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Variability in the susceptibility of wool to yellowing

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ABSTRACT

Clean wool colour is an important textile property affecting dyeing performance. Colour varies greatly between districts and seasons. For example, the average colour (Tristimulus Y minus Z) of full fleece crossbred wool sold at Dunedin between 1987/88 and 1991/92 was 2.95, while that of wool sold at Auckland was 5.74. Over all selling centres, the whitest wools were sold between August and October, and the yellowest in March. These district and seasonal patterns reflect the extent to which wool is challenged environmentally by high temperatures and humidity.

If wools are challenged by high temperatures and humidity post-harvest, apparently white wool is likely to become yellow, while yellow wool will discolour further. When fleece samples from Coopworth ewes and Merino wethers were challenged in the laboratory, mean clean colour (Y minus Z) changed from 3.30 to 7.45 for Coopworth fleeces and from 1.98 to 5.35 for Merinos. The colour change varied between individual fleeces within each breed.

Selection of sheep for breeding on the basis of the propensity of their wool to yellow in laboratory challenge should enable improvements in the colour of the New Zealand wool clip.

Keywords: Wool yellowness, Coopworth, Merino, environment, propensity.

INTRODUCTION

As the colour of clean wool is an important textile property affecting dyeing performance it is a major determinant of price (Maddever, *et al.*, 1991). In New Zealand the colour of wool is measured by a standard procedure (NZS8707:1984) which includes a thorough cleaning procedure to remove contaminants. Yellowness is expressed as the difference between the Y and Z tristimulus co-ordinates. Currently colour is measured on over 90% of greasy wool lots sold at auction in New Zealand (Hammersley, 1991).

Yellow discolouration develops in damp wool when it is exposed to high atmospheric temperatures and high humidity (Henderson, 1968). However, as demonstrated by Wilkinson (1981) and Wilkinson and Aitken (1985), fleeces differ in their propensity to develop yellow discolouration. Thus maximum yellow colour develops when sheep susceptible to yellowing are exposed to high temperature and humidity in the environment - ie an environmental challenge. As this environmental challenge is highest in summer, full fleece wools shorn in late summer and autumn tend to show greater yellow colour than those shorn in winter and spring. With the general trend of increasing mean temperatures and humidity from South to North in New Zealand, a corresponding increase in wool colour could be expected.

To improve their understanding of the problem of wool yellowing, Wilkinson (1981) and Raadsma and Wilkinson (1990) developed a laboratory test to differentiate fleeces on the basis of propensity to yellow. The test involved estimating the colour of an acetone extract of the yolk fraction after incubating wool for 5 d at 40°C and 100% humidity. An alternative test has since been developed (F.J.Aitken, unpublished data) in which wool is incubated for 14 d followed by measurement of the resulting wool colour. The latter procedure was used in this study.

The objectives of this paper are to review geographical and seasonal differences in the colour of wool sold at auction in New Zealand and to demonstrate potential differences in propensity to discolour in two groups of sheep. Seasonal and geographical comparisons of wool sold were made for full fleece crossbred wool. As Merino wool is sold almost exclusively through Christchurch, Timaru and Dunedin, in the three months September to November inclusive (NZWB 1992), no geographical or seasonal comparisons were possible for that breed type.

MATERIALS AND METHODS

In the first section of this paper, data for the yellowness (Tristimulus Y minus Z) of all full length crossbred type wool sold at auction for the years 1987/88 to 1991/92 inclusive were obtained from the New Zealand Wool Board database. The second section describes results of an experiment in which propensity to yellow was determined on samples from 30 Coopworth and 28 Merino fleeces.

Auction Data

Yellowness data were obtained from the New Zealand Wool Board database as the weighted (by clean weight) mean values of lots of full length crossbred fleece wool, summarised by month for each NZ selling centre between 1987/88 and 1991/92. From these data and the corresponding weights of wool, weighted mean values were calculated for each year, for each centre and for each month. To enable more detailed comparisons to be made, monthly weighted mean yellowness values over all years were calculated for two of the three centres at which most wool was sold - Napier and Dunedin. Invercargill was not included in the comparison as nearly 65% of the wool was sold over the three months December to February (NZWB 1992). Thus it was not possible to compare seasonal patterns of colour with those at other centres which have longer selling seasons.

