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PRELIMINARY GENETIC CORRELATIONS OF MERINO MEAT COLOUR TRAITS WITH LEAN MEAT YIELD AND EATING QUALITY

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SUMMARY

Genetic correlations were estimated among retail colour stability and fresh meat colour traits assessed on Merino lamb loins, as well as genetic correlations of the colour traits with lean meat yield and objective eating quality traits of intramuscular fat and shear force. The meat colour traits were confirmed to be heritable. Improving intramuscular fat or shear force is expected to lead to less redness and faster rate of browning of the meat during retail display. Selection for lean meat yield is expected to improve slightly retail colour stability.

INTRODUCTION

Of the MERINOSELECT standard indexes, the Merino Lamb index has been developed to improve profitability of a self-replacing production system where income is mostly derived from lamb production and some from adult wool production (MLA 2024). In addition to improving fleece weight, reproduction and growth, the index aims to achieve genetic gains in lean meat yield and eating quality in line with their economic values. Lean meat yield combined with growth and together with eating quality traits contribute approximately 20% of the index's economic response.

While there is no information on the cost of meat discolouration during retail display for Australian lamb meat, its colour influences decisions made by consumers and retailers. Consumers use meat colour to assess the quality and freshness of meat cuts at the point of purchase. For retailers, reduced display life of meat products from browning over time lowers their value due to discounting and downgrading of products. Impacts on retail colour stability of lamb cuts following selection for lean meat yield or eating quality are unknown, unlike the situation for fresh meat colour traits where favourable genetic relationships have been reported (Mortimer *et al.* 2017b, 2018). Using data from carcases of the wether progeny of Australian Wool Innovation's Merino Lifetime Productivity (MLP) project, this study reports genetic correlation estimates among retail colour stability and fresh meat colour traits assessed on loins and of the meat colour traits with lean meat yield and objectively measured eating quality traits of intramuscular fat and shear force.

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MATERIALS AND METHODS

The traits for this study were recorded on carcases produced from 2017- and 2018-born wethers at the Macquarie and New England sites of the MLP project (Ramsay *et al.* 2019), with pre-slaughter procedures described by Mortimer *et al.* (2021). After 24 h of chilling post-slaughter, the fresh meat colour traits of relative redness (*a**, CFA), yellowness (*b**, CFB) and lightness (*L**, CFL) were measured on the cut surface of the left *longissimus lumborum* (LL, loin) at the 12th rib of each carcase as described by Newell *et al.* (2020). A sub-sample from the LL of each carcase was collected and aged for 5 days to measure retail colour stability traits (Holman *et al.* 2021). Colourimetric measurements of *a** (RCA), *b** (RCB) and *L** (RCL) were recorded initially and at 1-day intervals over 3 days, with values after 2 days of simulated retail display defined as the trait of interest. The oxymyoglobin/metmyoglobin ratio (RCR), a measure of discolouration of meat, was estimated by dividing the captured light reflectance at a wavelength of 630 nm by that at a wavelength of 580 nm. From other sub-samples of the LL of each carcase, the objective eating quality traits of intramuscular fat (IMF, %) and shear force (SF5, N) were measured, using methods as described by Holman *et al.* (2019) and Fowler *et al.* (2014), respectively. Lean meat yield (LMY, %) was predicted as first described by Gardner *et al.* (2010), but with a variant developed for the Merino breed (GE Gardner, personal communication). Summary statistics for each trait are shown in Table 1.

Statistical analysis. Variance and covariance components for each trait were estimated using ASReml (Gilmour *et al.* 2015). Phenotypic variances and heritabilities were estimated from pedigree only univariate analyses fitting an animal model. Fixed effects included in the model were birth-rearing type, age of dam, age at measurement, Merino wool type (ultra/superfine, fine/fine-medium, medium/strong) and contemporary group (as defined in the MERINOSELECT data base, modified for slaughter group). For the objective eating quality traits, hot carcase weight was included as a covariate. A direct genetic effect of animal was fitted as the random effect. A maternal permanent environmental effect and a sire by site interaction were also included as random effects but were found to be not significant for all traits. Genetic and phenotypic correlations among the traits were estimated from bivariate analyses.

Table 1. Summary statistics for meat colour, objective eating quality and lean meat yield traits and estimates of phenotypic variance (σ^2_P) and direct heritability (h^2)

Trait	Records	Mean	SD	Range	σ^2_P (SE)	h^2 (SE)
CFA	1446	20.5	1.4	14.2-25.2	1.89 (0.08)	0.23 (0.08)
CFB	1446	3.2	1.1	-1.0-7.1	0.78 (0.04)	0.52 (0.10)
CFL	1446	35.2	2.2	28.9-44.1	3.69 (0.17)	0.45 (0.10)
RCA	1437	16.5	1.8	10.2-22.7	2.98 (0.12)	0.09 (0.05)
RCB	1437	15.9	1.6	8.9-22.1	2.31 (0.10)	0.11 (0.06)
RCL	1437	39.2	2.9	30.6-48.8	5.56 (0.28)	0.59 (0.12)
RCR	1437	3.3	0.6	1.9-5.6	0.26 (0.01)	0.11 (0.06)
IMF	1437	4.28	1.33	0.81-10.8	1.34 (0.07)	0.87 (0.10)
SF5	1438	25.4	5.6	13.0-58.4	27.28 (1.33)	0.52 (0.11)
LMY	683	57.6	2.6	46.8-64.4	4.60 (0.34)	0.47 (0.17)

