of potassium salts of various carboxylic acids. The Maillard reaction occurring in the fleece can be described as follows:

- Simple carbohydrates such as glycolaldehyde are derived from the metabolism of potassium salts of various carboxylic acids in the suint by bacterial populations on the skin surface
- These carbohydrates react with amino acids within the yolk of the fleece and skin debris to produce yellow discolouration
- Wool fibres absorb the yellow discolouration.

Other reactions within the fleece are involved in wool discolouration. During the production of the reactive carbohydrates, the bacterial activity also generates carbonates and bicarbonates, causing a rise in the pH of the fleece. As conditions become more alkaline, the wool fibres become more susceptible to decomposing and absorbing the yellow discolouration present in the yolk of the fleece. Also, the bacterial population is implicated in wool discolouration via the formation of ammonia following degradation of the non-fibre protein components of the fleece. During this process of bacterial deamination of amino acids, potassium present in the suint is likely to act as a catalyst. Additionally, the potassium component may possibly increase the rate of absorption of discolouration into the fibre.

4.3 Factors associated with resistance to yellow wool discolouration

Given these possible reactions, the following factors are likely to be important in determining the level of yellow discolouration present in wool:

- Suint content of the fleece, influencing the concentration of reactive carbohydrates (derived via the Maillard reaction) and carbonates and bicarbonates (effect of more alkaline conditions) and total amount of potassium present
- Potassium concentration in the suint, influencing the bacterial degradation of amino acids that produces ammonia (deamination)
- Bacterial activity, influencing the rates of production of reactive compounds
- Temperature and moisture, influencing the size of the bacterial population and rate of bacterial activity.

For the fleece characteristics, fleeces resistant to discolouration show a lower level of suint (as a percentage of greasy sample weight) and a lower concentration of potassium in the suint and a less alkaline suint (Table 4.3). Fleeces resistant to discolouration may also tend to be of lower fibre diameter and higher yield. Wax/suint ratio, but not wax content, is associated with yellow discolouration, with resistant fleeces tending to have higher ratios. Apart from potassium, inconsistent differences between resistant and susceptible fleeces have been observed in the concentrations of minerals and the relative proportions of amino acids in clean wool.

Some of these associations may also be predictors of the potential for the development of yellow wool discolouration between Merino strains, and possibly between Merino bloodlines. Significant differences occur between Merino strains and between bloodlines in wax content, suint content and fibre diameter (Table 4.4). At the breed level, the finer breeds, such as the Merino,
generally have brighter and whiter wools than wools from the broader wool and crossbred types used in sheep meat production.

Table 4.3 Fleece characteristics associated with resistance to yellow discolouration, including an expected range of values. Source: Aitken et al. (1994).

	Resistant fleeces have	Range
Suint (%)	Lower	1.4 - 15.4
Wax/suint ratio	Higher	1.6 - 20.4
Potassium content of suint (mg/gm)	Lower	0.4 –19.9
Fresh suint pH	Lower	4.5 – 8.5
Yield (%)	Higher	55.4 – 86.5
Fibre diameter (μm)	Lower	19.4 – 29.7

Table 4.4 Range in bloodline averages for wax content, suint content and fibre diameter in mid-side samples from fine (n=2) medium non-Peppin (n=2), medium Peppin (n=10) and strong (n=1) Merino strains. Source: Mortimer and Atkins (1989, 1993).

	Wax (%)	Suint (%)	Fibre diameter (μm)
Fine	19.5 – 22.3	7.5 – 9.5	18.8 – 18.9
Medium non-Peppin	16.9 – 18.0	7.7 – 9.5	20.6 – 21.4
Medium Peppin	18.8 – 22.4	8.8 – 10.6	20.2 – 21.9
Strong	14.6	9.3	21.5

Flock management can influence the occurrence of yellow wool discolouration in situations where shearing can be timed to avoid long wool on animals during prolonged periods of high humidity and temperature.

