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BRIEF COMMUNICATION: Genetic parameters for colour stability of chilled lamb

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Keywords: colour stability; heritability; lamb; meat quality.

INTRODUCTION

An increasing proportion of New Zealand lamb meat is shipped to the European Union market as chilled rather than frozen product, with 29% exported as chilled product in 2005/06 (Meat and Wool New Zealand, 2006). New Zealand's lamb export markets are located such that the chilled product travels large geographical distances via freighted shipping, taking six to twelve weeks to reach the destination. Once chilled lambs arrives at its destination it is further processed and packaged to specification for retail sale. Shelf life and colour stability are particularly important for this chilled product market, as signalled by United Kingdom retail companies to New Zealand processing companies (A. Charteris, Unpublished data). Consumers use meat colour as a first impression of the product and associate bright red meat with meat freshness (Killinger *et al.*, 2004). Shelf life of lamb can be improved through many after slaughter and chilling methods (Moore & Young, 1991), however there are also opportunities to achieve longer shelf life through genetics (Johnson *et al.*, 2008).

A multi-year study has been undertaken since 2003 to determine the role that genetics plays in influencing colour stability of chilled aged New Zealand lamb and any interactions that genetic selection for colour stability may have on other meat quality and meat production traits of importance.

MATERIALS AND METHODS

A total of 7,372 lambs born in 2003, 2005, 2006 and 2007 from a progeny test of composite breed sires of the Suffolk, White Suffolk and Poll Dorset breeds were used. All progeny born within each year were grown out in the same environment and slaughtered on one day at approximately five months of age. Lambs were slaughtered through the same commercial plant in 2004, 2006 and 2008, with a different plant used in 2007. The carcasses were electrically stimulated and aged following accelerated conditioning and aging criteria (Chrystall *et al.*, 1989). The day following slaughter the carcasses were weighed and one loin cut (*M. longissimus dorsi*) with silver skin on, was collected to investigate colour stability, tenderness and pH. The boneless loin was weighed, cut in half and vacuum packed with one half stored at -1°C for eight weeks, in line with standard exported chilled

product specifications, to investigate colour stability. The other half was stored frozen at -20°C to measure tenderness. At eight weeks, the chilled loin was removed from the vacuum pack and three pH measurements taken across the muscle and averaged. The loin was cut into three 2 cm thick slices in preparation for colour stability measurements. The cuts were placed on plastic trays with the fresh surface face up and then wrapped in an oxygen permeable film wrap and stored at 4°C. Colour was measured using a Minolta chromameter using the CIE L*, a*, b* scale at two hours after wrapping to capture the initial bloom, and then every twenty four hours from when the sample was first prepared, for a period of 216 hours (9 days). The average value across the three slices at each time was used in subsequent data analyses.

Tenderness was measured using a MIRNZ tenderometer. Loins were thawed to 4°C and cooked following the protocol of Graafhius *et al.* (1991). Tenderometer readings were converted into kg shear force using the following equation:

$$\text{Shear force (kgF)} = (0.2 \times \text{Tenderometer reading (Kpa)} - 1.9).$$

Genetic parameters were estimated using ASREML (Gilmour, 2006) fitting an animal model with animal fitted as a random effect. The model included direct effects of year and sex, with carcass weight fitted as a covariate for all models, excluding models containing carcass weight as a variate. The output from this analysis was used to calculate direct heritability ($\text{Var}_{\text{animal}}/\text{Var}_{\text{total}}$). Multivariate analysis was carried out in REML to estimate genetic correlations between the traits.

RESULTS

Only heritabilities of colour measurements of CIE L*, CIE a* and CIE b* made at 168 hours (7 days), are reported in this paper as an estimate of genetic variability in colour stability after 8 weeks chilled storage. Genetic correlations between the colour measurements and carcass weight, boneless loin weight and meat quality measures including pH and tenderness are given in Table 1.

Heritabilities ranged between 0.20 and 0.26 for CIE colour measurements at 168 hours. Genetic correlations between the measures of CIE L*, CIE a* and CIE b* were all positive and significant with the exception of the genetic correlation between CIE

TABLE 1: Heritability estimates \pm standard error for measures of CIE L*, CIE a* and CIE b* made on slices of lamb *M. longissimus* muscle cut after eight weeks chilled storage and 168 hours after cutting, of the whole muscle and genetic correlations \pm standard error between the colour measurements and carcass weight, loin weight, loin pH and loin tenderness.

