
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Relationship between wool colour and fibre diameter in four breeds of sheep

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ABSTRACT

Wool samples from 28 Merino wethers, 31 Corriedale ewes, 37 Perendale ewes and 30 Coopworth ewes were examined for propensity to develop yellow discolouration in relation to the mean fibre diameter and its variability.

The propensity of wool to develop yellow discolourations was estimated by two techniques, namely, an incubation technique which measures the colour developed in the wool fibre during a incubation in the laboratory, and the predictive technique described by Aitken *et al.*, 1994

Correlations between propensity to yellow (Y-Z) and mean fibre diameter were low in the Corriedale, Perendale and Coopworth samples, but high in the Merinos. Correlations between propensity to yellow and standard deviation of fibre diameter were also low in the Corriedales, Perendales and Coopworths, but moderate in the Merinos. The correlations between Y and Z and the fibre diameter statistics followed similar trends to those for Y-Z.

All correlations between propensity to yellow and coefficient of variation of fibre diameter were low.

Thus while the propensity to discolour during growth is positively related to fibre diameter in fine wool, no such relationship exists in medium and coarser wool. This provides a further reason for Merino breeders to produce a fine fleece type.

Keywords: Wool; Fibre diameter; Merino; Corriedale; Perendale; Coopworth; colour; propensity to yellow; yellowing.

INTRODUCTION

The ability of wool to dye consistently to a desired shade is a key attribute of processing performance. Dyeability is affected by the colour, particularly the degree of yellowness, of the scoured wool (Marler and Samuelsdorff, 1987; Whiteley *et al.*, 1987). Factors known to affect the yellowness of the raw wool are sheep management, the propensity of the wool to yellow (Reid, 1993; Wilkinson, 1981) and fleece architecture (Henderson, 1968). A key factor in fleece architecture is fibre diameter, which varies between and within different fleece types.

Fibre diameter itself is an important determinant of wool price, especially for fine wools which are produced by the Merino breed. In addition, there are discounts for yellow wool (Maddever *et al.*, 1991).

It has been proposed that selecting sheep for low propensity of their wool to develop yellow discolouration would assist in reducing the incidence of yellow discolouration in New Zealand wool (Reid, 1993; Wilkinson, 1981; Wilkinson and Aitken, 1985).

Propensity to yellow has been estimated by means of a predictive test first described by Wilkinson (1981) and later used by Aitken *et al.*, (1994), Raadsma and Wilkinson (1990) and Wilkinson and Aitken (1985). The test measures the intensity of colour extracted from the yolk of wool samples after incubation at 40°C and 100% relative humidity. Incubating wool under these conditions enhances the ability to differentiate wool with low propensity to develop yellow discolouration from susceptible wool.

This paper describes the relationships between colour measurements before and after incubation with statistics of fibre diameter in four breeds of sheep representing the major wool types produced in New Zealand.

MATERIALS AND METHODS

Wool samples

The wool samples were obtained from several different sources:

Merino

Twenty-eight full fleeces were collected at the final shearing of the Central Otago Merino Wether Trial (Cottle and Wilkinson, 1989). The fleeces were selected by stratified random sampling based on the appearance of the yolk layer of the fleece. The Merino and Corriedale fleeces were stored frozen and sub-sampled as required for laboratory testing.

Corriedale

Full fleeces from 31 mixed age ewes were collected at shearing in May 1992 from LandCorp Tirimoana, near Waipara in North Canterbury. The procedure used to select the samples was similar to that used for the Merino fleeces.

Perendale

Thirty-seven mid-side wool samples were obtained from Perendale ewes at Whatawhata Research Centre selected for and against loose wool bulk (Sumner *et al.*, 1991). The samples were collected at hogget shearing in October 1990. After being stored for two years in plastic bags in a laboratory, they were sub-sampled for use in this trial (Reid *et al.*, 1995).

Coopworth

Thirty mid-side samples were collected at random from the flock of mixed age Coopworth ewes at Lincoln University. The samples were collected at shearing in February 1992 and stored in the laboratory for approximately two months until required for testing.