Wool Samples

Fleeces from 28 Merino wethers from the Central Otago Merino Wether Trial (Cottle and Wilkinson, 1989) were collected at shearing in 1990 and stored frozen. Each fleece was randomly grab sampled as required.

Mid-side samples were collected from 30 Coopworth ewes at shearing in February 1992 at Lincoln University. These samples were processed in the laboratory within one month of collection.

Laboratory Challenge Procedure

Duplicate samples of approximately 10 g of greasy wool were prepared by removing the weathered tips and cutting the remainder into 2 cm snippets. These were incubated on a petri dish at 40°C and 100% humidity for 14 days. Each sample was moistened by spraying with water initially and then every alternate day, avoiding run off of excess water. The water used was saturated with thymol to prevent fungal growth.

Colour Measurement

The colour of wool before and after challenge was measured by the NZ Standard method (NZS8707:1984) using a Hunterlab DM25 colorimeter for the Merino fleeces and an ACS3 spectrophotometer for the Coopworth samples. Data obtained on the Hunterlab for the Merino samples were adjusted by regression analysis of the individual tristimulus values to be equivalent to data from the ACS spectrophotometer.

RESULTS

Auction Data

Napier, Dunedin and Invercargill are NZ's three major wool selling centres for full length crossbred wool, accounting for a total of 70% of this type of wool sold in NZ (Table 1a). The individual centres sold between 9 and 11 thousand tonnes per annum between 1987/88 and 1991/92. Overall there was a general trend of increasing yellowness from South to North. The wool sold at Dunedin showed the least discolouration (Y minus Z = 2.95), and Auckland, with less than 1,000 tonnes annually, the most discolouration (Y minus Z = 5.74). These changes reflect the general trend of increasing atmospheric temperatures and humidity from South to North in New Zealand.

There were differences in mean wool yellowness between years (Table 1b), presumably reflecting climatic differences between years. Data on the colour of wool has been available since 1984/85 (Hammersley, 1991). Changes in management and breeding since then could be expected to have reduced the incidence of yellow discolouration in the national flock. No such consistent trend towards lower yellowness was evident in the 5 years of data used in this study.

There was a distinct monthly pattern in the yellowness of wool sold (Fig. 1). This pattern was consistent between years. As no wool was sold in July in the South Island, no mean data for that month has been included. The wool with the least yellow discolouration was sold between August and October (mean Y minus Z = 2.80 to 2.85), while that with most colour was sold in March (mean Y minus Z = 4.84). The differences between major centres in the yellowness of wool is illustrated by Napier (mean Y minus Z = 3.99) and Dunedin (mean Y minus Z = 2.95). While the weighted mean colour of the wool sold at Napier was more than 1 Y minus Z unit higher than that at Dunedin, the monthly pattern of yellowness at these two centres was similar.

TABLE 1: Weight and weighted mean colour of full length Crossbred wool sold by auction in the years 1987/88 to 1991/92 inclusive.

a. By Centres.

