Proc. Assoc. Advmt. Anim. Breed. Genet: 26: 343-346

MULTIBREED GENOMIC SELECTION FOR SENSORY EATING QUALITY OF LAMB USING CONSUMER ASSESSMENTS

D.J. Brown[1], S.Z.Y. Guy[1], S.I. Mortimer[2], L. Pannier[3], P. McGilchrist[4], D. Pethick[3] and A.A. Swan[1]

[1] Animal Genetics Breeding Unit*, University of New England, Armidale, NSW, 2350 Australia
[2] NSW Department of Primary Industries and Regional Development, Armidale, NSW, 2351 Australia
[3] School of Agricultural Science, Murdoch University, Perth, WA, 6150 Australia
[4] School of Environmental and Rural Science, University of New England, Armidale, NSW, 2351 Australia

SUMMARY

This paper reports updated genetic parameter estimates for correlations between consumer eating quality and carcase traits for Australian sheep. Seven consumer sensory-assessment traits (tenderness, flavour, juiciness, smell, overall liking, star rating and MQ4 index) were collected on loin and topside cuts (n ~ 6,500). Heritability estimates ($\hat{h}^2$) were low to moderate for these traits ($0.09 < \hat{h}^2 < 0.26$), with the topside cut having slightly more genetic variation than the loin. Genetic correlations ($\hat{r}_g$) between sensory traits were high within cuts ($\hat{r}_g > 0.96$) and across cuts ($\hat{r}_g > 0.73$). There were moderate to high genetic correlations between the consumer sensory and the objective eating quality traits (intramuscular fat and shear force), and low to weakly negative correlations between the sensory traits and carcase lean meat yield. These estimates will be used to revise selection indexes and develop breeding values for consumer eating quality.

INTRODUCTION

Breeding programs can balance the antagonistic relationship between yield and eating quality using modified selection indexes. These indexes are based on breeding objectives where an economic value is defined for consumer-assessed eating quality (Swan *et al*. 2015). Balanced selection for carcase yield and eating quality was further enhanced from 2017 underpinned by substantial investment in genomic reference populations. Genomically enhanced breeding values are now available for carcase yield traits and objectively measured eating quality traits.

Genetic correlations between consumer eating quality and selection traits (carcase yield and objective measures of eating quality) are required to develop selection indexes. Current eating quality indexes are based on correlations estimated from consumer eating quality trials on approximately 1,500 animals from multiple breeds. The continued collection of this information has resulted in almost four-fold the amount of both consumer and carcase data available across all sheep breeds. This paper reports updated genetic parameter estimates between consumer eating quality and carcase traits for Australian sheep breeds. These estimates will be used to further revise selection indexes, and potentially develop new multi-trait breeding values for consumer eating quality.

MATERIALS AND METHODS

Data were available for crossbred lambs recorded in Australian sheep reference populations across multiple years and data sources; mainly from the Sheep CRC Information Nucleus Flock (lambs born in 2009 and 2010) (van der Werf *et al.* 2010), and the MLA Resource Flock (lambs

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

born across 2017-2021). Lambs were processed at an average age of 266 ± 92 days (mean ± SD), with an average hot carcase weight of 23.7 ± 4.1 kg and carcase subcutaneous fat of 4.4 ± 2.4 mm. Carcase composition and objective eating quality traits examined were hot carcase weight (kg), lean meat yield (%) assessed from computed tomography scanning and dual energy x-ray, loin intramuscular fat (%) measured by chemical analysis and loin shear force at 5 days of aging (N).