4.4 Measurement of propensity for yellow wool discolouration

As a combination of moisture and warm temperature is required for discolouration to occur, susceptible sheep can only express their propensity to discolour if the environmental conditions are conducive to the development of discolouration. Observation and recording of discolouration in sheep is then not always possible. There are a number of implications of this for Merino breeding programs:

- The emphasis given to wool colour in a breeding program is likely to vary with location, where greater emphasis is likely in environments characterised by a summer-dominant rainfall pattern (providing conditions of moisture combined with warm temperatures)
- Susceptible animals cannot be assessed and identified for culling unless seasonal conditions favour the development of discolouration
- If wool colour is in the breeding objective, selection and purchase of rams in a breeding program will need to consider the environmental conditions under which the rams are raised as compared to those environmental conditions under which their progeny would be born. As a result of genotype by environment interaction, progeny may only express their propensity to discolour only under certain environmental conditions.

4.5 Incubated colour test

Consequently, a procedure has been developed whereby a greasy wool sample is artificially challenged to induce yellow discolouration. The procedure involves incubating the sample at both high temperature (40^{o}C) and humidity for 1-7 days. This incubated colour test simulates the environmental conditions necessary to induce discolouration in susceptible fleeces. Following incubation, the development of colour is scored on a scale from 1 (bright and white) to 5 (dark brown/yellow discolouration). The procedure was first described by Wilkinson (1981), then modified by Raadsma and Wilkinson (1990). Later, Aitken et al. (1994) modified the procedure to assess the development of discolouration by measuring the absorbance at 430 nm on a colour extract taken from the wool samples following incubation. Under this approach, susceptibility to yellow discolouration increases as absorbance increases. Each of the traits associated with susceptibility to yellow discolouration has been shown to be correlated strongly (at the phenotypic level) with the level of discolouration developed under the incubated colour test (Table 4.5).

As there is little economic incentive for its use in Australia, little commercial use of the incubated colour test has occurred in Australia, with more attention given to its application in New Zealand. During the 2002/03 wool auction season, colour accounted for less than 1% of the value of Australian Merino fleece wool. However, the incubated colour test has provided a means of identifying factors influencing wool discolouration and strategies to improve wool colour. For example, use of the test has allowed evaluation of the relative contributions of bacterial activity and fleece characteristics to wool discolouration. A comparison of yellowness change after incubation of sterilised (by gamma radiation) and non-sterilised wool showed the bacterial effect to be at least twice that of the temperature-moisture-wool interaction, particularly at higher temperature (Cottle et al. 1992). This suggests that there could be differences between resistant and susceptible animals in the bacterial population (via differences in basal numbers and/or species) on their skin surface.

Table 4.5 Phenotypic correlation between fleece characteristics associated with discolouration and the level of colour induced by the incubated colour test (absorbance at 430 nm of extract). Source: Aitken et al. (1994).

	Phenotypic correlation
Suint (%)	0.85
Wax/suint ratio	-0.72
Potassium content of suint (mg/gm)	0.95
Fresh suint pH	0.74
Yield (%)	-0.20
Fibre diameter (μm)	0.69

4.6 Fleece rot

Fleece rot is a skin disease that develops in the fleeces of susceptible animals after prolonged wetting and bacterial proliferation at the skin level. It is best described as a mild superficial dermatitis (Raadsma 1987). Other names for fleece rot include 'water stain', 'weather stain', 'water rot', 'wool rot', 'pink rot', 'cakey yolk' and 'dead yolk'.

Fleece rot develops following prolonged wetting of the fleece that results in moisture at skin level. The presence of free moisture on the skin causes a breakdown in the wax layer on the skin and the release of serous exudate that matts the fibres together in bands. The serous exudate provides a medium for the growth of a range of bacteria, including *Pseudomonas aeruginosa*. The bacteria usually produce pigments that stain the fleece in well-defined bands, so that most forms of fleece rot are associated with bacterial stain. The colour of the resultant stain is dependent on the various bacteria present in the fleece. For example, *P. aeruginosa* usually produces a blue-green pigment (pyocyanin). The serous exudate eventually dries into a crusted band which is characteristic of fleece rot. Bacterial staining without skin exudation is not considered exudative fleece rot but the condition of weather stain.

