LAMB EATING QUALITY CAN BE MANAGED BY USING TERMINAL SIRES WITH DESIRABLE BREEDING VALUES FOR INTRAMUSCULAR FAT AND SHEAR FORCE

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SUMMARY

The lamb industry has made significant genetic change in growth rate, leanness and muscling, but has not been able to efficiently effect genetic change in eating quality. Research breeding values (RBVs) for intramuscular fat (IMF) and shear force (SF5) have been developed for the Australian sheep industry and the effectiveness of these was determined in 16 prime lamb production systems. Ewes were inseminated with semen from rams with divergent RBVs for IMF and SF5 and their lambs were processed through 13 abattoirs for seven lamb supply chains.
A 1% increase in terminal sire IMF RBV resulted in a 0.57% increase in lamb IMF and a 1N decrease in sire SF5 RBV resulted in a 0.7N decrease in shear force. However, there were unfavourable effects of these eating quality RBVs on other carcase traits; in particular, selection for improved eating quality using SF5 or IMF RBV is likely to decrease lean meat yield (LMY). Therefore, both eating quality and other carcase traits need to be taken into consideration simultaneously in genetic improvement programs in terminal lamb productions systems.

INTRODUCTION

Eating quality of lamb meat is largely driven by tenderness, juiciness and flavour, with consumers both domestically and internationally demanding premium quality and value for money when purchasing prime lamb meat (Pethick *et al.*, 2011). Meat tenderness, measured objectively as shear force at five days aging (SF5) and intramuscular fat (IMF) are the two key traits that determine eating quality and therefore consumer satisfaction for lamb (Pannier *et al.*, 2014) and both traits are heritable (IMF h^2=0.48; SF5 h^2=0.27; Mortimer *et al.*, 2014). The lamb industry has made significant genetic change in growth rate, leanness and muscling, but has not been able to efficiently effect genetic change in eating quality (EQ) due to the difficulty in measuring and selecting for these traits. In addition, there is a growing concern that the use of sires that are superior for lean growth might have a negative impact on the eating quality of lamb meat for consumers. Genetic selection for leanness and muscling has been linked to declining IMF levels (Hopkins *et al.*, 2005), which can have detrimental effects on the eating quality of lamb (Pannier *et al.*, 2014). The development of research breeding values (RBVs) for hard to measure traits by the Sheep CRC and Sheep Genetics may enable the sheep industry to genetically manage eating quality of lamb (Daetwyler *et al.*, 2012). Meat quality traits lend themselves particularly well to genomic prediction given they are currently impossible to measure in a live sheep. The aim of this project was to deliver “proof of concept” for eating quality attributes within major lamb supply chains and to determine the impact that selection of sires for these newly generated RBVs will have on eating quality of their lamb progeny in a commercial production system.

MATERIALS AND METHODS

Producer demonstration sites (PDS) were located in Western Australia (N=2), South Australia (N=2), Victoria (N=6), Tasmania (N=3) and New South Wales (N=3). Animal use in the project was approved by the respective organisational Animal Ethics Committees.

