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HERITABILITY ESTIMATES FOR RETAIL COLOUR STABILITY OF LAMB MEAT

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SUMMARY

Data from progeny of the Information Nucleus program of the CRC for Sheep Industry Innovation, born between 2007 and 2009, were used to estimate genetic parameters for measures of lamb meat colour stability recorded during 3 days of simulated retail display. Initial values of oxy:met (a measure of browning of meat) and *a** (meat redness) had a slightly lower heritability (0.15 ± 0.04 for oxy:met and 0.08 ± 0.03 for *a**) than measurements taken over each of the following 3 days, but overall the estimates tended to be moderate in size (for values at day 2, heritabilities of 0.27 ± 0.05 for oxy:met and 0.23 ± 0.04 for *a**). Genetic correlations among the initial and daily values for both oxy:met and *a** were all strong and positive (estimates all greater than 0.5), with the estimates among values taken on days 1, 2 and 3 approaching 1.0. There is potential for genetic improvement of lamb meat colour stability during retail display.

INTRODUCTION

Retail meat colour is important both for consumers, who use it as a cue to assess the quality and freshness of red meat, and retailers, for whom meat discolouration reduces the display life of retail cuts and their subsequent value (Khiliji *et al*. 2010). Although standard definitions of colour stability during retail display are not available (Jacob *et al*. 2011), objective colour measures of meat redness and browning of lamb meat have been calibrated to consumer acceptance scores and acceptability benchmarks established (Khiliji *et al*. 2010). Early evidence indicates that genetic variation exists for both initial colour of displayed red meat (King *et al*. 2010) and colour stability during display (McLean *et al*. 2009; King *et al*. 2010, Mortimer *et al*. 2010). This study presents heritability estimates for retail colour stability traits of Australian lamb recorded during 3 days of simulated retail display and the genetic relationships among these traits.

MATERIALS AND METHODS

Data were available from animals generated by the Information Nucleus (IN) program of the CRC for Sheep Industry Innovation, described by van der Werf *et al*. (2010). For this study, records were used from 3328 animals born between 2007 and 2009 at 5 IN sites (Cowra, Trangie, Hamilton, Rutherglen and Katanning), progeny of 266 sires of various breeds. The protocol that measured meat colour during simulated retail display of samples taken from each animal and the calculation of the oxymyoglobin:metmyoglobin (oxy:met) parameter have been presented by Jacob *et al*. (2011), with slaughter procedures for the animals described by Mortimer *et al*. (2010). Briefly, a 5 cm sample, taken from the cranial end of the short loin (*m. longissimus lumborum*)

from each animal at slaughter, was vacuum packed and aged for 5 days. The sample then had a fresh surface cut on it after 5 days and was placed individually on a black foam tray and over wrapped with PVC food film wrap (15 μm). After blooming (a period of 30 minutes), initial colour values were measured with a Hunter Laboratory meter (Models 45/0-L). Samples were displayed in a chiller at 2–6°C under lighting (1000 lux) and measured once a day over 3 days. Each sample was measured twice at each time point and the two values were averaged for analysis. Oxy:met was calculated as the percentage of light reflectance at wavelength 630 nm to the percentage of light reflectance at wavelength 580 nm. Relative redness (a^*) of each sample was measured also at each time point.

Variance and covariance estimation was performed using ASReml (Gilmour *et al*. 2009). Univariate analyses were used to estimate heritabilities for each single day measurement. Fitted models included fixed effects of site, year of birth, slaughter group, sire breed, dam breed, sex, birth-rearing type and age of dam, together with significant interactions. Age of the lamb at slaughter, hot carcass weight and meat ultimate pH were fitted as covariates. Random terms consisted of effects for animal and genetic group. Bivariate analyses were used to estimate genetic and phenotypic correlations among the retail meat colour measured on different days. Traits analysed were oxy:met and *a** measured at day 0 (RCR0, RC*a**0), 1 (RCR1, RC*a**1,), 2 (RCR2, RC*a**2) and 3 (RCR3, RC*a**3). As the largest daily change in oxy:met values occurred most often between days 0 and 1 and the data could be categorised as having either a positive or negative change during this period (Jacob *et al*. 2011), the difference between day 1 and day 0 values (RCRΔ) was also analysed. Summary statistics for each trait are presented in Table 1. Average oxy:met value was 5.31 at initial reading, with average values of 4.35, 3.49 and 3.07 at days 1, 2 and 3. Average *a** values were 16.91 initially and 18.16, 16.50 and 15.51 at days 1, 2, and 3.

