Technical Report

Program and KPI: Sub-program 4.2 KPI 3.30

Report Title: Genetic analysis of intramuscular fat data collected with MEQ probe and SOMA NIR device

Prepared by: Rea Alexandri, Sam Walkom, Sarah Stewart,
Peter McGilchrist, Cameron Steel and Daniel Brown

AGBU

Date published: 30 November 2022

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

Citation

Rea Alexandri, Sam Walkom, Sarah Stewart, Cameron Steel, Pete McGilchrist and Daniel Brown (2023). Genetic analysis of intramuscular fat data collected with MEQ probe and SOMA NIR device. An *Advanced measurement technologies for globally competitive Australian meat* Project.

Acknowledgements

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

Abstract

The objective of this report was to investigate the genetic association between intramuscular fat predicted with MEQ probe (IMFMEQ) and SOMA NIR device (IMFSOMA) with chemically analysed intramuscular fat, tenderness, carcase eye muscle dimensions and fat and tissue depth. MEQ and SOMA predicted IMF remain lowly recorded traits with data limited to 1,380 and 1,320 records respectively, from the resource flock and associated overlay projects. Consequently, results within this report should be considered as preliminary but none the less are promising. Genetic analysis showed that IMFMEQ has a moderate heritability (0.42 ±0.1) and a high genetic correlation (0.95 ±0.07) with chemical intramuscular fat. Similarly IMFSOMA was estimated to have a moderate heritability (0.42 ±0.1) and a strong genetic correlation with chemical IMF (0.94 ±0.03). Because of this high correlation IMFMEQ and IMFSOMA can be used to determine intramuscular fat in lamb, however further work is needed to clarify the genetic association between these traits and other carcase and eating quality traits.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

Executive Summary

1. Intramuscular fat (IMF) is an important determinant of eating quality in lamb. Visual marble score is not routinely used in Australian lamb, and the best way to determine intramuscular is chemically through laboratory methods that can be expensive and time consuming. New technologies can enable the collection of intramuscular fat records without invasive laboratory processes.
2. The aim of this report was to estimate genetic parameters for intramuscular fat predicted with the MEQ probe (IMFMEQ) and the SOMA NIR device (IMFSOMA) and investigate the genetic correlations between IMFMEQ and IMFSOMA with chemical intramuscular fat and other carcase and eating quality traits.
3. IMFMEQ data were collected from 1,380 lambs born in 2021 and measured across 2021 and 2022 at a mean carcase weight of 24.95 (±4.4) Kg. The genetic analysis used records for chemical IMF, meat tenderness (shear force, SF5), carcase eye muscle depth (CEMD) and width (CEMW) and fat (CFAT) and tissue depth (GRFAT).
4. IMFSOMA data were collected from 1,320 animals born in 2021 and measured in 2022. Because of limited data availability for this data set, only chemical IMF records were used for the genetic analysis.
5. Heritability for IMFMEQ was moderate (0.42 ±0.1) and the genetic correlation between IMFMEQ and chemical IMF was 0.95 ±0.07.
6. Heritability for IMFSOMA was also moderate (0.42 ±0.1) and the genetic correlation between IMFSOMA and chemical IMF was 0.94 ±0.03.
7. With one exception, the genetic correlations between IMFMEQ and other carcass traits were aligned to those between these traits and IMF%.
8. When more IMFMEQ and IMFSOMA data becomes available, the results of the present report will be re-assessed to conclude that IMFMEQ and IMFSOMA are equivalent to chemical IMF based on variance estimates, heritability and genetic correlations with the other traits used in the main Sheep Genetics genetic evaluation.
9. These results are very encouraging and support the further investment in more IMFMEQ and INFSOMA measuring in the genetic resource flocks. This will then lead to routine implementation into Sheep Genetics.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

Contents

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

1 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 will be favoured by consumers (Pannier *et al.* 2014). Selection for lean meat yield in lamb deteriorates eating quality (Gardner *et al.* 2018) as the genetic correlation between intramuscular fat and lean meat yield is unfavourably negative. To counter balance this effect, feedback on lamb eating quality is essential. Contrary to beef, there is no visual marble score routinely used in lamb, and currently intramuscular fat must be determined chemically using laboratory approaches which can be 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, objective and non-destructive methods to measure intramuscular fat. For this study two new technologies to measure intramuscular fat were tested: i) the Meat Eating Quality (MEQ) probe, and ii) the SOMA Near Infra-Red (NIR) device. The aim of this report is to investigate the genetic association of lamb intramuscular fat measurements obtained with the MEQ probe and the SOMA NIR device, with chemical intramuscular fat (%IMF), and, were possible, with other eating quality (e.g. shear force) and carcase traits.