Commercial lamb producers prepared ewes for an artificial insemination (AI) program and commercial AI operators were engaged to undertake the process. Composite, Merino, White Suffolk x Merino, Corriedale, Cormo and Coopworth ewes (N=5752) were mated with semen from terminal sires (Poll Dorset and White Suffolk). Rams were selected for divergent RBVs for IMF and SF5. RBVs were calculated using single step genomic prediction that included all known genomic information from sheep with a 50K SNP test and all phenotypic information collected from the Sheep CRC Information Nucleus and Resource Flocks. The IMF RBVs ranged from -0.89% to 1.21% between sires and the SF5 RBVs ranged from -5.3N to 6.4N. Eight rams were used at each site with the exception of one site where semen from one sire was unviable so only seven rams were used at this site. A total of 86 terminal sires (39 Poll Dorset, 47 White Suffolk) and one maternal sire (Corriedale) were used, with 24 terminal sires (9 PD; 15WS) used at more than one site. Sires were given equal opportunity within site with ewes randomised for weight and body condition score. Sire RBVs were provided by Sheep Genetics from a run completed in September 2014, which did not contain data from the progeny in this experiment. A small blood sample was collected from the ear of each lamb at marking and sent to a commercial provider for parentage testing (sire only). Lambs were finished under normal commercial conditions to meet the individual producers target market and were slaughtered at 13 different plants. Carcase and eating quality measurements were undertaken in accordance with those developed by the Sheep CRC (Pearce, 2009). The carcases had an average IMF of 4.05% (SD=0.852%, min=1.42%; max=7.98%) across the 1303 lambs measured and PDS averages ranged from 3.33 ± 0.893% to 4.81 ± 0.865% across the 16 PDS. The average shear force was 36.9N (SD=13.63N; min=14.2N; max=100.1N) across the 1292 lambs and PDS averages ranged from 23.9 ± 7.89N to 53.4 ± 13.66N across the 16 PDS.

Statistical Analysis. IMF and SF5 data were analysed with a linear mixed effects model (SAS v9.3, SAS Institute, Cary, NS, USA). The model included site, kill group within site, birth type within site (single, multiple, unknown), sex and breed (PD, WS) as fixed effects. The curve linear term for each RBV along with interactions with sex and farm were also included in the models. Sire was included as a random effect. HCWT and its interaction were included as a covariate. The sire solutions from the analysis of each trait were estimated from the model with the RBV removed.

RESULTS & DISCUSSION

Relationship between IMF RBV and progeny performance. Sire was a significant covariate for IMF (P=0.0002). When IMF RBV was included as a covariate, the RBV had a significant effect on progeny IMF (P<0.0001). Across a 1.5% IMF RBV range, progeny IMF increased by 0.86 units of IMF, resulting in a 0.57 ± 0.097% increase in IMF associated with 1% increase in IMF RBV (Figure 1a). The use of the IMF RBV is likely to illicit a more rapid change in IMF levels than using PFAT ASBV which achieves between 0.1% IMF to 0.17%IMF per mm PFAT (Pannier *et al.*, 2014; Hopkins *et al.*, 2007).

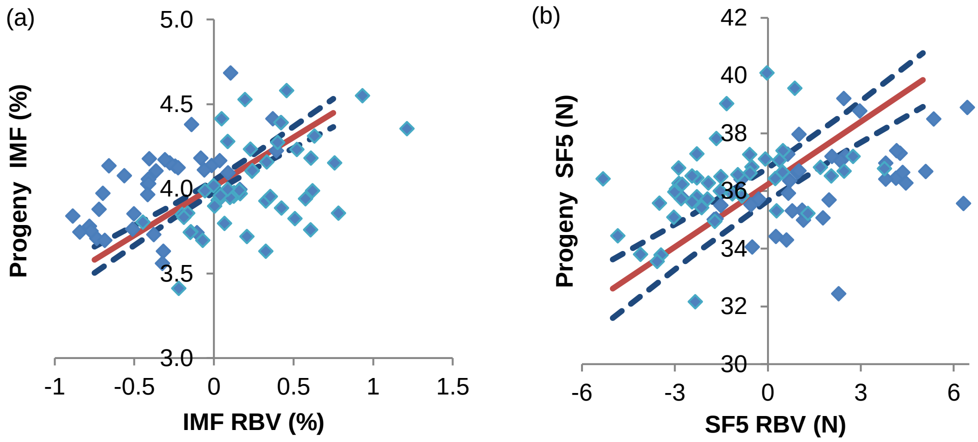

Figure 1. Relationship between (a) intramuscular fat (IMF) RBV and sire estimate of progeny IMF and (b) shear force (SF5) RBV and sire estimate of progeny SF5. Solid lines represent least square means of the sires RBV and dashed lines are the SEM. Sire estimates are obtained from the model not containing sire RBV.

