MERITS OF USING NEW INTRAMUSCULAR FAT MEASUREMENT TECHNOLOGIES IN GENETIC EVALUATION OF AUSTRALIAN LAMB

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SUMMARY

This study investigated the genetic association of intramuscular fat predicted with the MEQ probe (MEQIMF) and the SOMA NIR device (SOMAIMF) with Near Infra-Red analysed intramuscular fat (IMF%), tenderness, carcass eye muscle, fat and tissue depth. MEQ and SOMA NIR predicted IMF have only just became available to Australian processors, with data on genetic resources limited to 1,380 and 1,320 records, from research and seedstock flocks, respectively. Genetic analysis showed that MEQIMF has a moderate heritability (0.42 ± 0.1) and a high genetic correlation (0.95 ± 0.07) with chemical intramuscular fat. Similarly, SOMAIMF was estimated to have a moderate heritability (0.42 ± 0.1) and a strong genetic correlation with IMF% (0.94 ± 0.03). The results of the genetic analysis for IMF measured with the new technologies are likely to facilitate identifying the high intramuscular fat carcasses and in turn animals that have genetically superior eating quality.

INTRODUCTION

Eating quality in lamb is positively influenced by intramuscular fat, which has been found to increase tenderness, flavour and juiciness (Stewart *et al.* 2021). It is accepted that animals with higher levels of intramuscular fat produce meat which will be favoured by consumers (Pannier *et al.* 2014). Negative genetic correlations between intramuscular fat and lean meat yield (Gardner *et al.* 2018) also suggest that selection to improve the later needs to be undertaken with consideration for eating quality, because of its genetic correlation with intramuscular fat (Mortimer *et al.* 2018). Unlike beef, there is no visual marble score routinely used in the grading of lamb carcasses, with intramuscular fat percentage records (IMF%) in the national genetic evaluation determined by applying chemical analysis laboratory methods, which are time consuming and expensive. New technologies for measuring intramuscular fat objectively can facilitate adoption of Meat Standards Australia (MSA) grading in lamb (Pannier *et al.* 2014) because they offer fast, cheap, objective, on chain and non-destructive methods to measure the trait. For this study, two new technologies: i) the Meat Eating Quality (MEQ) probe (Carbone 2022), and ii) the SOMA Near Infra-Red (NIR) device were evaluated. The aim was to investigate the genetic relationship between lamb intramuscular fat measurements obtained with the MEQ probe and the SOMA NIR device, with IMF%, and, where possible, with other eating quality metrics (e.g. shear force) and carcass traits.

MATERIALS AND METHODS

Chemical IMF data. Eating quality and carcass traits were collected from 32,735 Merino and Merino-crossed lambs from the MLA Resource Flock (RF) and from seedstock ram breeding flocks. Mean lamb age was 264 (±76) days. Traits included intramuscular fat percentage (IMF%), shear

* A joint venture of NSW Department of Primary Industries and the University of New England

force 5 days after slaughter (SF5), eye muscle (*M. longissimus thoracis et lumborum* (LL)) depth (CEMD), fat at 45 mm from spine midline over the 12th rib (c site, CFAT) and total tissue depth measured at the 12th rib (GRFAT). Carcass traits were measured after slaughter in commercial abattoirs according to the procedure described by Mortimer *et al.* (2018). The percentage of intramuscular fat (IMF%) at the eye muscle was determined using a near infrared procedure (NIR) as described by (Perry *et al*. 2001). Shear force (SF5) at 5 days after slaughter was measured on a section of the LL as described by Hopkins *et al*. (2010).

MEQ probe data. For a subset of 1,380 of the above lambs, intramuscular fat was predicted using the MEQ probe (MEQIMF). MEQIMF was measured on the hot carcass where the MEQ probe was inserted in the area around the 13th rib and scans were completed to estimate intramuscular fat (Carbone 2022). The lambs with MEQIMF measures were born in 2021 and were measured between 2021 and 2022 (mean age at slaughter was 182 ±67 days) and originated from eight different flocks and 95 sires.

