Intramuscular fat is reduced in lambs from sires selected for leanness

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Abstract— **The Australian lamb industry selects for lean meat yield through the use of Australian Sheep Breeding Values, however there is concern regarding the impact of this on eating quality, as selection for lean growth has been linked with declining intramuscular fat (IMF) levels. Sires with reduced subcutaneous fat depth breeding values (PFAT) have reduced carcass fatness and increased loin muscle weight, whereas those with higher post-weaning eye muscle depth breeding values (PEMD) have increased muscularity. We hypothesised that selection for reduced PFAT and increased PEMD will decrease IMF levels. IMF was measured on 5556 lamb loins and linear mixed effects models were used to analyse this data. Fixed effects included site, drop, sex, birth type-rear type, dam breed and sire breed within sire type, sire type and kill group within site by drop, with sire and dam by drop identification as random terms. Hot carcass weight (HCWT), PFAT and PEMD were used as covariates to assess their association with IMF. HCWT (P<0.05) increased IMF levels by 2.40 IMF% units across the 28kg HCWT range. Reducing PFAT below 1.25 mm PFAT, decreased IMF by 0.61 IMF% units over the PFAT range. PEMD demonstrated a weaker association with IMF, reducing IMF levels by 0.44 IMF% units. Current selection objectives with high PEMD sires to increase lean meat yield would not impact as strongly on IMF levels as sires with low PFAT, however continuous selection for leanness might need to slow down to avoid IMF levels to drop below the consumer acceptable levels.**

Keywords— **Intramuscular fat, lamb meat, breeding values.**

I. INTRODUCTION

The Australian lamb industry selects for increased lean meat yield through the use of Australian Sheep Breeding Values. Sires with reduced subcutaneous fat depth (PFAT) breeding values have reduced carcass fatness and increased loin muscle weight, whereas those with higher post-weaning eye muscle depth (PEMD) breeding values have increased muscularity. Increasing selection for lean growth has been linked to declining intramuscular fat (IMF) levels with subsequent detrimental effects on meat eating quality [1]. Lamb contains about 4-5% IMF [1], and studies have demonstrated that this level is required to achieve consumer satisfaction [2]. We hypothesised that lambs from sires with reduced PFAT breeding values and increased PEMD breeding values would have decreased IMF levels in lamb meat.

II. MATERIALS AND METHODS

Details of the design of the Australian Sheep CRC Information Nucleus Flock have been presented elsewhere [3]. Approximately 6000 lambs were produced over a 3 year period (drop 2007-2009) at 8 research sites across Australia (Katanning WA, Cowra NSW, Trangie NSW, Kirby NSW, Struan SA, Turretfield SA, Hamilton VIC, and Rutherglen VIC). The lambs were progeny of 278 key industry sires representing major production types (maternal, merino, terminal) in the Australian sheep industry and were mated to Merino and crossbred (Border Leicester–Merino) ewes. Lambs were measured and sampled for carcass, meat and growth traits and were slaughtered at a target average carcass weight of 22kg. At 24h post-mortem the *longissimus thoracis lumborum* muscle was excised and samples (40g) were taken for IMF analysis using a near infrared procedure in a Technicon Infralyser 450 [4].

IMF data was analysed using linear mixed effects models (SAS) including fixed effects for site, drop, sex, birth type-rear type, sire type, dam breed within sire type, sire breed within sire type and kill group within site by drop. Hot carcass weight (HCWT) was

included as a linear covariate, and sire identification and dam identification by drop were included as random terms. All relevant first order interactions between fixed effects and covariate were tested and non-significant (P>0.05) terms were removed in a stepwise manner. Within this model, covariates such as weight of short loin fat and muscle, and eye muscle area were included one at the time to assess their phenotypic association with IMF.

The associations between IMF and sire breeding values for post weaning weight (PWWT), eye muscle depth (PEMD) and c-site fat depth (PFAT) were also tested by including all 3 breeding values as covariates in the model, as well as their first order interactions with other terms, with non-significant (P>0.05) terms removed in a stepwise manner.