Fleece rot can result in unscourable colour. However, the phenotypic relationship between fleece rot (expressed either as incidence or severity score) with greasy colour score is not strong (phenotypic correlations of the order of 0.1 to 0.2), so that fleece rot resistant animals tend to have whiter and brighter fleeces (Table 4.6).

Table 4.6 Association between greasy wool colour score (higher score indicating more favourable colour) and the incidence and severity of fleece rot in Merino sheep. Source: McGuirk and Atkins (1980).

Greasy wool colour score	Fleece rot incidence (%)	Fleece rot severity score
1	60	1.6
2	65	1.4
3	49	1.1
4	31	0.8
5	33	0.6

The economic impact of fleece rot in a flock is evident in reductions in wool production and quality and in deaths of animals or the need to cull animals affected with fleece rot. For a given incidence of fleece rot, a proportion of animals with fleece rot will have fleeces or areas of the fleece that are discoloured (with unscourable colour) and/or tender leading to a reduced value of the wool as discounts for these faults are incurred.

Fleece rot also has economic consequences because of its role as a major pre-disposing factor influencing the development of body strike in susceptible Merino sheep. The bands of serous exudate and the odours produced during fleece rot development are highly attractive to gravid (pregnant) sheep blowflies (namely *Lucilia cuprina*). The serous exudate also provides ideal conditions for egg laying and hatching and subsequent larval growth. Infestation of the skin on the sheep's body with the larval stages of sheep blowflies is known as body strike. In addition to the strong phenotypic relationship existing between fleece rot and body strike, the genetic correlation between the two conditions is at least 0.75 (Raadsma 1991). McLeod (1995) estimated an annual cost of $161 million of the sheep blowfly to the sheep industry in 1994.

4.7 Factors associated with resistance to fleece rot

Amount of rainfall, bacterial activity, age of sheep and flock management will influence the incidence and the severity of fleece rot in a flock (reviewed by Raadsma 1987). Young sheep (less than 12 months of age) are more severely affected by fleece rot than adult sheep, so that culling of affected young animals can improve a flock's level of resistance to fleece rot. Sheep with 4-6 months wool growth are most susceptible to fleece rot during critical times of the year. Strategic timing of shearing is important to consider if periods of prolonged rainfall are likely to coincide with sheep having 4-6 months wool growth. Also, lamb shearing (tipping) could increase the susceptibility of young sheep to fleece rot.

A number of fleece, skin and immunological characteristics of sheep within a flock have been studied for their association with fleece rot. These studies show that the phenotypic correlations are small (range between 0.3 and –0.3) and often inconsistent in the direction of the association (O'Meara and Raadsma 1995). The characteristics studied should be used carefully to identify animals for culling due to their relative inefficiency as predictors of fleece rot resistance. However, the fleeces of more resistant animals have: whiter colour; longer, thinner staples of higher crimp frequency; lower average and variability of fibre diameter; higher wax content; lower suint content; and higher wax/suint ratio. Factors that are components of fleece structure (e.g. average and variability of fibre diameter) will influence fleece wettability and the retention of moisture in the fleece.

Sheep classers are able to grade animals resistant to fleece rot within a flock, with the phenotypic association between predicted and observed fleece rot ranging between 0.05 to 0.39 (Raadsma et al. 1987a). Visual fleece and skin traits used by sheep classers include handle, crimp, fibre diameter, staple length, staple thickness and its uniformity, staple tip formation, greasy fleece colour, fleece condition and yield, fleece density, and the skin's thickness, tone and texture. Conformational faults of the withers on the sheep increase the susceptibility of sheep to fleece rot (Raadsma et al. 1987b). These faults include high shoulder blades, broad withers and 'pinch' (an abnormal narrowing which may be seen as a depression) behind the withers.