2 Methodology

2.1 Data

2.1.1 MEQ probe data

Intramuscular fat MEQ records were collected from 1,380 lambs born in 2021 and measured between 2021 and 2022, according to the procedure described by Carbone (2022). The lambs came from eight different flocks and were progeny of 95 sires. Sire types included Merino sires, Maternal (Dohne Merino) and Terminal sires (Poll Dorset, White Suffolk and Texel). Lamb age at slaughter ranged from 103 to 334 days, and hot carcase weight ranged from 15.1 to 40.8 Kg. Carcase traits for the lambs were measured after slaughter in commercial abattoirs. Weight (H*CWT*) and tissue depth at the GR site (*GRFAT*, total tissue depth measured with a GR knife 110mm from the carcase midline over the 12th rib) and MEQ intramuscular fat (MEQIMF) were measured on the hot carcase. For the MEQIMF, the MEQ probe was inserted in the area around the 13th rib and scans were completed to get intramuscular fat measurements (Carbone 2022). After overnight chilling (3 – 4 º C), at a cut between the 12th and 13th ribs of each carcase, eye muscle (*M. longissimus thoracis et lumborum*, LL) depth (*EMD*), and fat depth at the C site (*CFAT*) were measured. The percentage of chemical intramuscular fat (IMF%) at the LL 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 at a section of the LL as described by Hopkins et al. (2010). The number of animals from each flock and mean values for each trait are shown on Table 1.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

Table 1. Number of records for each flock, mean age (standard deviation) and mean trait values (standard deviation) for all the MEQ animals used in the analysis. HCWT: hot carcase weight, IMFMEQ: intramuscular fat recorded with the MEQ probe, IMF%: chemical intramuscular fat percentage, SF5: shear force 5 days after slaughter, CEMD: eye muscle depth, CEMW: eye muscle width, CFAT: fat at the c-side, GRFAT: fat at the GR site.

Flock	N	Age	HCWT	IMFMEQ	IMF%	SF5	CEMD	CEMW	CFAT	GRFAT
1	131	123 (7)	24.3 (3.7)	3.50 (0.8)	3.53 (0.9)	43.36 (14.1)	37.17 (3.5)	60.68 (3.9)	3.81 (1.6)	16.45 (4.4)
2	219	140 (7)	27.93 (3.8)	4.42 (0.9)	4.36 (0.9)	34.24 (9.2)	37.95 (3.2)	59.02 (4.4)	6.19 (2.8)	19.37 (5.5)
3	57	185 (3)	31.33 (3.9)	4.03 (0.8)	3.95 (0.9)	32.18 (9.2)	38.49 (4.1)	64.86 (4.3)	6.56 (1.9)	18.86 (4.7)
4	229	157 (27)	25.12 (4.8)	3.77 (0.8)	3.32 (1.0)	34.2 (9.9)	35.13 (4.3)	63.15 (5.1)	4.51 (2.0)	13.54 (5.3)
5	116	198 (0)	26.49 (3.6)	4.91 (0.7)	4.67 (0.9)	25.91 (4.7)	33.08 (2.8)	58.89 (5.0)	5.29 (1.7)	17.94 (3.7)
6	200	169 (5)	24.1 (2.5)	4.04 (0.8)	3.61 (0.8)	37.95 (11)	33.00 (3.7)	53.83 (4.4)	4.76 (2.1)	15.06 (3.8)
7	220	144 (2)	20.78 (2.8)	3.16 (1.0)	3.18 (0.8)	33.4 (8.5)	30.6 (3.4)	56.74 (4.1)	2.81 (1.0)	7.31 (3.4)
8	208	332 (1)	24.67 (3.6)	3.92 (1.0)	4.03 (1.1)	55.8 (17.1)	31.36 (4.1)	63.98 (4.9)	4.59 (1.4)	11.42 (4.4)
Total	1380	182 (67)	24.95 (4.4)	3.92 (1.0)	3.77 (1.0)	37.99 (14.1)	34.14 (4.6)	59.72 (5.8)	4.64 (2.2)	14.24 (6.0)