III. RESULTS

Data of 5556 lambs was used in the phenotypic linear mixed effects model within which there were significant (P<0.05) effects for site, drop, sex, sire type, dam breed within sire type, kill group within site by drop and HCWT. Within each of the sites IMF% differed between drops by as little as 0.18 IMF% units for the Katanning site to as much as 1.10 IMF% units for the Rutherglen site. On average, lambs from Kirby (4.73 IMF%) and Katanning (4.95 IMF%) had the highest IMF levels compared to all other sites, and had fairly consistent levels of IMF across the 3 drops. Females had about 0.15 IMF% units more than males, but this difference varied between the 8 sites with some sites showing no difference, and at others females differed from males by as much as +0.25 IMF% units. Merino and maternal sired lambs had 0.11 and 0.14 IMF% units more than terminal sired lambs, and within the terminal sired lambs, the progeny of merino dams had 0.10 IMF% units less compared to the progeny of Border Leicester–Merino dams. Furthermore, within each site by drop there were marked differences between kill groups which varied by as much as 1.82 IMF% units however these differences showed no obvious trend across site by drop.

HCWT as a covariate had a positive relationship with IMF, increasing levels by 2.40 IMF% units across the 28kg HCWT range (Fig.1). Loin fat weight had a positive relationship with IMF which increased by about 1.62 IMF% units between 10 and 500 g loin fat. The opposite relationship was seen for short loin weight and eye muscle area, with IMF decreasing by about 1.42 IMF% units between a loin weight range of 200 to 550 g and decreasing by about 0.60 IMF% units between 10 and 20 cm^2 eye muscle area values.

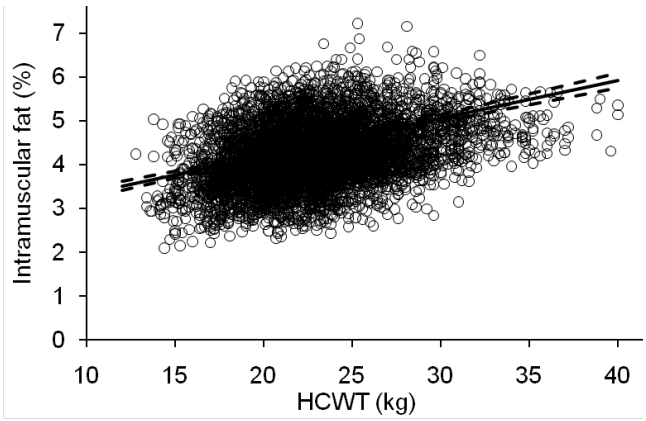

Fig. 1. Effect of hot carcass weight on IMF levels

When the 3 sire breeding values for PWWT, PFAT and PEMD were included simultaneously in the model, only PFAT and PEMD (P<0.05) impacted on IMF%. A reduction in PFAT from 1.25 mm to -2.25 mm was associated with a decrease of about 0.61 IMF% units (Fig. 2). Above PFAT values of 1.25 mm there was no impact on IMF%. Across the PEMD range, IMF decreased by 0.44 IMF% units (Fig. 3).

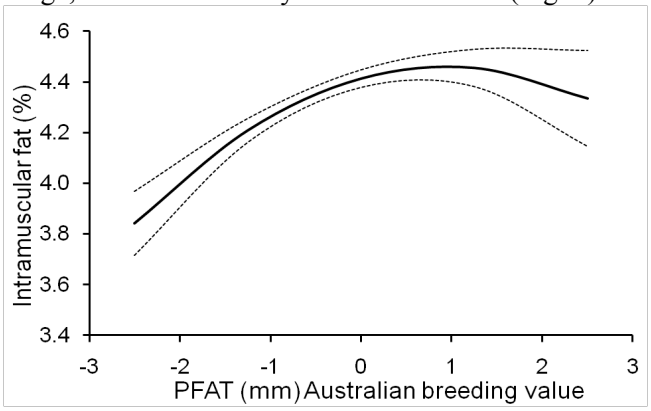

Fig. 2. Effect of PFAT on IMF concentration (%) for Merino, Maternal and Terminal sires