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Incubation methods

Wool preparation

The preparation of wool was as described by Aitken et al. (1994). Samples of wool were prepared by removing the weathered tips and cutting the remainder into 2 cm snippets. Each sample was blended by hand before testing. Duplicate sub-samples of this prepared wool were used, except for the Perendale samples where there was sufficient for only one sub-sample to be tested.

All incubations were carried out at 40°C and 100% relative humidity, using water saturated with thymol to wet the wool. Two systems were tested for evaluating the response of the wool to incubation.

Predictive test

The predictive colour test used was described by Aitken *et al.*, (1994) and was similar to that described by Wilkinson and Aitken (1985). It involved incubating approximately 2.5 g of the prepared wool sample in a glass tube for 5 days. Water was added initially and on the third day. The coloured material developed in the yolk was then extracted in 61% acetone (63% for Merinos). The absorbance of the extract was then measured at 430 nm.

The colour extracted from the yolk of a second set of samples before incubation was measured using a similar technique.

Development of yellow discolouration in wool

The technique used was as described by Reid (1993). Samples of approximately 10 g of wool were incubated on petri dishes for 14 days. Each sample was moistened initially and every alternate day by spraying with water, avoiding run off of excess water. Preliminary tests had shown that under these conditions, colour development was complete after 14 days.

The colour of the wool was measured before and after incubation using the New Zealand Standard method (NZS 8707:1984). Because there was very little vegetable matter present the polyethylene glycol step was omitted. A Hunterlab D25M was used for the Merino samples and an ACS CS-3 spectrophotometer for the Corriedales, Perendales and Coopworths. Data obtained for the Merinos on the Hunterlab were adjusted by regression analysis of the individual tristimulus values to be equivalent to data from the ACS spectrophotometer.

Fibre diameter

Mean, standard deviation and coefficient of variation of fibre diameter of the Merino, Corriedale and Coopworth samples were measured using an Optical Fibre Diameter Analyser (OFDA) after colour measurement. The fibre diameter measurements were made on the Perendale samples using FFDA (Lynch and Michie, 1976).

RESULTS AND DISCUSSION

The incubation procedures used caused decreases in tristimulus Y and Z, and increases in tristimulus Y-Z (yellowness) and in the colour of the acetone extract of yolk (Table 1). In general there was also an increase in the standard deviations of all colour measured. The only exception to the increasing variation was for the Perendale samples, in which the standard deviation of Z was almost unchanged and that of Y-Z decreased with incubation. This difference in the response of Perendales to incubation may have resulted from colour changes occurring during storage (Reid *et al.*, 1995).

TABLE 1: Colour of wool samples measured before and after incubation at 40°C and 100% relative humidity for 14 days (fibre colour) or 5 days (predictive colour).

a. Fibre colour

Breed	n		Before incubation Mean	SD	After incubation Mean	SD
Merino	28	Y	76.2	1.2	72.0	3.8
		Z	74.2	1.8	66.6	6.4
		Y-Z	2.0	0.9	5.4	2.7
Corriedale	31	Y	73.6	1.3	69.5	2.1
		Z	70.3	1.2	60.5	4.4
		Y-Z	3.3	0.7	9.0	2.5
Perendale	37	Y	63.1	2.3	53.5	3.0
		Z	53.0	3.8	39.8	3.8
		Y-Z	10.1	2.1	13.7	1.3
Coopworth	30	Y	73.8	1.4	70.9	1.8
		Z	70.5	3.2	63.4	3.9
		Y-Z	3.3	2.1	7.4	2.5

b. Predictive colour (absorbance)

Breed	n	Before incubation Mean	SD	After incubation Mean	SD
Merino	28	0.09	0.07	0.35	0.21
Corriedale	31	0.23	0.04	0.50	0.15
Coopworth	30	0.36	0.11	0.85	0.15

The fibre diameter statistics are given in Table 2. The statistics in Tables 2b and 2c are calculated from the within-sheep standard deviations and coefficients of variation in fibre diameter. The Merino samples were collected from sheep grazing together and selected at random across approximately 30 originating flocks (Cottle and Wilkinson,