RESULTS AND DISCUSSION

Except for RCL, heritability estimates for the retail colour stability traits recorded after 2 days of simulated retail display were less than 0.15 (Table 1) and were similar to estimates reported by Mortimer *et al.* (2017b). Heritabilities were higher (estimates all greater than 0.20) for the fresh meat colour traits than published estimates for Merino loins (Greeff *et al.* 2008; Mortimer *et al.* 2017b). With all estimates greater than 0.40, heritability estimates for LMY, IMF and SF5 were much higher (0.29±0.11, 0.58±0.11 and 0.10±0.09, respectively) than estimates presented by Mortimer *et al.*

(2017a, b). Compared with the earlier reports, our estimates of additive genetic variances for LMY and the fresh meat colour and objective eating quality traits were much higher.

Genetic correlations between retail colour stability traits and LMY tended to be low and favourable though not significantly different from zero (Table 2). Estimates of LMY with RCR (0.10±0.39), RCA (0.18±0.41) and RCL (0.28±0.24) suggest that selection for LMY would not increase the rate of discolouration of Merino loins during retail display or unfavourably lower meat redness and lightness. Genetic correlations of the retail colour stability traits with IMF and SF5 were generally moderate to high, with the sign of estimates being consistent with the strong negative genetic correlation between IMF and SF5 (-0.79±0.08, Table 2). Selection yielding favourable increases in IMF or decreases in SF5 is expected to lead to greater meat discolouration (-0.71±0.18 and 0.66±0.20, respectively) and less red meat (-0.49±0.21 and 0.53±0.24, respectively), although lighter meat colour (0.69±0.08 and -0.51±0.14, respectively). These estimates were consistent with those derived from a larger multi-breed population (Mortimer *et al.* 2014).

Genetic correlations of LMY with fresh meat colour traits were low and not significantly different from zero. Previously, stronger estimates also with large standard errors had been reported, which suggested selection to increase LMY would reduce meat redness and increase meat lightness (Mortimer *et al.* 2018). The genetic correlations of the fresh meat colour traits with IMF and SF5 were generally consistent with estimates reported by Mortimer *et al.* (2017b), with favourable responses expected to occur following selection to improve the objective eating quality traits.

Table 2. Genetic (below diagonal) and phenotypic (above diagonal) correlations among meat colour, objective eating quality and lean meat yield traits

	CFA	CFB	CFL	RCA	RCB	RCL	RCR	IMF	SF5	LMY
CFA		0.55	-0.44	0.19	-0.02	-0.10	0.13	0.08	-0.16	0.06
CFB	0.57 (0.14)		0.43	0.13	0.14	0.33	0.04	0.41	-0.30	-0.05
CFL	-0.03 (0.22)	-0.06 (0.24)		-0.05	0.17	0.50	-0.09	0.35	-0.19	-0.05
RCA	0.36 (0.30)	-0.19 (0.25)	-0.47 (0.24)		0.67	-0.21	0.95	-0.17	0.00	0.17
RCB	0.12 (0.31)	0.58 (0.23)	0.68 (0.22)	0.13 (0.38)		n.e.[1]	0.60	0.03	-0.05	0.16
RCL	0.00 (0.21)	0.70 (0.11)	0.92 (0.05)	-0.17 (0.25)	n.e.		-0.29	0.34	-0.17	0.04
RCR	0.18 (0.30)	-0.43 (0.21)	-0.61 (0.20)	0.96 (0.03)	0.02 (0.37)	-0.34 (0.22)		-0.23	0.03	0.15
IMF	0.24 (0.17)	0.73 (0.08)	0.74 (0.09)	-0.49 (0.21)	0.28 (0.23)	0.69 (0.08)	-0.71 (0.18)		-0.38	-0.17
SF5	-0.32 (0.19)	-0.69 (0.10)	-0.69 (0.12)	0.53 (0.24)	-0.30 (0.26)	-0.51 (0.14)	0.66 (0.20)	-0.79 (0.08)		0.08
LMY	0.16 (0.30)	0.07 (0.25)	-0.03 (0.26)	0.18 (0.41)	-0.16 (0.39)	0.28 (0.24)	0.10 (0.39)	-0.12 (0.20)	-0.20 (0.25)	

[1] n.e., not estimable

These results are preliminary, as the analyses were based on a small Merino data set and did not fit a genetic group effect. With many genetic parameter estimates associated with relatively large standard errors, more accurate estimates are required for all traits to extend understanding of the implications of selection using the MERINOSELECT Merino Lamb index for meat colour traits. While the genetic correlation estimates among each of the retail colour traits, the fresh colour traits and among LMY, IMF and SF5 were in reasonable agreement with literature estimates, some estimates differed markedly. For example, the estimates of LMY with IMF (-0.12±0.20) and SF5 (-0.20±0.25) were weaker and in the case of SF5 the estimate was negative rather than positive.

CONCLUSION

The heritability estimates confirm that genetic variation in retail display and fresh meat colour traits exists and can be exploited by Merino breeding programs. Where selection programs focus on improving intramuscular fat or shear force, less redness and faster rate of browning of the meat during retail display is expected to occur. Selection for lean meat yield is expected to improve slightly retail colour stability. If analyses of more data confirm these relationships, responses in these traits from selection on the Merino Lamb index should be predicted and monitored.

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