Within the Merino breed, large differences between strains in resistance to fleece rot occur. The order of resistance increases from the strong wool to medium wool to fine wool strains (Table 4.7). These differences become greater as the average incidence of fleece rot increases in response to more favourable conditions for the development of fleece rot. As well, there are significant differences between bloodlines within a strain in the average level of resistance to fleece rot (Table 4.8). These differences between strains and bloodlines within strain are due to many influences such as differences in breeding programs (use of selective breeding and crossbreeding) and environments. The differences present a means of rapidly improving resistance to fleece rot through bloodline substitution, but choice of bloodline would need to consider other economically important traits to the production system.

Table 4.7 Average incidence of fleece rot among weaners of fine wool, medium wool and strong wool Merino strains over a three year period. Source: Atkins et al. (1980).

		Incidence (%)	
	Year 1	**Year 2**	**Year 3**
Fine	6.0	3.1	6.7
Medium	39.9	23.7	6.9
Strong	67.2	33.7	14.3
Mean	37.2	21.5	7.3

Table 4.8 Average incidence of fleece rot between Merino strains and average range for bloodlines within strain. Source: Atkins and McGuirk (1979).

	Average incidence (%)	
	Strain	Bloodline within strain range
Fine (n=2)	9	3-14
Medium non-Peppin (n=2)	28	20-36
Medium Peppin (n=10)	23	13-39
Strong (n=1)	38	38

Between bloodline correlations indicate that bloodlines of greater resistance to fleece rot are associated with finer fibre diameter and better style and colour but reduced clean fleece weight, yield and body weight and shorter staple length (Mortimer and Atkins 2001). However, these traits would need to be used cautiously as predictors of resistance to fleece rot when considering different bloodlines.

At the breed level, there is inconclusive evidence for differences between breeds in resistance to fleece rot (Raadsma 1991), due to a lack of designed studies to compare breeds under the same environment and management conditions.

Although potentially the incidence and severity of fleece rot could be influenced by the coating of sheep (by providing a physical barrier) and vaccination against fleece rot (protection against bacterial activity), the effectiveness of these control measures is either uncertain or limited at this stage. In the case of coating of sheep, the trials to date have not been able to identify a consistent benefit of sheep coats on incidence of fleece rot in addition to the existing protection provided by the fleece and the animal's resistance to fleece rot (Hatcher et al. 2003). Similarly, the vaccine against fleece rot developed to date has not been effective against a range of strains of *P. aeruginosa* nor effective against other species of bacteria involved in the development of fleece rot (Tellam and Bowles 1997).

4.8 Assessment of fleece rot

Scoring sheep for fleece rot provides an easy and cheap method of assessing the severity of the condition and of grading individuals on their relative susceptibility to fleece rot. The information then allows decisions on the culling of animals within a mob to be made. A detailed scoring system, developed by NSW Agriculture, is available to the sheep industry (Murray and Mortimer 2001). The system uses the following scores:

- Score 0: no bacterial colour or crusting
- Score 1: band of bacterial staining less than 10mm wide with no crusting
- Score 2: band of bacterial staining more than 10mm wide with no crusting
- Score 3: band of crusting less than 5mm wide with or without bacterial staining
- Score 4: band of crusting from 5mm to 10mm wide with or without bacterial staining
- Score 5: band of crusting more than 10mm wide with or without bacterial staining.

A full description of the scoring system, including photographs and diagrams, can be viewed at NSW Agriculture's web site, http://www.agric.nsw.gov.au/reader/18066.

Readings

The following readings are available on CD:

1. Aitken, F.J., Cottle, D.J., Reid, T.C. and Wilkinson, B.R. 1994, 'Mineral and amino acid composition of wool from New Zealand Merino sheep differing in susceptibility to yellowing', *Australian Journal of Agricultural Research*, vol. 45, pp. 391-401.
2. Raadsma, H.W. 1987, 'Flystrike control: an overview of management and breeding options', *Wool Technology and Sheep Breeding,* vol. 35, pp. 174-185.