2.1.2 SOMA NIR device data

Intramuscular fat records were collected from 1320 lambs born in 2021 and measured between May and July 2022. The lambs came from the MLA Resource flock (flocks IN01 and IN08) and they were progeny of 152 sires. Sire types included Merino sires, Maternal (Dohne Merino, Coopworth and Corriedale) and Terminal sires (Poll Dorset, White Suffolk, Southdown and Texel). Lamb age at slaughter ranged from 257 to 480 days, and hot carcase weight ranged from 12.1 to 34.9 Kg. Lambs were slaughtered in commercial abattoirs and carcases were chilled overnight (3 – 4 º C). They day after slaughter, the left short loin was removed from the saddle region of the carcass, or carcasses were split between the 12th and 13th rib and the lumbosacral junction and the whole saddle removed, packaged and shipped to the University of New England Meat Science lab for further processing. Intramuscular fat was predicted using SOMA NIR device based on the procedures described by Stewart *et al.* (2022). The number of animals for each flock, mean age, mean hot carcase weight, and mean SOMA IMF values are illustrated in Table 2.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

Table 2. Number of records for each flock, mean age (standard deviation) and mean trait values (standard deviation) for all the SOMA animals used in the analysis. HCWT: hot carcase weight, IMFSOMA: intramuscular fat recorded with the SOMA NIR device, IMF%: chemical intramuscular fat percentage.

Flock	N	Age	HCWT	IMFSOMA	IMF%
IN01	680	340 (54)	20.83 (2.6)	4.54 (1)	3.81 (1.1)
IN08	627	359 (44)	22.07 (4.3)	3.88 (1)	3.93 (1.1)
Total	1307	349 (50)	21.41 (3.6)	4.23 (1.1)	3.87 (1.1)

2.2 Statistical analysis

2.2.1 MEQ probe data

Variance components and genetic parameters for IMFMEQ were estimated using a linear mixed model and REML methods with ASReml software (Gilmour *et al.* 2015). Fixed effects included type of birth (coded 1, 2, 3 or 4 for singles, twins, triplets and quadruplets respectively), contemporary group (n = 18 levels), sex (male or female), age of the animal and the age of dam. The quadratic function of hot carcase 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. The animal effect represented the additive genetic variance. Contemporary group was defined by breed, flock, management group, sex, date of measurement and kill group. Phenotypic variance was calculated as the sum of the additive genetic and the residual variance.

To estimate genetic correlation and covariance between IMFMEQ and the other carcase and eating quality traits a series of bivariate analyses were performed in ASReml. Because of difficulty for the REML to converge, genetic groups were not fitted in the bivariate analysis and only animal was included in random effects.

To compare variance components between IMFMEQ and IMF%, two univariate analyses were performed using two different %IMF data sets: i) a dataset including all 1,380 lambs present in the IMFMEQ analysis (Dataset 1) and, ii) a dataset consisting of 32,375 records of IMF% (chemical IMF) measured in lambs born between 2007 and 2021 (Dataset 2). Lamb age for Dataset 2 ranged from 88 to 504 days and hot carcase weight from 10.9 to 47.0 Kg. It included 1287 contemporary groups and its mean IMF% was 4.49 (± 1.23).

2.2.2 SOMA NIR data

Variance components and heritability were estimated in a univariate analysis and genetic correlation with %IMF in a bivariate analysis with ASReml using the same fixed effects as the

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

ones in the MEQ data analysis. Because of difficulties converging, neither univariate nor bivariate analysis included genetic groups; only the random effect of the animal was included.

3 Results and Discussion

3.1 IMFMEQ Heritability

Heritability for IMFMEQ estimated using an animal model adjusted for hot carcass weight and age was moderate (0.42±0.1, Table 3) and thus IMFMEQ displays genetic variation and can be used in genetic evaluation. IMFMEQ heritability was similar to the heritability estimated for IMF% for Dataset 2 consisting of 32,375 records (0.42±0.1 and 0.50±0.03, respectively). However, estimated IMF% heritability was higher when only the 1,380 lambs with IMFMEQ records (Dataset 1, 0.71±0.1) were included in the analysis, indicating more data is needed to conclude that IMFMEQ is equivalent to IMF%. Comparing IMFMEQ with chemical IMF%, previous studies have reported heritabilities for IMF% which are similar to the estimated one for IMFMEQ in the present report. For IMF%, previously estimated heritabilities for Australian sheep ranged from 0.39 to 0.58 for Merino and Merino crossed lambs (Mortimer *et al.* 2010; Mortimer *et al.* 2014; Mortimer *et al.* 2018). Moderate to high heritability values were also reported for computer tomography scanned intramuscular fat in different sheep breeds (McLaren *et al.* 2021).