Trait	CIE L*	CIE a*	CIE b*
Heritability	0.23 \pm 0.04	0.26 \pm 0.04	0.20 \pm 0.03
Genetic correlation			
CIE a*	0.12 \pm 0.01		
CIE b*	0.60 \pm 0.01	0.15 \pm 0.11	
Carcass weight	-0.30 \pm 0.13	0.13 \pm 0.13	-0.25 \pm 0.14
Boneless loin weight	0.00 \pm 0.00	0.01 \pm 0.10	0.24 \pm 0.10
pH	-0.46 \pm 0.09	-0.16 \pm 0.11	-0.71 \pm 0.07
Tenderness	-0.19 \pm 0.12	0.08 \pm 0.12	-0.20 \pm 0.13

a* and CIE b* which was not significant. Genetic correlations between the colour measurements and pH were negative, although only significant for CIE L* and CIE b*. The genetic correlation between tenderness and the colour measurements was negative and significant for CIE b* and trended towards being negative for CIE L*. Genetic correlations between carcass weight and CIE L* were negative and significant, the negative relationship between carcass weight and CIE b* only approached significance. There was a significant genetic correlation between carcass weight, adjusted boneless loin weight and CIE b*. There were no significant or trending genetic correlations between CIE a* and any of the production or quality measurements collected.

DISCUSSION

The main colour measurement of interest is CIE a* which represents the degree of redness, with redness highly correlated with consumers subjective measurement of colour acceptability (Moore & Young, 1991). In this study all measures of colour on loins displayed after eight weeks chilled storage had a moderate heritability. No other studies have considered the heritability of colour on aged loin slices similar to this. Other studies in lamb, where estimates of heritability are made on CIE a* on meat allowed to bloom for a short period of less than one hour on the day following slaughter, have had a comparable heritability for CIE L* (0.04 to 0.23), but a lower heritability for CIE a* (0.02 to 0.10) and CIE b* (0.02 to 0.10) (Greeff *et al.*, 2008; Ingham *et al.*, 2007; Safari *et al.*, 2005), the differences in CIE a* may be due to a reduced variability in CIE a* after only a short period of blooming as in the other reported trials.

That there were no significant genetic correlations between colour CIE a* and either meat quality or production trait means that genetic selection pressure in this population can be placed

on colour stability of CIE a*, to improve display life of chilled meat, without impacting on other important meat quality and production traits. Conversely, selection pressure on other meat production and quality traits will not negatively impact the colour stability of CIE a*.

It is unlikely that selection based on CIE L* or CIE b* as independent traits will occur as they play a lesser role in the visual appearance of lamb meat. However, the negative genetic correlations between carcass weight with CIE L* and CIE b* means that any selection for growth rate, which in this study was expressed as increased carcass weight at a fixed slaughter time, would lead to lower CIE L* and CIE b* values. Selection for growth in some pig lines has resulted in deterioration in muscle colour (Oksbjerg *et al.*, 2000). Selection for increasing muscling, independent of growth, is unlikely to have any impact on any of the colour measures.

Whether these relationships are true across all sheep populations requires further investigation as this study is limited to one composite breed. Factors that may influence the relationships include breed type as maternal versus terminal sire, and different genetic lines within breeds, as the proportion of the different muscle fibre types and relativity between hypertrophy and hyperplasia in obtaining the muscle varies. These variations may impact on meat colour.

CONCLUSION

These results indicate that colour stability of lamb based on CIE a* can be improved through genetic selection. The low genetic correlations between CIE a* and both production and quality traits means that concurrent selection can successfully be made to improve colour stability and production traits. Non-inclusion of CIE a* will not detrimentally affect colour stability in the population assessed.

ACKNOWLEDGEMENTS

This work was funded by Ovita. Rissington Breedline Limited owned and carried out the progeny test which generated the lambs used in this study. The authors acknowledge the staff at PPCS Takapau and AFFCO Wanganui.

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