TABLE 2: Fibre diameter data for the wool samples from 4 breeds of sheep tested.

a. Mean fibre diameter

Breed	n	Mean	SD	CV	Range
Merino	28	23.6	2.5	10.7	18.7 - 27.4
Corriedale	31	31.0	2.0	6.6	27.4 - 36.5
Perendale	37	33.6	2.1	6.3	29.3 - 37.8
Coopworth	30	39.5	2.3	5.9	35.4 - 43.0

b. Standard deviation of fibre diameter

Breed	n	Mean	SD	CV	Range
Merino	28	4.9	0.7	14.8	3.7 - 6.6
Corriedale	31	6.2	0.8	13.0	4.9 - 8.8
Perendale	37	7.7	0.8	10.8	6.2 - 10.3
Coopworth	30	8.2	0.9	10.7	6.6 - 10.5

c. Coefficient of variation of fibre diameter

Breed	n	Mean	SD	CV	Range
Merino	28	20.5	1.6	7.9	17.6 - 24.9
Corriedale	31	20.0	2.1	10.4	16.9 - 24.5
Perendale	37	22.9	2.8	12.4	17.0 - 29.8
Coopworth	30	21.0	2.8	13.4	17.3 - 29.8

TABLE 3: Relationships of the colour of wool before and after incubation at 40°C and 100% relative humidity for 14 days with fibre diameter for four breeds of sheep.

a. Mean fibre diameter

Breed	n	Correlation coefficients	Y	Z	Y-Z
Merino	28	Before incubation	-0.54	-0.78	0.84
		After incubation	-0.70	-0.77	0.83
Corriedale	31	Before incubation	-0.26	-0.56	0.45
		After incubation	-0.20	-0.18	0.16
Perendale	37	Before incubation	-0.02	-0.02	0.01
		After incubation	0.24	0.20	-0.05
Coopworth	30	Before incubation	-0.33	-0.11	-0.06
		After incubation	-0.28	-0.11	-0.03

b. Standard deviation of fibre diameter

Breed	n	Correlation coefficients	Y	Z	Y-Z
Merino	28	Before incubation	-0.31	-0.55	0.68
		After incubation	-0.45	-0.54	0.63
Corriedale	31	Before incubation	-0.07	-0.37	0.49
		After incubation	-0.19	-0.14	0.09
Perendale	37	Before incubation	-0.17	-0.18	0.15
		After incubation	-0.03	-0.09	0.18
Coopworth	30	Before incubation	-0.26	-0.41	0.45
		After incubation	-0.23	-0.34	0.37

c. Coefficient of variation of fibre diameter

Breed	n	Correlation coefficients	Y	Z	Y-Z
Merino	28	Before incubation	0.15	-0.06	0.08
		After incubation	0.13	-0.06	0.03
Corriedale	31	Before incubation	0.09	-0.09	0.31
		After incubation	-0.07	-0.02	-0.02
Perendale	37	Before incubation	-0.14	-0.15	0.13
		After incubation	-0.17	-0.20	0.20
Coopworth	30	Before incubation	-0.05	-0.28	0.38
		After incubation	-0.04	-0.21	0.30

1989). They therefore represent a considerably wider range of fibre diameter (both mean and variation) than would normally be expected from any one flock. The values for the Coopworth, Corriedale and Perendale samples reflect the normal degree of within sheep variation in fibre diameter expected in any flock of these breeds.

In the Merinos, the correlations between mean fibre diameter and colour, representing estimates of the between flock relationships, were generally high to very high and very highly significant (Table 3a). The exception was the correlation with tristimulus Y before incubation, where the correlation was lower than for the Z or Y-Z. In this breed, the standard deviation of tristimulus Y before incubation was considerably lower than after incubation and lower than that for the other tristimulus values. The low correlation between mean fibre diameter and tristimulus Y in the Merinos may reflect this lack of variability in tristimulus Y before incubation.

