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ESTIMATES OF HERITABILITY FOR COLOUR CIE a* MEASUREMENTS AT FOUR TIME POINTS FOR CHILL AGED LAMB

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SUMMARY

This paper investigates genetic control of redness for 8 week chill aged lamb. Heritability of CIE a* values (Commission Internationale de l' Eclairage, 1976, a measure of redness) has been estimated from 18,913 carcasses of crossbred lambs born 2003-2010. Colour was recorded at 24, 48, 96 and 168 hours post display wrapping. Heritability estimates for the combined dataset were 0.55±0.03, 0.57±0.03, 0.58±0.03 and 0.29±0.03 respectively for the 4 time points, indicating that the colour of chill aged lamb loins is under moderate genetic control.

INTRODUCTION

More than 90% of New Zealand lamb is exported as chilled product. Predicting and controlling shelf life of this product is of crucial importance. Colour stability of lamb meat entering the fresh retail market is a primary factor in determining retail shelf life. The colour of the meat when on retail display is a major selection criterion for purchasers (Killinger *et al.* 2004; Savell *et al.* 1989) with the majority of consumers preferring bright red coloured meat which they associate with freshness (Killinger *et al.* 2004).

Data from a number of industry progeny tests, spanning multiple years, were available to investigate genetic variation in colour stability of New Zealand lamb**.** This paper investigates the role of genetics at 4 time points of long term chilled pasture-fed lamb. In addition, we investigate the role that genetics plays expanding on work completed by Campbell *et al.* (2004, unpublished) and Johnson *et al.* (2007, unpublished).

MATERIALS AND METHODS

Eight week colour stability data was available from the *M. longissimus dorsi* (loin) on 18,913, 2003-2010 born lambs from 1075 sires. Lambs were sourced from a number of industry progeny tests, with the majority of lambs sourced from the Beef + Lamb New Zealand Central Progeny Test (McLean *et al.* 2006) and the Rissington Breedline Primera Progeny Test (Johnson *et al.* 2007, McLean *et al.* 2009). Mixtures of terminal and dual-purpose sires were used to generate progeny. Lambs were slaughtered in commercial plants with the carcasses electrically stimulated. One day post slaughter the carcasses were processed into primal cuts. The boneless loins were vacuum packed and stored at -1°C for 8 weeks.

At 8 weeks, pH was measured on the loin. Three 2cm thick slices (avoiding the ends) of the loin were placed on small plastic trays and wrapped using semi permeable cling film to replicate supermarket conditions (no gas flushing). These were stored at 4°C. Meat colour was measured using a Minolta Chromameter (Konica Minolta Sensing, Inc., Osaka Japan) with the CIE L* a* b* system (which measures relative lightness, redness and yellowness respectively) at 24, 48, 96 and 168 hours post display wrapping, using. One measurement was taken from each of the three slices with the average of these values recorded in the Sheep Improvement Limited (SIL) database. The primary measure of interest was CIE a* which is the objective measure of redness/brownness most correlated with consumers subjective measures of colour acceptability (Moore & Young, 1991). From the 2007 born animals onwards, a change in facility (new processing room and chillers for storage and display) in which the measurements were made was the only alteration in protocol.

Variance components were estimated using restricted maximum likelihood (REML) procedures fitting an animal model in ASREML3 (Gilmour *et al.* 2009). Univariate analyses were used to estimate the heritability for each trait. Genetic variation of CIE a* measured 24, 48, 96 and 168 hours after processing for lamb loins that were chill aged was estimated. Birth rearing rank, age of dam and contemporary group were fitted as fixed effects, live weight at 6 months of age and pH as covariates, and animal as a random effect. An interaction between sex, birth flock and contemporary group was also fitted as a fixed effect. For the analysis of data spanning multiple years, birth year was fitted as a fixed effect.

Table 1. Summary of colour CIE a* of chill aged lamb loin records collected on 2003-2010 born lambs

			24 Hour		48 Hour		96 Hour		168 Hour	
Year	Records	Sires	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2003	1155	118	22.76	1.89	20.91	1.82	18.23	1.87	14.69	2.09
2004[a]	2241	117	19.98	1.45	18.04	1.38	15.35	1.37	NA[b]	NA
2005	2216	106	21.98	1.73	20.84	1.71	18.79	1.71	16.82	1.83
2006	2170	135	22.96	1.71	22.05	1.62	20.68	1.56	18.77	1.75
2007	1062	66	19.53	1.91	18.89	1.62	17.36	1.46	15.77	1.38
2008	2629	157	17.91	1.39	16.41	1.38	14.03	1.65	12.52	1.54
2009	3187	164	16.47	1.78	14.4	1.66	12.52	1.92	10.02	1.81
2010	4253	235	16.21	1.97	14.56	1.73	12.08	1.69	10.24	2.08
All Years	18913	1075	18.97	3.14	17.45	3.32	15.26	3.49	15.66	3.65

[a]2004 data affected post slaughter by inadequate refrigeration, [b]NA=Not Available

RESULTS AND DISCUSSION

Narrow sense heritability estimated for each birth year from 2003-2010 and for the combined data are shown in Figure 1. The greatest variation in estimated heritability was at 96 hours. At this time point the greatest estimates of heritability 0.55±0.06 and 0.58±0.03 were observed in the 2009 and 'all years' data respectively. Two thirds of heritability estimates were greater than 0.2 with the exception of years 2004 and 2007. Heritability was significant ($p<0.05$) for all values except for 2007 at 48, 96 and 168 hours. This is likely to be a result of reduced sampling with only 66 sires in 2007 (Table 1)