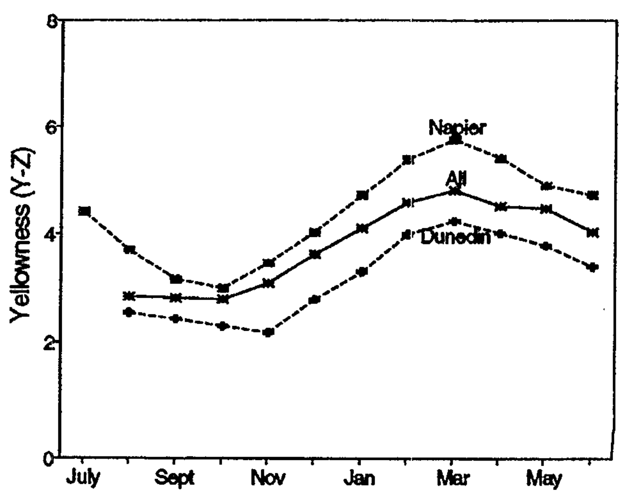
Centre	Weight of wool mean (t * 10³)	Colour (Y minus Z) mean	SD
Auckland	0.98	5.74	0.24
Napier	10.13	3.99	0.08
Wanganui	3.05	4.42	0.14
Wellington	1.80	3.87	0.18
Christchurch	3.29	3.80	0.13
Timaru	2.45	3.38	0.16
Dunedin	9.37	2.95	0.08
Invercargill	11.38	3.61	0.07

b. By Year

Year	Weight total (t * 10³)	Colour (Y minus Z) mean	SD
87/88	43.9	3.84	0.10
88/89	40.9	3.43	0.10
89/90	40.6	3.88	0.10
90/91	42.5	3.72	0.10
91/92	44.4	3.51	0.10

Source: New Zealand Wool Board database

FIGURE 1: Yellowness of full length Crossbred wool sold at auction at Napier and Dunedin compared with the mean of all selling centre for years 1987/88 to 1991/92 inclusive. Data presented as weighted means (by weight of each lot). From New Zealand Wool Board database.



Effect of Laboratory Challenge

Prior to incubation the apparent colour of Coopworth wool samples ranged from white to highly discoloured (Table 2a), while the Merino wool samples generally showed minimal discolouration (Table 2b). Individual fleeces changed colour to varying extents. The four fleeces of each breed which developed the least colour on incubation (ie. those most resistant to yellowing) changed colour by 2.8 Y minus Z units (Coopworth) and 1.0 Y minus Z unit (Merino). The four fleeces developing the greatest colour (ie. those most susceptible to yellowing) changed by 5.3 and 5.9 Y minus Z units for Coopworth and Merino fleeces respectively. While there was a moderate relationship between pre-challenge and post-challenge colour for Merino fleeces (Figure 2b), that for crossbred fleeces was low (Figure 2a). One extremely susceptible Coopworth fleece (Y minus Z after incubation = 18) had a marked influence on the apparent relationship between colour before and colour after challenge.

TABLE 2: Effect on yellowness of clean wool of incubation at 40°C, 100% humidity for 14 d. Yellowness expressed as the differences between Y and Z tristimulus values

a. Coopworth (n=30)	Mean	SD	Range
Before incubation	3.30	2.07	2.0 - 13.3
After incubation	7.45	2.44	4.3 - 18.1
Change in colour	4.14	1.13	2.2 - 6.8
Four most resistant fleeces:			
before incubation	2.18	0.20	2.0 - 2.5
after incubation	4.97	0.50	4.3 - 5.7
Four most susceptible fleeces:			
before incubation	6.52	4.18	2.7 - 13.3
after incubation	11.86	3.59	9.5 - 18.1
b. Merino (n=28)	**Mean**	**SD**	**Range**
Before incubation	2.02	0.88	-0.2 - 3.7
After incubation	5.40	2.67	1.4 - 13.2
Change in colour	3.38	2.06	0.5 - 9.9
Four most resistant fleeces:			
before incubation	0.96	0.76	-0.2 - 1.9
after incubation	1.91	0.35	1.4 - 2.4
Four most susceptible fleeces:			
before incubation	3.25	0.31	2.8 - 3.7
after incubation	9.71	2.05	8.3 - 13.2

