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Unravelling the causes of wool yellowing
Part I: Involvement of a water soluble component

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ABSTRACT

The change in yellowness (△Y-Z) of wool samples maintained in an environment intended to stimulate yellow discolouration was determined in two experiments. In the first experiment, △Y-Z was determined following one of six treatments - no extraction (control), solvent wax extraction (-W), aqueous suint extraction (-S), extraction of wax and suint (-WS), removal then reapplication of wax and suint (+WS), or detergent washing (D). Removal and reapplication of wax and suint, or removal of wax alone resulted in similar yellowing to the control (△Y-Z mean±SD); (control 1.6±1.2; +WS 1.5±2.8, $p = 0.92$; -W 2.1±1.3, $p = 0.37$). Detergent scouring, and removal of suint, or both wax and suint, reduced wool yellowing (D 0.6±2.2, $p = 0.24$; -S 0.5±1.6, $p = 0.09$; -WS 0.3±1.3, $p = 0.04$).

In the second experiment, greasy wool from two chimaeric sheep producing both Lincoln and Merino wool types yellowed to a similar extent (Y-Z post challenge; mean±SD) (Lincoln 7.3±1.5; Merino 6.5±1.1; $p = 0.45$), suggesting that the fleece environment influences the propensity for yellow discolouration when distinct wool types are grown together.

The data presented here support the hypothesis that a water soluble component of the fleece is involved in wool yellowing.

Keywords: wool; yellowing; wool wax; wool suint.

INTRODUCTION

Non-scourable yellow discolouration of wool develops during growth, storage and processing of the fibre (Aliaga *et al*., 1996). Both genetic and environmental factors have been implicated. Individual animals can be classified as susceptible or immune on the basis of their genetic predisposition, although environmental factors, including warmth, dampness and humidity promote yellowing in genetically susceptible sheep (Wilkinson, 1982). It has also been noted that sheep susceptible to fleece rot are more likely to suffer from non-scourable yellowing (Wilkinson, 1981b). While studies have suggested an association between wool wax and suint concentration, and fleece rot (Thornberry *et al*., 1980), previous manipulations of wax and suint concentrations have been unable to identify a role in fleece yellowing (Wilkinson, 1981b).

Under laboratory conditions, temperature and humidity are important factors in the development of yellow discolouration in wool (Wilkinson, 1981a; Aliaga *et al*., 1996). Two distinct tests have been developed to predict the susceptibility of a wool sample to discolour. The yellow predictive test (YPT) is an indirect method developed by Raadsma and Wilkinson (1990). For this test, samples of greasy wool are maintained in a warm environment, at high humidity, for 5 d. The supernatant is then extracted and colour of the liquid used as an indicator of yellow discolouration. The yellow challenge test (YCT) is a direct method which measures the yellowness of clean fibres after incubation of greasy wool in a warm and humid environment for 14 d. The YCT was developed by Aliaga *et al*. (1996) and has been modified to form the basis of experiments described here.

The specific aim of this study was to examine the hypothesis that wool wax and/or suint are involved in the yellowing of wool. This hypothesis was tested using objective measures of Y-Z to evaluate effects of manipulating wax and suint concentration, and to compare different wool types on chimaeric sheep.

METHOD

Yellow challenge test

Wool samples were collected from the midside of five adult sheep susceptible to yellow discolouration (L M Winder, unpublished data). The tip of each staple was removed to reduce dust contamination and weathering effects (Aliaga *et al*., 1996). Wool samples were pre-treated as described below, and cut into 2 cm lengths, sprayed with 6 ml $_{d}H_2O$ and mixed to ensure uniform wetting. In contrast to the method of Aliaga *et al*. (1996), thymol was excluded from the wetting solution. Inclusion of thymol would have reduced establishment of bacterial populations during incubation (A P Maher, personal communication). In the current study it was deemed desirable not to disrupt what may be a natural fleece yellowing mechanism (Winder *et al*., 1998). Seven grams of the wet wool pieces were then incubated at 40°C in open plastic containers (11cm high x 7cm wide). High humidity was maintained by placing several open vessels of water on the floor of the incubator. Samples were incubated for 6 d. Mean measured base colour (Y-Z) of each wool sample was determined before and after the yellow challenge test (YCT).