Current literature contains very few estimates of heritability for meat quality traits in sheep, as noted in Hopkins *et al.* (2011) in their update of the extensive review of Safari *et al.* (2003). Heritability of CIE a* in Merino has been reported as 0.10±0.03 (Greef *et al.* 2008) and has also been reported to not be significantly different from zero (Fogarty *et al.* 2003, Cloete *et al.* 2008). In Scottish Black Face it is reported as 0.45±0.19 (Karamichou *et al.* 2006). A heritability of 0.19 was reported for a Central Progeny Test (CPT) subset of the data used in this analysis (Payne *et al.* 2009). A Rissington Breedline Progeny Test subset reported an estimated heritability for CIE a* at 168 hours among Suffolk, White Suffolk and Poll Dorset to be 0.26±0.04 (McLean *et al.*, 2009). Mortimer *et al.* (2011) present results for a* from 3328 animals of various breeds in the Information Nucleus program of the CRC for Sheep Industry Innovation. One, 2 and 3 day values are reported as 0.18±0.04, 0.23±0.04 and 0.20±0.04 respectively. Other than merino, the reported values are in the same range as those reported in this paper.

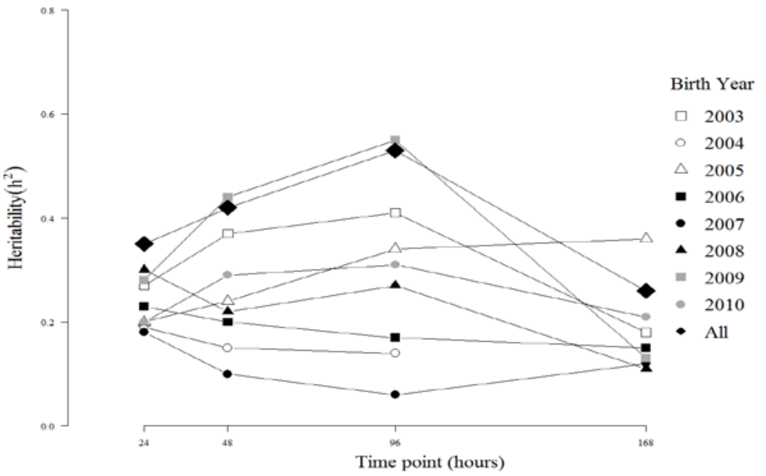

Figure 1. Heritability estimates of colour CIE a* of chill aged lamb loin at 24, 48, 96 and 168 hours after further processing by Birth Year and for the combined data.

Data in the initial year of collection was for a greater number of time points, every 24 hours until 90% of samples fell below CIE a* = 16 (Figure 2. dashed line). Subsequent data collection was terminated at 168 hours where 75% of the samples had fallen below the value of 16. In 2005, 2006 and 2007 less than 75% of the samples fell below this threshold.

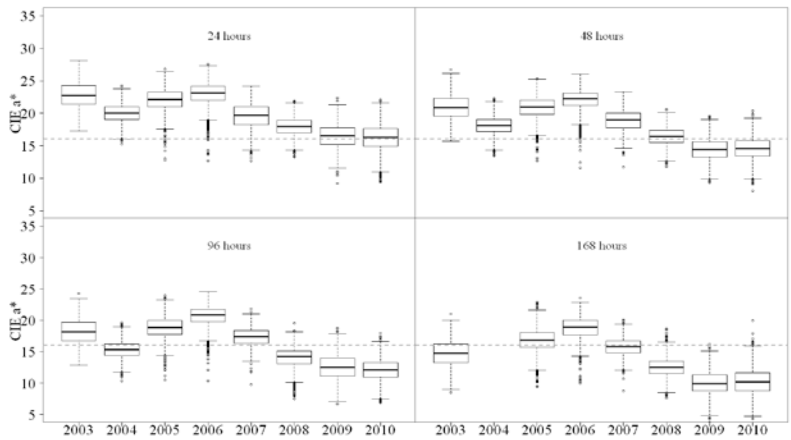

Figure 2. Variation of CIE a* values at 4 time points by each year of data collection. Dashed horizontal line is CIE a* = 16.

From 2008 (birth year 2007) new facilities were used for data collection and there are marked differences in the datasets from this year on, see Figure 2. Almost half of the samples are now below the original lower limit of 16 by 24 hours, making analysis of time to 16 somewhat difficult or redundant. In the 2004 born cohort there is also a notable decrease in initial colour values. This was attributed to the storage temperature not being maintained at -1°C early post slaughter. This has an effect in the All Years mean values in Table 1. Excluding 2004 would see an increase in values. However, even within a facility there is significant variation between years and between flocks within year (significant in the linear model analysis). This would suggest that un-known pre-slaughter factors and storage facilities are also important in determining the colour stability of chill aged lamb loins.

Ultimately the objective of the colour analysis was to determine whether or not redness of chill aged lamb loins is under genetic control, and as such can be used as a selection criterion to enhance the shelf life of the product. The heritability estimates do suggest that the redness of chill aged lamb loins is under moderate genetic control. There is interest by some overseas supermarkets in genetic selection for colour stability of redness, however, financial rewards are not currently offered to commercial producers. Despite the lack of financial rewards some breeders are using breeding values generated from this data set to exclude outliers with poor colour stability breeding values from their breeding programme in the aim of producing premium product for future market differentiation. Further analysis will investigate the genetic correlations between colour measurements and other meat quality and production traits.

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