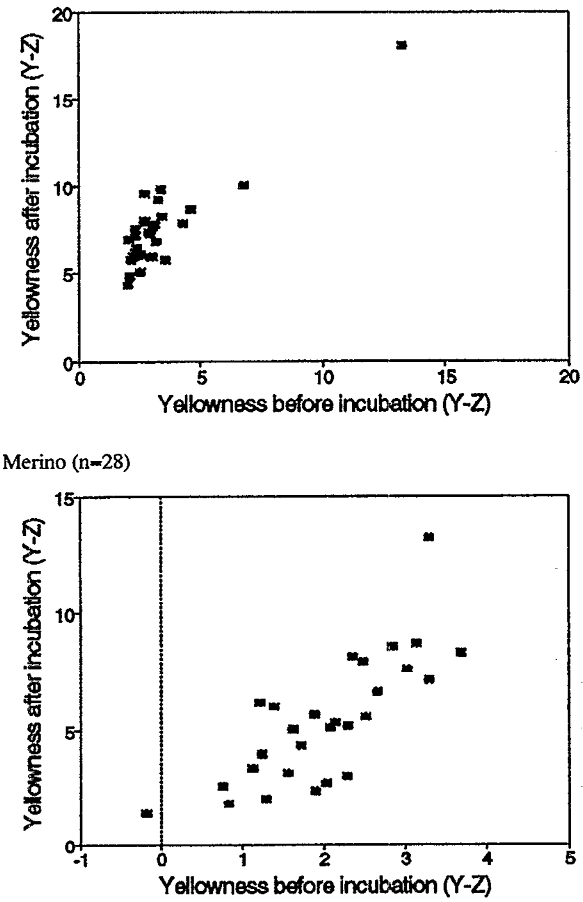
DISCUSSION

The geographical and seasonal variations in yellowness described here can be attributed to the extent to which the wool was challenged environmentally. High temperatures over summer combined with high humidity resulted in yellow discolouration, especially in full length fleeces. Wool sold in March and April would have been shorn in late summer after a period of challenge and would therefore show a high degree of yellow colour. Fleeces which were short over summer would have been challenged to a lesser extent and hence exhibit a lower degree of yellow discolouration than those which were long over summer. Such fleeces would be shorn in late winter and spring and sold between August and October.

FIGURE 2: Comparison of clean colour (Tristimulus Y minus Z) of fleeces before and after challenge at 40°C, 100% relative humidity for 14 days.

a) Coopworth (n=30)

b) Merino (n=28)



It is clear that there has been little change over the last 5 seasons in the colour of New Zealand crossbred wools (Table 1b, NZWB 1992). This is despite attempts to alter shearing dates to reduce the environmental influence causing yellowing of wool. The observations by Raadsma and Wilkinson (1990) and Wilkinson and Aitken (1985) that the propensity to yellow is heritable, suggest that selection for lower propensity to yellow is possible and may enable the production of better coloured wool while still shearing at a time suited to on-farm management. Wide ranges in the colour after challenge were evident in the Coopworth and Merino fleeces tested in the experiments reported in this paper. This reflects differences in the propensity to yellow within these groups of sheep, giving considerable scope for selection on that basis.

As susceptible wool which is not challenged environmentally will not develop yellow discolouration in the field, selection on the basis of apparent colour is difficult. Only after standard laboratory challenge is it possible to differentiate resistant and susceptible wools and allow selection to be made for decreased propensity to yellow.

Using the incubation technique to standardise the extent to which wool is challenged will allow selection of sheep with wool which has lower propensity to yellow. Little progress has been made in reducing the colour of New Zealand wool based on the colour measurements currently available. Selection and breeding for lower propensity to yellow may enable progress to be made in reducing wool colour.

Wool which is susceptible to discolouration may also change colour during storage and processing. Selection against propensity to yellow should reduce the tendency for such changes in wool colour.

Reductions in yellowness are likely to increase returns by 1.4% per Y minus Z unit, based on a price of $4.50 per kg clean wool for the seasons 1984/85 to 1989/90 (Maddever *et al.* 1991). In more recent seasons, as prices have declined further, the discount for colour has increased and discoloured wool is now difficult to sell.

Thus there is a financial incentive to produce white wool. In addition, wools with low propensity to yellow will change colour less during processing than susceptible wools. Selection for decreased propensity to yellow can therefore be expected to improve the processing performance of wool.

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