SOMA NIR data. SOMA NIR predicted intramuscular fat records (SOMAIMF) were collected from a different subset of the RF animals which included 1,307 lambs born in 2021 and measured between May and July 2022. The lambs were from the MLA resource flock and were progeny of 152 sires. They were slaughtered in commercial abattoirs, carcasses were chilled overnight (3 – 4 ºC) and intramuscular fat was measured with the SOMA NIR device positioned directly over the surface of the loin at a cut between the 12th and 13th rib, based on the procedures described by Stewart *et al.* (2022). The number of animals and mean values for each trait and data set are illustrated in Table 1. Both MEQ probe and SOMA NIR device had previously been validated on independent data, not included in this study.

Table 1. Number of records (N) for each data set and mean trait values (standard deviation). HCWT: hot carcase weight, IMF%: chemical intramuscular fat percentage, MEQIMF: MEQ probe predicted IMF, SOMAIMF: SOMA NIR predicted IMF, SF5: shear force 5 days after slaughter, CEMD: eye muscle depth, CFAT: fat at the c-side, GRFAT: fat at the GR site

Data set	N	HCWT	IMF%	MEQ IMF	SOMA IMF	SF5	CEMD	CFAT	GRFAT
IMF%	32,735	23.63 (4.0)	4.49 (1.2)	-	-	32.40 (11.9)	30.93 (5.0)	4.37 (2.5)	14.02 (6.1)
MEQ probe	1,380	24.95 (4.4)	3.77 (1.0)	3.92 (1.0)	-	37.99 (14.1)	34.14 (4.6)	4.64 (2.2)	14.24 (6.0)
SOMA NIR	1,307	21.41 (3.6)	3.87 (1.1)	-	4.23 (1.1)	-	30.72 (5.0)	3.35 (2.0)	11.91 (5.2)

Statistical analysis. Variance components and genetic parameters for IMF, MEQIMF and SOMAIMF were estimated using a linear mixed model and REML methods with ASReml software (Gilmour *et al.* 2015). Fixed effects included type of birth, contemporary group, age of the animal and the age of dam (in days). The quadratic function of hot carcass weight was included to adjust all traits. The model also included the random effect of animal and genetic group (Swan *et al.* 2016). Maternal effects were not fitted since preliminary analysis showed they were non-significant. For all data sets, contemporary group was defined by breed, flock, management group, sex, date of measurement and kill group (Huisman *et al.* 2008).

To estimate genetic correlation and covariance of MEQIMF and SOMAIMF with other carcass and eating quality traits, a series of bivariate analyses were performed in ASReml. Due to convergence difficulties genetic groups were not fitted in the bivariate analysis and only animal was included in random effects.

RESULTS AND DISCUSSION

Heritability for MEQIMF and SOMAIMF was moderate (Table 2) and thus both traits display genetic variation and can be used effectively in selection. These estimates were similar to the heritability for IMF% data set (Table 1), which was also moderate (0.50 ± 0.03) and similar to estimates previously reported for the trait in Merino and Merino-cross lambs (Mortimer *et al.* 2010; Mortimer *et al.* 2014; Mortimer *et al.* 2018). Variance components of MEQIMF and SOMAIMF were consistent with those for IMF. However, smaller number of records in the MEQ probe and SOMA NIR data sets have limited ability to account for genetic groups. In this case more data is needed to clarify how these effects may impact variance estimates.

Table 2. Estimates of phenotypic ($\widehat{\sigma}_p$), additive ($\widehat{\sigma}_a$), and residual ($\widehat{\sigma}_\varepsilon$) variance and heritability (h^2) for chemical IMF (IMF) and IMF predicted with MEQ probe (MEQIMF) and SOMA NIR device (SOMAINF). Variance components were estimated separately for each data set. Standard error in parentheses