Table 3. Estimates of phenotypic ($\hat{\sigma}_p$), additive ($\hat{\sigma}_a$), genetic group ($\hat{\sigma}_{gg}$), and residual ($\hat{\sigma}_\varepsilon$) variance and heritability (h^2) for the IMFMEQ. Standard error in parentheses.

Trait	h^2	$\hat{\sigma}_p$	$\hat{\sigma}_a$	$\hat{\sigma}_{gg}$	$\hat{\sigma}_\varepsilon$
IMFMEQ	0.42 (0.10)	0.61 (0.03)	0.25 (0.06)	0.00 (0.00)	0.35 (0.05)
IMF% (Dataset 1)	0.71 (0.10)	0.77 (0.04)	0.55 (0.10)	0.00 (0.00)	0.22 (0.10)
IMF% (Dataset 2)	0.50 (0.03)	1.12 (0.06)	0.57 (0.02)	0.19 (0.06)	0.37 (0.02)

3.2 MEQIMF Genetic correlations

Estimates of genetic and phenotypic correlations between IMFMEQ and other carcass and meat quality traits are shown in Table 4. Genetic correlations for IMFMEQ in general were aligned to the ones estimated using Dataset 2 which included a large number of records (32,375 records, Table 5). IMFMEQ was highly genetically correlated with chemical IMF% (0.95 ± 0.07), suggesting that IMFMEQ can be used to select for intramuscular fat in breeding programs. Moderate genetic correlations of IMFMEQ and other carcase traits have been observed: 0.32±0.20 for CFAT and 0.35±0.17 for GRFAT. These correlations were higher than the ones previously observed by Mortimer *et al.* (2018) between CFAT, GRFAT and IMF%.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

The same authors reported slightly negative genetic correlations between IMF% and CEMD and CEMW. In the present report, the correlation between IMFMEQ, CEMD and CEMW were low but with high standard errors, indicating more records are needed to determine the genetic relationship between these traits. On the other hand, the genetic correlation between IMFMEQ and SF5 was negative (-0.26±0.17), and only slightly higher than similar estimates between IMF% and SF5 reported in previous studies (Mortimer *et al.* 2014).

Table 4. Genetic and phenotypic correlations between IMFMEQ and other carcase and meat quality traits. Standard error in parentheses. IMFMEQ: intramuscular fat recorded with the MEQ probe, IMF: chemical intramuscular fat, SF5: shear force 5 days after slaughter, CEMD: eye muscle depth, CEMW: eye muscle width, CFAT: fat at the c-side, GRFAT: fat at the GR site.

	IMFMEQ	
Trait	**Genetic**	**Phenotypic**
IMF%	0.95 (0.07)	0.53 (0.02)
CEMD	0.06 (0.21)	0.02 (0.03)
CEMW	0.09 (0.20)	0.00 (0.03)
CFAT	0.32 (0.20)	0.20 (0.03)
GRFAT	0.35 (0.17)	0.19 (0.03)
SF5	-0.26 (0.17)	-0.14 (0.03)

Table 5.Genetic and phenotypic correlations between IMF% and other carcase and meat quality traits using Dataset 2. Dataset 2 included 32,375 records of IMF% and was used to compare genetic parameters. Standard error in parentheses. IMFMEQ: intramuscular fat recorded with the MEQ probe, IMF: chemical intramuscular fat, SF5: shear force 5 days after slaughter, CEMD: eye muscle depth, CEMW: eye muscle width, CFAT: fat at the c-side, GRFAT: fat at the GR site.

Trait	IMF%	
	Genetic	**Phenotypic**
CEMD	0.11 (0.03)	0.19 (0.03)
CEMW	0.25 (0.03)	0.22 (0.03)
CFAT	0.20 (0.03)	0.11 (0.03)
GRFAT	0.20 (0.03)	0.04 (0.04)
SF5	-0.39 (0.03)	-0.27 (0.02)

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

3.3 IMFSOMA heritability and genetic correlation with chemical IMF

The heritability estimates of IMFSOMA was 0.42 (±0.1), indicating the trait can be used for genetic evaluation. For the same data, the heritability of IMF% was 0.51 (±0.1) which is similar to the heritability estimated for IMF% from Dataset 2. The genetic correlation between IMF% and IMFSOMA was strong and positive 0.94 (±0.03), which is encouraging for the utilisation of IMFSOMA as an objective measure of chemical IMF% in lamb. Within this report, no genetic correlations were estimated between IMFSOMA and other carcase and eating quality traits, because of limited data availability. When more data becomes available, the genetic relationship between IMFSOMA and other traits will be estimated and its suitability to select for IMF% will be re-assessed.