Table 1. Summary statistics for oxy:met and *a values at day 0 (RCR0, RC*a**0), 1 (RCR1, RC*a**1), 2 (RCR2, RC*a**2) and 3 (RCR3, RC*a**3) and difference in oxy:met between days 1 and 0 (RCRΔ)**

Trait	Records	Mean	(s.d.)	Minimum	Maximum
RCR0	3327	5.31	0.96	2.30	9.97
RCR1	3328	4.35	1.19	2.00	12.33
RCR2	3328	3.49	0.83	2.00	9.93
RCR3	3195	3.07	0.75	1.70	8.05
RCRΔ	3327	-0.96	1.44	-5.48	6.62
RC*a**0	3327	16.91	2.19	5.97	27.35
RC*a**1	3328	18.16	2.84	10.43	29.96
RC*a**2	3328	16.50	2.39	9.91	27.65
RC*a**3	3195	15.51	2.29	6.75	27.00

RESULTS

Estimates of phenotypic variance and heritability for the colour stability traits at different times during simulated retail display, and their phenotypic and genetic correlations, are presented in Tables 2 and 3. Oxy:met at each time point showed a moderate heritability, with the highest estimate for day 2 (0.27 ± 0.05). The difference in oxy:met between days 1 and 0 had a low heritability (0.11 ± 0.04). *a** had low heritability initially, but heritability increased for later time points (highest estimate at day 2 of 0.23 ± 0.04). Among the different time points, genetic correlation estimates among the oxy:met and *a** values were all positive and high. Estimates involving oxy:met and a* at day 0 were lower (ranges of 0.52 to 0.64 and 0.76 to 0.85) than genetic correlations among values measured on days 1, 2 and 3 (estimates of about 1.00). The corresponding phenotypic correlations followed a similar pattern, but were slightly weaker. The

difference in oxy:met between days 1 and 0 had negative genetic (-0.19 ± 0.21) and phenotypic correlations with the value at day 0. In contrast, oxy:met measured at the later days all had strong positive genetic correlations (range of 0.63 to 0.71) with the difference in oxy:met between days 1 and 0. Genetic correlations of oxy:met at each time point with a* values at the initial daily measurements were all positive and strong.

Table 2. Estimates of phenotypic variance, heritability and correlations (genetic correlations below the diagonal, phenotypic correlations above the diagonal), and their standard errors, for oxy:met values at day 0 (RCR0), 1 (RCR1), 2 (RCR2) and 3 (RCR3) and difference in oxy:met between days 1 and 0 (RCRΔ)

	RCR0	RCR1	RCR2	RCR3	RCRΔ
Phenotypic variances					
	0.41 (0.1)	0.61(0.02)	0.34 (0.01)	0.25 (0.01)	0.61 (0.02)
Heritability estimates					
	0.15 (0.04)	0.16 (0.04)	0.27 (0.05)	0.20 (0.04)	0.11 (0.04)
Correlation estimates					
RCR0		0.41 (0.01)	0.36 (0.02)	0.31 (0.02)	-0.41 (0.02)
RCR1	0.64 (0.13)		0.82 (0.01)	NC	0.66 (0.01)
RCR2	0.60 (0.12)	0.99 (0.02)		0.86 (0.00)	0.52 (0.01)
RCR3	0.52 (0.15)	NC[A]	0.98 (0.02)		0.51 (0.01)
RCRΔ	-0.19 (0.21)	0.63 (0.13)	0.66 (0.12)	0.71 (0.12)	

[A]NC, not converged.