Consumer eating quality traits were collected from a representative subset of animals from each project. There were 979 sires represented by an average of 6.9 progeny per sire. Samples were collected, prepared, cooked and tasted by consumers according to the protocol described by Pannier *et al*. (2025). Briefly, five slices from the topside (*Musculus semimembranosus*) and loin (*M. longissimus lumborum*) muscles from each carcase were prepared and grilled under standardised conditions. Samples were allocated to untrained consumers according to a 6x6 Latin square design, who scored each sample for tenderness, juiciness, flavour, smell and overall liking between zero and 100 (100 being most preferred). Consumers also assessed each sample according to quality grades (star rating) of 'unsatisfactory' (2 star), 'good every day' (3 star), 'better than every day' (4 star) or 'premium' (5 star) (Pannier *et al.* 2025). Each loin and topside were eaten 10 times, with the average across the 10 consumer responses utilised for each muscle. An MQ4 value was also calculated according to Pannier *et al.* (2025) by averaging the consumer scores across traits within cuts (MQ4) and across all traits for both cuts (Overall MQ4).

Table 1. Summary statistics for eating quality (consumer-assessed and objectively measured) and carcase composition traits

Trait		*n*	Mean	Min	Max	CV (%)
Loin (0 to 100)	Tenderness	6,429	70.4	27.6	94.2	14.2%
	Flavour	6,429	68.5	39.2	93.0	12.1%
	Juiciness	6,429	64.9	28.1	94.8	14.9%
	Overall liking	6,429	69.3	37.8	95.0	12.6%
	Star rating[A]	6,103	3.7	2.5	5.0	9.9%
	MQ4	6,429	68.3	37.3	91.8	12.6%
Topside (0 to 100)	Tenderness	6,486	47.0	5.0	93.3	26.1%
	Flavour	6,486	54.7	5.0	89.8	16.4%
	Juiciness	6,486	51.0	6.0	87.3	21.0%
	Overall liking	6,486	52.0	6.0	89.6	19.4%
	Star rating[A]	6,161	3.0	2.0	4.4	12.2%
	MQ4	6,486	51.2	6.0	90.0	19.0%
Overall MQ4		6,749	59.7	30.8	90.0	13.2%
Hot carcase weight (kg)		45,356	23.7	9.2	47.0	17.2%
Lean meat yield (%)		11,184	56.3	38.8	70.7	8.1%
Intramuscular fat (%)		40,921	4.4	1.1	14.4	27.5%
Shear force (N)		37,116	32.3	10.8	107.0	33.7%

[A] Star rating is scored on a 4-point scale from 2 to 5.

The above traits were analysed in a series of bivariate models ASReml (Gilmour *et al.* 2021) using a mixed model, fitting a fixed effect of contemporary group defined as flock, management group, year of measurement, sex, and kill group sub-classes (as well as laboratory for shear force and intramuscular fat) and random effects of animal (additive genetic effect based on the pedigree) and genetic groups defined by breed to account for different base animal breeds. Additional fixed effects of birth type, rearing type, age of dam and age at measurement were also fitted. Intramuscular fat and shear force were also corrected for hot carcase weight. Heterosis was not fitted in the model.

RESULTS AND DISCUSSION

On average, the loin samples scored higher for eating quality compared to the topside samples, though there was generally more variation in the topside cuts (Table 1). Smell was not heritable for both cuts and thus no results were shown. Heritability estimates were moderate for all the other consumer eating quality traits (0.09 to 0.20 for the loin, 0.12 to 0.26 for the topside), with the topside generally having higher estimates (Table 2). Heritability estimates were high for carcase weight, intramuscular fat and lean meat yield, and moderate for shear force. The variance attributed to breed was 0.75 to 2.3 times that of the within-breed variance for loin consumer scores, carcase weight and lean meat yield, while for the other traits, it tended to be small relative to the genetic variance.

Consumer-assessed eating quality exhibited genetic variation, with the highest heritability estimated for topside tenderness which agrees with multi-breed estimates reported by Mortimer *et al*. (2015).