Measurement of base wool colour

Wool colour is calculated from the tristimulus values

X, Y and Z which correspond to the sample's absorbance at the wavelengths of red, green and blue light respectively. Wool yellowing is determined as the absorbance measured at the wavelength of green light minus the absorbance measured at the wavelength of blue light. Using the tristimulus values, wool yellowing is therefore defined as Y-Z (Reid, 1993).

Extraction of wool wax and suint

Wax was removed using a modification of the method of Daly and Carter (1954). Duplicate weighed samples of greasy wool (5±0.5 g) were placed in a 30ml syringe barrel fitted at the tip with a circular wire gauze. The wool was then thoroughly wet with about 10 ml of solvent (AnalaR petroleum spirit 60-80°C; BDH #10179). The syringe plunger, from which the rubber seal had been removed, was then inserted and the wool compressed by the application of pressure on the plunger by placing the syringe in a custom-built rack, designed such that eight syringes were supported above eluant collection tubes. Additional solvent was dripped into the compressed syringe at a rate of 1ml/min until a total volume of 20 ml was collected. This procedure resulted in >95% of the wool wax present being extracted from the sample (L M Winder, unpublished data).

Suint was extracted by a procedure similar to that described above for wool wax using water as the eluant. Samples were wet with cold water for one hour prior to syringe compression. In excess of 95% of wool suint was extracted following collection of 20 ml of aqueous eluant (L M Winder, unpublished data). Where both wax and suint were removed from a sample, wax was extracted first and the wool air dried prior to suint extraction.

Where stated, reapplication of wool wax and suint was performed following air drying of the extracted sample. The first 10 ml of petroleum spirit eluant from the sample was then reapplied to the sample and the solvent evaporated by air drying. The first 10 ml of aqueous suint eluant was reapplied and the wool air dried. The first 10 ml contained 92% of all components extracted by either solvent or water (L M Winder, unpublished data).

Scouring of wool samples

Wool was scoured by hand in 0.05% Teric GN9 detergent at room temperature for two min. Following a fresh water rinse the wool was air dried.

TABLE 1: Change in Y-Z following the yellow challenge test for wool sub-samples which had undergone different treatments prior to incubation (n = 10). *p<0.1, **p<0.05, NS = not significant.

Treatment	△Y-Z following YCT (mean ± SD)	Significance (Treatment-Control)
Control	1.6±1.2	-
Wax and suint reapplied	1.5±2.8	NS
Wax off	2.1±1.3	NS
Suint off	0.5±1.6	*
Wax and suint off	0.3±1.3	**
Scoured	0.6±2.3	NS

Chimaeric sheep

Chimaeric sheep which produced small patches (ca. 1-2 cm diameter) of both Lincoln and Merino wool types were identified (Scobie *et al*., 1997). Duplicate greasy wool samples which were characteristic of Merino and Lincoln wool were collected from each of two chimaeric sheep. The propensity of the two wool types to discolour was evaluated using the modified Yellow Challenge Test described above. The data are presented as post-YCT Y-Z values (rather than △Y-Z), as only small quantities of wool were available; insufficient for measurement of both pre- and post-YCT values.

RESULTS AND DISCUSSION

Greasy wool samples held in a humid, warm environment for 6 d increased in yellowness by an average of 1.6 Y-Z units (Table 1). This change in yellow discolouration was also seen when both wax and suint were removed from the samples but reapplied prior to the YCT incubation. In contrast, the absence of both wax and suint due to detergent scouring or solvent/aqueous extraction of the wool sample resulted in less yellow discolouration during the YCT (p = 0.24 and <0.05 respectively). This observation suggests that at least one of these components is necessary for the development of wool yellowing.

Removal of the two components individually showed that aqueous washing of the wool prior to YCT resulted in significantly less discolouration (p<0.1). However, solvent extraction of wax alone slightly increased yellowing of the samples (p = 0.37). These data support the hypothesis that suint is involved in the yellow discolouration of wool. This concurs with the findings of Wilkinson (1982), who found that the water wash (suint extract) from susceptible fleeces induced moderate fleece yellowing in otherwise resistant wool. This suggests the genetic basis of wool susceptibility may be due to variability in the nature of the suint from sweat glands present in the epidermis. Aitken *et al*. (1994) showed a correlation between potassium content and yellowing propensity. Potassium salts are the main excretion products of the suint gland (Cottle, 1996). The relative potassium salt concentration of suint associated with genetically susceptible and resistant wool is unknown.