Table 3. Estimates of phenotypic variance, heritability and correlations (genetic correlations below the diagonal, phenotypic correlations above the diagonal), and their standard errors, for meat redness values at day 0 (RC*a0), 1 (RC*a**1), 2 (RC*a**2) and 3 (RC*a**3)**

	RC*a**0	RC*a**1	RC*a**2	RC*a**3
Phenotypic variances				
	1.76 (0.04)	3.33 (0.09)	2.40 (0.06)	2.04 (0.05)
Heritability estimates				
	0.08 (0.03)	0.18 (0.04)	0.23 (0.04)	0.20 (0.04)
Correlation estimates				
RC*a**0		0.58 (0.01)	0.51 (0.01)	0.45 (0.01)
RC*a**1	0.85 (0.09)		0.83 (0.01)	0.76 (0.01)
RC*a**2	0.76 (0.11)	1.00 (0.02)		0.85 (0.01)
RC*a**3	0.77 (0.13)	0.99 (0.03)	0.98 (0.02)	
RCR0	0.94 (0.04)	0.60 (0.13)	0.60 (0.13)	0.58 (0.14)
RCR1	0.82 (0.12)	0.98(0.01)	0.97 (0.03)	0.99 (0.04)
RCR2	0.74 (0.12)	0.97 (0.03)	0.99 (0.01)	0.94 (0.03)
RCR3	0.71 (0.14)	NC[A]	0.99 (0.02)	0.98 (0.01)
RCRΔ	0.10 (0.25)	0.64 (0.13)	0.65 (0.14)	0.64 (0.14)

[A]NC, not converged.

DISCUSSION

The colour stability traits of lamb examined in this study had moderate heritability. This indicates that selection can alter retail meat colour stability and likely result in lamb that is less susceptible to browning during retail display. This finding was consistent with an estimate of 0.26 for *a** value of lamb loins chilled for 8 weeks and displayed for 7 days as reported by McLean *et al*. (2009). Heritability estimates for oxy:met and *a** value at day 2 were consistent with estimates

reported by Mortimer *et al*. (2010), which were based on a subset of the data used in the present study. Heritability estimates were slightly higher at day 2, providing some support to the conclusion of King *et al*. (2010) that maintenance of meat colour stability may be under greater genetic influence than the initial colour. This conclusion was based on a study of meat colour of beef steaks, where King *et al*. (2010) reported a lower heritability estimate for *a** at day 0 than at day 6 of display, but these estimates had large standard errors. The difference in oxy:met between days 1 and 0 also was moderately heritable, indicating that genetic improvement of meat colour difference during retail display is feasible. For aged meat, average consumers have been shown to consider lamb meat to be of acceptable colour (i.e. red rather than brown) when oxy:met value is at least 3.3 or greater and the *a** value is not less than 14.8 (Khiliji *et al*. 2010). Based on these thresholds, only approximately 83%, 52% and 32% of lamb samples in the present study were above the threshold for oxy:met after 1, 2 and 3 days of simulated retail display and therefore likely to be of acceptable colour. Around day 2 of retail display is often the point at which retailers apply discounts to meat to promote sales and avoid loss of sales due to its discolouration. This emphasises the need to improve lamb meat colour stability during retail display and extend its shelf life.

This study has shown that it is possible to implement improvement of retail colour stability of lamb in breeding programs. Very high correlations between oxy:met and *a** values at different time points suggest that improvement can be based on a single measurement on any of these days. Further information is needed on the genetic relationships of the colour stability traits with meat production and other meat quality traits, including other fresh and retail colour traits. Estimates of such correlations will come from further analyses of data generated by progeny of the IN program. Based on such parameters, an assessment can be made of the predicted change in retail colour in current breeding programs and if there is a need to measure this trait to achieve improvement in lamb meat in the desired direction. McLean *et al*. (2009) concluded for New Zealand lamb that it was possible to simultaneously improve meat production and retail colour stability (based on the *a** measure) in the breeding program.

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