Moderate to high correlations have been reported elsewhere between fibre diameter and yellowness of clean wool sampled on the basis of sale lots (Thompson, 1987; 1989; Whiteley *et al.*, 1980), with superfine Merino wool noted as being of exceptionally good colour (Whiteley *et al.*, 1983). Moderate between flock correlations have also been reported between fibre diameter statistics (mean, standard deviation and coefficient of variation) and the incidence or severity of fleece rot (Raadsma, 1993) and between colour score after incubation and mean fibre diameter (Raadsma and Wilkinson, 1990). Genetic variations between flocks in liability to fleece rot among 15 Merino strains was attributed largely to strain variations, with liability increasing from fine-wool to medium-wool to strong wool strains (Raadsma *et al.*, 1989).

The correlations between colour and mean fibre diameter were low both before and after incubation in the Coopworth, Corriedale and Perendale samples.

The correlations between the standard deviation of fibre diameter and colour were generally moderate in the Merinos and low in the other three breeds (Table 3b). When the variability in fibre diameter was expressed as the coefficient of variation, all correlations with colour were low (Table 3c). Although still low, the correlations in the Coopworths between variability of fibre diameter (viz standard deviation and coefficient of variation) and tristimulus Z and Y-Z were higher than those of mean fibre diameter with colour and several were statistically significant

The correlations of fibre diameter (mean and variability) with predictive colour showed similar trends to those between mean fibre diameter statistics and yellowness in the fibre (tristimulus Y-Z) (Table 4). A high correlation between mean fibre diameter and predictive colour has been reported previously in Merino samples from the same source as those used in this trial (Aitken *et al.*, 1994).

TABLE 4: Relationships of predictive colour with mean, standard deviation and coefficient of variation of fibre diameter in samples of wool from three breeds of sheep.

Breed	n	Correlation coefficients	Mean	SD	CV
Merino	28	Before incubation	0.28	0.29	0.14
		After incubation	0.65	0.55	0.12
Corriedale	31	Before incubation	0.16	0.07	-0.02
		After incubation	0.16	0.21	0.16
Coopworth	30	Before incubation	-0.21	0.15	0.21
		After incubation	-0.01	0.22	0.18

The effect of colour changes induced by incubation on the correlations observed was in general small. However, the correlations between yellowness (Y-Z) and fibre diameter (mean and standard deviation) in the Corriedales were significantly lower after incubation than before.

In the Merino samples there was a high correlation between the mean and standard deviation of fibre diameter. The correlations between colour and mean fibre diameter tended to be higher than those between colour and standard deviation. When the variability was corrected for the mean by being expressed as the coefficient of variation, the correlations with colour were low. This suggests that the primary relationship of colour is with the mean fibre diameter rather than with its variability.

While the range in fibre diameter in the Merinos examined in this trial was greater than would be expected with any one flock, this was not true for the other breeds. This range in values may have influenced the relationships observed for that breed. However, the ranges in mean fibre diameter and the means of the within-sheep coefficients of variation of fibre diameter were similar in all four breeds. The low correlations between mean fibre diameter and colour in the Corriedales, Perendales and Coopworths contrast with the findings in the Merinos. This suggests that the relationships between measures of colour and fibre diameter are different in Merinos than in the other three breeds.

Because fibre diameter is the major determinant of price in fine wool (Maddever *et al.*, 1991), selection for decreased fibre diameter is an important criterion for Merino breeders. The results of this trial indicate that propensity to discolour during growth is positively correlated to fibre diameter in Merinos. This provides further impetus for Merino breeders to include finer fibre diameter among their selection criteria.

ACKNOWLEDGMENTS

The wool yellowing studies reported in this paper were conducted as part of a Wools of New Zealand, Lincoln University jointly funded research programme in the Department of Wool Science. The concepts of propensity to yellow were developed by B.R. Wilkinson and F.J. Aitken, Department of Wool Science, whose help and input were valuable to the Wool Yellowing Project. The samples of Perendale wool and the related fibre diameter data were supplied by R.M.W. Sumner, Whatawhata Research Centre. A. Smith, C. Nesbit and the Lincoln University farm staff are thanked for allowing access to their stock at shearing and the purchase of the wool used in these studies. Kerri Mann, Department of Wool Science carried out the OFDA analyses.

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