Activities	Available on WebCT
Multi-Choice Questions	Submit answers via WebCT
Useful Web Links	Available on WebCT
Assignment Questions	Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCT

Summary

Summary Slides are available on CD

Unscourable colour can have an important impact on the value of the fleece. Stained fibres result from chemical reactions occurring at skin level under the influence of moisture, temperature and bacterial activity. Colour can range from yellow to through red, orange, blue, pink, violet, grey, brown or green. Fleece rot is a disease that develops with prolonged wetting and bacterial activity at skin level and causes crusting and staining of the wool fibres. Animals differ in their susceptibility to the disease depending on rainfall, strain, age, conformation, and flock management. Sheep are generally scored for fleece rot susceptibility allowing for decisions to be made with regards to culling susceptible animals within a flock.

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Glossary of Terms

Bacterial staining	staining that occurs in bands as bacteria present on the sheep's skin increase numbers under moist and warm conditions. These bacteria produce pigments (green, brown, red, pink, blue) that discolour, i.e. stain, the fleece
Body strike	the form of blowfly strike that occurs on the body of a sheep. Blowfly strike occurs when the skin of a susceptible sheep is infested by the larval stages (maggots) of specific sheep blowflies
Brightness	a measure of the intensity of reflectance of a wool sample in the green spectral region and is expressed as the Y tristimulus value
Canary stain	a bright yellow stain in the fleece that is not removed by normal scouring processes
Clean colour	the colour of wool following scouring. It may be expressed using tristimulus values or derivations of the tristimulus values, brightness and yellowness
Colorimeter	an instrument used to determine colour of a wool sample by measuring its tristimulus values
Colour of wool	the average yellowness (Y-Z) of a wool sample
Greasy wool	wool from the sheep's back in its unprocessed form. It contains wax and suint excreted from the skin and dust and vegetable matter from the environment
Fleece rot	a superficial dermatitis that is caused by moisture over a prolonged period and bacterial growth at the skin level. The crusty exudate produced results in a matted band of fibres next to the skin. Fleece discolouration is common
Incubated colour test	a procedure to induce yellow discolouration involving the incubation of a greasy wool sample at both high temperature and humidity for 1-7 days
Maillard reaction	a 'browning' effect that results from the interaction of reactive simple carbohydrates and proteins in the fleece
Mid-side sample	a wool sample of about 30 grams shorn or clipped from the mid-side of a sheep
Objective measurement	a system in which measurement is used to specify the characteristics of greasy wool rather than by visual assessment or subjective appraisal
Scouring	the process of washing wool to remove impurities (grease, suint, dust, vegetable matter)

Scourable colour	discolouration in greasy wool that can be removed by scouring, leaving the wool creamy-white in colour
Spectro-photometer	an instrument used to determine the reflectivity of a wool sample within the visible light spectrum. It provides an alternative means for the measurement of clean wool colour
Suint	the water-soluble component (sweat) secreted from the sweat gland attached to primary wool follicles. It consists mainly of potassium salts of various carboxylic acids and inorganic salts such as carbonates
Tender wool	wool in which the fibres have a weakness at a certain point of the staple such that if tension is applied to the staple, it will break
Tristimulus value	one of the three reflectance readings provided by a colorimeter. The specific values are X (red), Y (green) and Z (blue). The clean colour of wool is specified by Y and Z
Unscourable colour	discolouration in greasy wool that is not removed by scouring, leaving the wool off white or yellow in colour
Wax	the water-insoluble component secreted from the sebaceous gland of wool follicles that coats the fibres as grease. It consists of lipids (fats)
Yellowness	the difference between the reflectance of a wool sample in the green and blue regions of the spectrum. It is expressed as the difference between the tristimulus values Y and Z (Y-Z)
Yolk	the grease or natural fats contained in greasy wool