Table 2. Additive genetic ($\hat{\sigma}_a^2$), phenotypic ($\hat{\sigma}_p^2$), genetic group ($\hat{\sigma}_{GG}^2$) and heritability estimates ($\hat{h}^2$)(± standard error), averaged across bivariate analyses of eating quality and carcase traits

Trait		$\hat{\sigma}_a^2$	$\hat{\sigma}_p^2$	$\hat{\sigma}_{GG}^2$	$\hat{h}^2$
Loin (0 to 100)	Tenderness	16.8 ± 2.77	85.3 ± 1.56	11.1 ± 4.69	0.20 ± 0.03
	Flavour	5.2 ± 1.59	60.7 ± 1.09	5.8 ± 2.60	0.09 ± 0.03
	Juiciness	10.1 ± 2.31	81.0 ± 1.46	6.5 ± 3.10	0.12 ± 0.03
	Overall liking	8.6 ± 1.90	66.5 ± 1.20	7.1 ± 3.13	0.13 ± 0.03
	Star rating	0.02 ± 0.00	0.12 ± 0.00	0.01 ± 0.01	0.16 ± 0.03
	MQ4	9.6 ± 1.89	63.4 ± 1.15	7.4 ± 3.20	0.15 ± 0.03
Topside (0 to 100)	Tenderness	31.4 ± 4.33	122.9 ± 2.25	2.9 ± 2.48	0.26 ± 0.03
	Flavour	9.0 ± 2.06	74.2 ± 1.33	0.00 ± 0.00	0.12 ± 0.03
	Juiciness	10.9 ± 2.71	93.8 ± 1.68	1.4 ± 1.41	0.12 ± 0.03
	Overall liking	16.2 ± 2.89	90.9 ± 1.64	0.6 ± 1.04	0.18 ± 0.03
	Star rating	0.03 ± 0.00	0.12 ± 0.00	0.00 ± 0.00	0.23 ± 0.03
	MQ4	16.2 ± 2.68	81.8 ± 1.48	0.8 ± 1.10	0.20 ± 0.03
Overall MQ4		11.9 ± 1.78	53.0 ± 0.95	3.5 ± 1.89	0.22 ± 0.03
Hot carcase weight (kg)		3.3 ± 0.12	6.7 ± 0.05	7.5 ± 1.60	0.49 ± 0.02
Lean meat yield (%)		2.4 ± 0.22	6.0 ± 0.09	3.0 ± 0.90	0.47 ± 0.03
Intramuscular fat (%)		0.5 ± 0.02	0.9 ± 0.01	0.1 ± 0.04	0.62 ± 0.02
Shear force (N)		21.7 ± 1.27	82.3 ± 0.68	3.2 ± 1.32	0.27 ± 0.01

Figure 1 presents estimates of genetic correlations ($\hat{r}_g$). The consumer eating quality traits were highly correlated with each other within cuts ($\hat{r}_g > 0.96$; SEs ~ 0.03), as well as across cuts ($0.73 < \hat{r}_g < 0.97$; SEs ~ 0.10). Consumer eating quality traits of the different muscles were genetically similar, and thus, selection for better eating quality for one muscle will still result in an improvement in eating quality in other muscles. Moderate to strong genetic correlations were observed between consumer eating quality traits and objective eating quality traits. Shear force had strong negative (favourable) correlations with loin and topside traits ($-0.88 < \hat{r}_g < -0.64$). Meanwhile, intramuscular fat had a slightly stronger positive relationship with the eating quality traits from the loin ($0.44 < \hat{r}_g < 0.63$) compared to the topside ($0.28 < \hat{r}_g < 0.43$). The relationships between consumer eating quality traits and lean meat yield were weak to negligible in both the loin and topside ($-0.21 < \hat{r}_g < -0.01$). The correlation between intramuscular fat and shear force was moderate at -0.47 ± 0.03.

Consumer eating quality traits were generally more highly correlated with shear force than intramuscular fat, particularly in the loin. However, both traits are very useful selection criteria in breeding programs. With technological advances in objective carcase measurements, price signals are now emerging for intramuscular fat measured at processing. Therefore, future indexes for all breeds should directly include eating quality in the breeding objective as an economic trait.