Trait	Data	h^2	$\widehat{\sigma}_p$	$\widehat{\sigma}_a$	$\widehat{\sigma}_\varepsilon$
IMF%	IMF%	0.50 (0.03)	1.12 (0.06)	0.57 (0.02)	0.37 (0.02)
MEQIMF	MEQ probe	0.42 (0.10)	0.61 (0.03)	0.25 (0.06)	0.35 (0.05)
IMF		0.71 (0.10)	0.77 (0.04)	0.55 (0.10)	0.22 (0.10)
SOMAIMF	SOMA NIR	0.42 (0.07)	0.81 (0.03)	0.34 (0.07)	0.47 (0.07)
IMF		0.51 (0.06)	0.93 (0.04)	0.48 (0.07)	0.45 (0.06)

Genetic correlations between MEQIMF and IMF, and between SOMAIMF and IMF were strong and positive (0.95 ± 0.07 and 0.94 ± 0.03, respectively), and suggest that both could be used as objective measurements to select for intramuscular fat in breeding programs.

Table 3. Genetic correlations between MEQIMF, SOMAIMF, IMF and other traits, with standard error in parentheses. MEQIMF: MEQ probe predicted IMF, SOMAIMF: SOMA NIR predicted IMF, IMF: chemical IMF, SF5: shear force 5 days after slaughter, CEMD: eye muscle depth, CFAT: c- side fat, GRFAT: GR site fat

	MEQ probe data	SOMA NIR data	Chemical IMF data
Trait	MEQIMF	SOMAIMF	IMF
IMF	0.95 (0.07)	0.94 (0.03)	-
CEMD	0.06 (0.21)	0.20 (0.11)	0.11 (0.03)
CFAT	0.32 (0.20)	0.40 (0.12)	0.20 (0.03)
GRFAT	0.35 (0.17)	0.22 (0.11)	0.20 (0.03)
SF5	-0.26 (0.17)	-	-0.39 (0.03)

Genetic correlations for MEQIMF and other carcass and eating quality traits in general were aligned to the ones estimated for IMF% (Table 3). Moderate genetic correlations of MEQIMF and

SOMAIMF have been observed for CFAT and GRFAT. These correlations were stronger than the ones estimated on the IMF% data set and higher than the ones previously observed by Mortimer *et al*. (2018) between CFAT, GRFAT and IMF%. The same authors reported slightly negative genetic correlations between IMF% and CEMD. In this study, the genetic correlation between IMFSOMA and CEMD was moderate positive and stronger than the correlation between IMF% and CEMD. On the other hand, the correlation between MEQIMF and CEMD was low but with high standard error, indicating more records are needed to determine the genetic relationship between these two traits. The genetic correlation between intramuscular fat and SF5 was moderate and negative for both the MEQ probe and IMF% data sets (Table3), and similar to estimates between IMF% and SF5 reported in previous studies (Mortimer *et al*. 2014). There was no correlation estimate for SOMAIMF and SF5 due to limited SF5 records for this cohort.

When more data becomes available, the genetic relationship between MEQIMF and SOMAIMF and other traits will be re-estimated, and their suitability to select for intramuscular fat will be re-assessed. More MEQIMF and SOMAIMF data will also help to define the capacity of the different technologies evaluated to predict intramuscular fat.

CONCLUSIONS

New technologies to measure intramuscular fat are becoming available and both MEQ probe and SOMA NIR device provide an opportunity to capture more intramuscular fat phenotypes as they provide a fast, cheaper and non-destructive alternative to laboratory procedures. The genetic variance and heritability of MEQ probe and SOMA NIR predicted intramuscular fat were generally similar to the ones observed for IMF% on the same animals. MEQIMF and SOMAIMF traits were found to be highly genetically correlated with IMF%, which suggests that intramuscular fat measured with the new technologies investigated for this study could be treated as the same trait as IMF% in genetic evaluation. More research is needed to determine the genetic association between MEQIMF and SOMAIMF, and other traits.

ACKNOWLEDGEMENTS

This work was part of the Advanced Measurement Technologies for globally competitive Australian meat project, funded by the Australian Government Department of Agriculture and Water Resources and a large number of industry partners. The authors thank the teams behind the Sheep CRC Information Nucleus Flock and MLA resource flock.

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