The non-significant increase in wool yellowing after the removal of wax (p = 0.37) may suggest a protective role for wool wax with respect to fleece yellowing. This is in direct contrast to the observations of Wilkinson (1981a) who found that degreased wool had reduced colour development. Nonetheless, he supports the suggestion of wool grease affording protection to the wool fibre. Wilkinson (1981b) showed that susceptible fleeces are degreased in the field and suggests this makes them vulnerable to degradation and discolouration.

Suint may have a detergent action which helps to remove the protective wax layer when the fleece is wet, making the fleece more susceptible to bacterial attack. Hence it may be an interaction between the wax and suint that is responsible for fleece yellowing rather than the concentration of the component. Aitken *et al*. (1994) and

Wilkinson (1982) both showed that susceptible wool has a low wax/suint ratio.

When greasy wool from distinct Lincoln and Merino patches of chimaeric sheep were maintained under YCT conditions, both samples became yellow (7.3±1.5 and 6.5±1.1 respectively; $p = 0.45$). This finding was in contrast to the observation of Reid (1993) that the fine wool of Merino sheep has less propensity for discolouration compared with coarse Lincoln wool. In chimaeric sheep it would be expected that wax and suint glands, in addition to fibre characteristics, are distinct with breed patch. The finding that in chimaeras, Merino type wool yellowed to the same extent as Lincoln type wool supports the hypothesis that in the chimaeric fleece, wax and/or suint from the distinct wool patches become homogeneous throughout the fleece. During YCT, the effects of suint become apparent with uniform discolouration of both wool types. This supports the hypothesis that yellow discolouration is an effect of the fleece environment rather than the fibre itself.

CONCLUSIONS

Yellow discolouration of wool is an effect of the fleece environment rather than components of the wool fibre itself. There is clearly a role for suint in the susceptibility of wool to discolour. Further study is required to investigate differences in the structure of epidermal sweat glands and the elemental composition of their exudate between susceptible and resistant animals.

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REFERENCES

Aitken, F.J.; Cottle, D.J.; Reid, T.C.; 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.* **45:** 391-401.

Aliaga, J.L.; Sanderson, R.H.; Maher, A.P.; Reid, T.C. 1996. Optimising of the challenge test for the susceptibility of wool to yellow discolouration. *Proceedings of the New Zealand Society of Animal Production.* **56:** 319-323.

Cottle, D.J. 1996. Selection programs for fleece rot resistance in Merino sheep. *Australian Journal of Agricultural Research.* **47:** 1213-1233.

Daly, R.A; Carter, H.B. 1954. A method of fractionating raw fleece samples and some errors encountered in its use in experimental studies of fleece growth. *Australian Journal of Agricultural Research.* **4:** 327-344.

Raadsma, H.W.; Wilkinson, B.R. 1990. Fleece rot and body strike in Merino sheep IV. Experimental evaluation of traits relating to greasy wool colour for indirect selection against fleece rot. *Australian Journal of Agricultural Research.* **41:** 139-153.

Reid, T.C. 1993. Variability in the susceptibility of wool to yellowing. *Proceedings of the New Zealand Society of Animal Production.* **53:** 315-318.

Scobie, D. R.; O'Connell, D.; Baird, D. B. 1997. Chimaeras overcome the genotype X environment interaction. *Proceedings of the 1st International Meeting of Hair Research Societies*. In press.

Thornberry, K.J.; Kowal, E.A.B.; Atkins, K.D. 1980. Skin, wax and suint characters as possible indirect selection criteria. *Australian Society of Animal Production.* **13:** 95-99.

Wilkinson, B.R. 1981a. Studies on fleece yellowing. Part I: Prediction of susceptibility to yellow discolouration in greasy fleeces. *Wool Technology and Sheep Breeding.* **29:** 169-174.

Wilkinson, B.R. 1981b. Studies on fleece yellowing. Part II: A fleece component causing yellowing in greasy fleeces. *Wool Technology and Sheep Breeding.* **29:** 175-177.

Wilkinson, B.R. 1982. Yellowing in wool. *Wool.* **7:** 9-12.

Winder, L.M.; Baronian, K.; Webber, J.; Muller, B. 1998. Unravelling the causes of wool yellowing. Part II: Involvement of bacteria. *Proceedings of the New Zealand Society of Animal Production.* This volume.