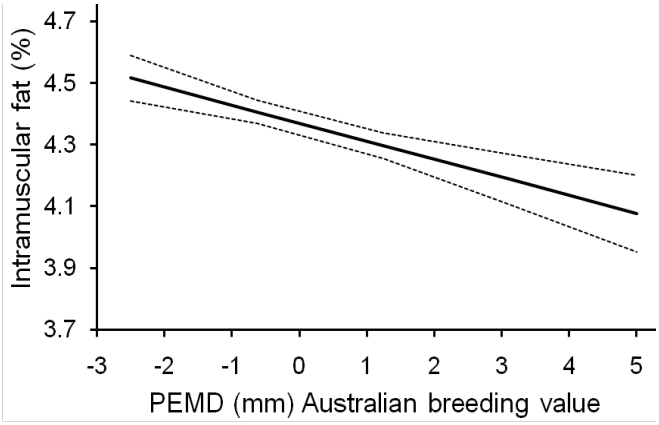

Fig. 3. Effect of PEMD on IMF concentration (%)

IV. DISCUSSION

To claim a source of 'low fat' meat cuts, the IMF content should be less than 3% fat [5], however levels above 4% are required to underpin consumer satisfaction [2,6]. The average level of IMF for all progeny lambs of the Sheep CRC Information Nucleus Flock was 4.23%, thus falling within the palatability target for IMF levels.

The major source of variation observed for IMF was between HCWT, drops, site by drop, followed by sex. There was more IMF in the heavier carcasses, aligning well with previous studies which have described this relationship in cattle [7], also demonstrating a linear increase in IMF by 0.47% for every 10kg of HCWT between a range of 200-400kg carcass weight [8-9]. The increase in IMF was expected as HCWT reflects growth rate within our study, emphasising the importance of growth rate as a strong driver of IMF. Most sites, except the Katanning and Kirby site, indicated a lot of variation between the 3 drops. The basis for these differences remains unclear, and may warrant further investigation to elucidate their underlying causes (e.g. nutrition). Within this analysis, female lambs demonstrated significantly higher IMF levels than male lambs, and this effect was still present when the model was corrected for weight of short loin fat, another measure of whole carcase fatness, indicating that the IMF difference between females and males may be due to more than just total carcase adiposity. There was a negative association between IMF and muscularity (short loin weight and eye muscle area) aligning well with the notion that selection of animals for lean growth results in a decline in IMF levels [10].

The PFAT sire breeding values had a significant impact on the IMF levels. This effect implies that current selection objectives for lean growth using sires with low PFAT are likely to reduce the IMF content in lamb meat. The PEMD sire breeding values demonstrated a weaker association with IMF levels, implying that using sires with high PEMD to increase lean meat yield would impact less strongly on IMF levels and eating quality than sires with low PFAT. Furthermore, the reduction of IMF driven by PFAT and PEMD reached minimum IMF levels of about 4 IMF% units, and preliminary association analysis of Sheep CRC data [Pannier et al., unpublished] indicates a strong negative effect of IMF on sensory tenderness score, further highlighting the importance of this trait in maintaining consumer satisfaction. The PWWT sire breeding value did not impact on IMF levels, however given that this model was corrected for HCWT, a measure of growth rate, this result is not unexpected. Hence, when the HCWT covariate was removed from the model, PWWT demonstrated a strong positive impact on IMF levels. This result further highlights the importance of growth rate to underpin adequate IMF.

V. CONCLUSIONS

Aligning with our hypothesis, selection for sires with reduced PFAT breeding values and increased PEMD breeding values decreased IMF levels in lamb meat, and therefore emphasises the current concerns of selecting for lean growth and its impact on the eating quality. For this reason continued selection for leanness should be carefully monitored to avoid IMF levels dropping below the critical 4% threshold required to underpin consumer acceptance. Alternatively, selection programs could incorporate a measure of IMF for inclusion within the selection index.

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