At a constant IMF RBV, progeny from PD rams had 0.22±0.092 units more IMF than lambs from WS sires (P=0.015; Table 1). There was no interaction between IMF RBV and breed, indicating that the effect of IMF RBV on IMF of the progeny is the same across the two terminal breeds.

Sex, PDS and HCWT had a significant effect on IMF (P<0.001; Table 1). Female lambs had 0.17 ± 0.041% units more IMF than males. As the HCWT of the lamb increased from 18kg to 30kg, IMF increased from 3.8 ± 0.08% to 4.5 ± 0.10%. Therefore, for every 1kg increase in HCWT, there was a 0.06 unit increase in IMF. These effects are similar to those reported for the Information Nucleus Flock (Pannier *et al.*, 2014).

Table 1. Degrees of freedom (number [NDF]; and denomimator [DDF]), F value and probabilites of the fixed effects in the mixed model for IMF and Shear Force

		IMF			Shear force	
	NDF, DDF	**F Value**	**Pr > F**	**NDF, DDF**	**F Value**	**Pr > F**
RBV	1, 1167	35.53	<0.001	1, 1125	21.26	<0.001
Breed	1, 1167	5.99	0.015	1, 1125	0.27	n.s.
FARM	15, 1167	15.13	<0.001	15, 1125	3.16	<0.001
SEX	1, 1167	17.59	<0.001	1, 1125	5.2	0.023
SLDATE(FARM)	6, 1167	1.37	n.s	6, 1125	15.1	<0.001
BT(FARM)	12, 1167	1.68	n.s.	12, 1125	1.44	n.s.
FARM*SEX				15, 1125	1.74	0.038
HCWT	1, 1167	35.17	<0.001	1, 1125	7.95	0.005
HCWT*HCWT				1, 1125	6.57	0.011
HCWT*FARM				15, 1125	2.65	<0.001
HCWT*SEX				1, 1125	4.28	0.039

Relationship between SF5 RBV and progeny performance. Sire was a marginally significant covariate for shear force (P=0.052). When SF5 RBV was included as a covariate, the RBV had a significant effect on progeny shear force (P<0.001). Across a 10N SF5 RBV range, progeny shear force increased by 7.2 N of shear force, resulting in a 0.7 ± 0.16N increase in shear force associated with 1N increase in SF5 RBV (Figure 1b). There was no effect of breed, nor any interaction between breed and SF5 RBV (Table 1).

PDS, sex and slaughter date within PDS had a significant impact on shear force (P<0.001; Table 1). Female lambs (35.9 ± 0.71N) were more tender than male lambs (37.4 ± 0.65N; P=0.023). HCWT and HCWT*HCWT were significant covariates for shear force (P<0.001; Table 1). As the HCWT of the lamb increased from 18kg to 30kg, shear force changed from 41.8 ± 1.38N to 37.1 ± 2.4N.

SF5 RBV had a significant effect on LMY (P<0.001); a 1 N decrease in SF5 RBV resulted in 0.1 ± 0.03% decrease in progeny LMY. There was a 1.9% range in LMY sire solutions across the dataset examined, and 11.7N range in sire SF5 RBVs. This means that producers of terminal sired lambs selecting rams based solely on SF5 are likely to decrease LMY in their lambs.

IMF RBV had a significant effect on SF5 (P=0.003); a 1% increase in IMF RBV resulted in a 3.3 ± 1.10N decline in shear force. Similarly, a 1N decrease in SF5 RBV resulted in a 0.08 ± 0.016% increase in IMF (P<0.0001). This means selecting for either SF5 or IMF will have a positive effect on both eating quality traits in terminal lambs.

CONCLUSION

The newly created RBVs for EQ traits for terminal sires have a significant linear impact on the phenotypic expression in their progeny for IMF and SF5. Use of terminal rams with desirable IMF and SF5 RBVs will provide lamb consumers with better eating quality product. Both eating quality and other carcase traits need to be taken into consideration simultaneously in genetic improvement programs in terminal lamb productions systems.

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