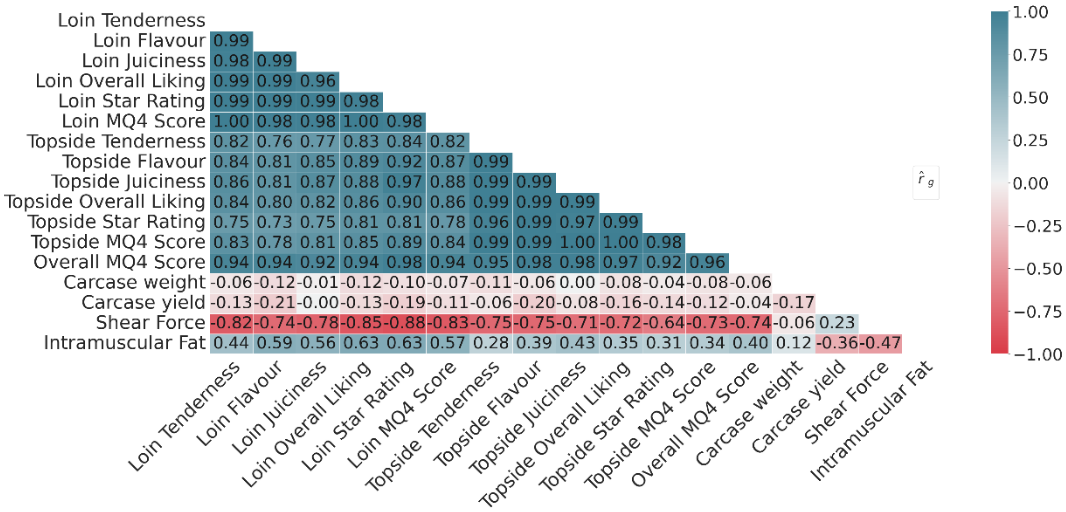

Figure 1. Genetic correlation estimates between eating quality and carcase composition traits (all SEs ~0.05)

The re-estimated genetic parameters between topside overall liking and lean meat yield align with previous estimates reported by Swan *et al.* (2015) and Guy *et al.* (2022). However, notably strong genetic correlations were evident between loin eating quality and shear force in the current study, which were similar to those reported by Guy *et al.* (2022) in Terminal sire breeds. Both these were significantly higher than those reported by Mortimer *et al.* (2015). Since this study used more data, there is greater confidence in the precision of estimates of genetic correlation between these traits. Due to the changes in correlations with the updated data, it will be necessary to review indexes that include eating quality, along with predictions of response to selection. Future work will explore the development of breeding values for consumer eating quality in multi-trait models.

ACKNOWLEDGEMENTS

This work was funded by MLA Project L.GEN.1704 and L.GEN.2204. The authors are grateful for the staff involved in collecting this data, funded through MLA L.GEN.1814 and B.SGN.0144.

REFERENCES

Gilmour A.R., Gogel B.J., Cullis B.R., Welham S.J. and Thompson R. (2021) 'ASReml SA User Guide Release 4.2' VSN International Ltd, Hemel Hempstead, HP1 1ES, UK.

Guy S.Z.Y., Mortimer S.I., Pannier L., McGilchrist P., Brown D.J., Pethick D. and Swan, A.A. (2022) *Proc.World Cong.Genet. Appl. Livest Prod*. **12**: 3000.

Pannier L., Tarr G., Pleasants T., Ball A., McGilchrist P., Gardner G.E. and Pethick D.W. (2025) *Meat Sci. In Press*

Mortimer S.I., Swan A.A, Pannier L., Ball A.J., Jacob R.H. *et al.* (2015) *Proc. Assoc. Advmt. Anim. Breed. Genet* **21**: 209.

Swan A.A., Pleasants T. and Pethick D. (2015) *Proc. Assoc. Advmt. Anim. Breed. Genet* **21**: 29.

van der Werf J.H.J, Kinghorn B.P. and Banks R.G. (2010) *Anim. Prod. Sci.* **50**: 998.