4 Conclusions

Genetic analysis based on 1380 intramuscular fat records of Australian lamb, predicted with the MEQ probe, has found IMFMEQ to be of moderate heritability, and able to be used in breeding programs. Selection for IMFMEQ favours IMF% as the two traits were found to be highly genetically correlated. More research is needed to determine the genetic association between IMFMEQ and other carcase traits like eye muscle dimensions (CEMD, CEMW).

Analysis of 1307 lambs with intramuscular fat predicted with the SOMA NIR device showed that IMFSOMA is moderately heritable and strongly genetically correlated with chemical IMF%, indicating this trait can be used to select for IMF%. More data is needed to assess the genetic association between IMFSOMA and other carcass and eating quality traits.

These results are very encouraging and support the further investment in more IMFMEQ and INFSOMA measuring in the genetic resource flocks. This will then lead to routine implementation into Sheep Genetics.

5 References

Carbone R. (2022) Real-Time Meat Eating Quality Probe: Tecnology Refinement. p. 16. Meat and Livestock Australia.

Gardner G.E., Starling S., Charnley J., Hocking-Edwards J., Peterse J. & Williams A. (2018) Calibration of an on-line dual energy X-ray absorptiometer for estimating carcase composition in lamb at abattoir chain-speed. *Meat Sci* **144**, 91-9.

Gilmour A.R., Gogel B.J., Cullis B.R., Welham S.J. & Thompson R. (2015) ASReml User Guide Release 4.1. In: *VSN International Ltd, Hemel Hempstead, UK*

McLaren A., Kaseja K., McLean K.A., Boon S. & Lambe N.R. (2021) Genetic analyses of novel traits derived from CT scanning for implementation in terminal sire sheep breeding programmes. *Livestock Science* **250**, 104555.

Mortimer S.I., Fogarty N.M., van der Werf J.H.J., Brown D.J., Swan A.A., Jacob R.H., Geesink G.H., Hopkins D.L., Hocking Edwards J.E., Ponnampalam E.N., Warner R.D., Pearce K.L. & Pethick D.W. (2018) Genetic correlations between meat quality traits and growth and carcass traits in Merino sheep. *Journal of Animal Science* **96**, 3582-98.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.

Mortimer S.I., van der Werf J.H., Jacob R.H., Hopkins D.L., Pannier L., Pearce K.L., Gardner G.E., Warner R.D., Geesink G.H., Edwards J.E., Ponnampalam E.N., Ball A.J., Gilmour A.R. & Pethick D.W. (2014) Genetic parameters for meat quality traits of Australian lamb meat. *Meat Sci* **96**, 1016-24.

Mortimer S.I., van der Werf J.H.J., Jacob R.H., Pethick D.W., Pearce K.L., Warner R.D., Geesink G.H., Hocking Edwards J.E., Gardner G.E., Ponnampalam E.N., Kitessa S.M., Ball A.J. & Hopkins D.L. (2010) Preliminary estimates of genetic parameters for carcass and meat quality traits in Australian sheep. *Animal Production Science* **50**, 1135-44.

Pannier L., Gardner G.E., Pearce K.L., McDonagh M., Ball A.J., Jacob R.H. & Pethick D.W. (2014) Associations of sire estimated breeding values and objective meat quality measurements with sensory scores in Australian lamb. *Meat Sci* **96**, 1076-87.

Stewart S.M., Corlett M., McGilchrist P., Steel C. & Gardner G.E. (2022) Report on independent validation and repeatability of the SOMA device. In: *An Advanced measurement technologies for globally competitive Australian meat Project*.

Stewart S.M., Lauridsen T., Toft H., Pethick D.W., Gardner G.E., McGilchrist P. & Christensen M. (2021) Objective grading of eye muscle area, intramuscular fat and marbling in Australian beef and lamb. *Meat Sci* **181**, 108358.

Swan A.A., Brown D.J. & van der Werf J.H.J. (2016) Genetic variation within and between subpopulations of the Australian Merino breed. *Animal Production Science* **56**, 87.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, Commercial Companies, State Departments & Universities.