ALPHA-LINOLENIC ACID (ALA) AND ITS LONGER CHAIN OMEGA-3 DERIVATIVES (EPA, DPA & DHA) IN MEAT FROM LAMBS REARED UNDER EXTENSIVE GRAZING ACROSS SEVERAL LOCATIONS OF AUSTRALIA

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***Abstract*—Within the Australian Sheep Industry CRC Information Nucleus flock, lamb progeny were produced at seven sites across Australia in 2007. Ninety four sires of Merino, maternal and terminal types were joined to 4500 Merino and crossbred (Border Leicester x Merino) ewes. The present study discusses the preliminary results on long chain polyunsaturated fatty acids in lamb meat particularly the parent (18:3n-3) and its longer chain derivative omega-3 fatty acids (20:5n-3, 22:5n-3 & 22:6n-3) from the 2007 drop progeny. Lamb progeny at each site were raised under grazing conditions with the provision of grain supplementation during periods of low availability of quality pasture. Slaughter data were obtained from crossbred progeny of the following breed crosses: Terminal x Merino, ewes and wethers, Border Leicester x Merino wethers and Terminal x Border Leicester x Merino, ewes and wethers and also Merino wethers. Homogeneous 0.5 g samples of *longissimus lumborum* were used for the determination of fatty acid composition. The major sources of variation in long chain omega-3 fatty acids were between flocks (sites, $P < 0.001$) and between kill groups ($P < 0.001$) within flocks. The effects of sire on long chain omega-3 fatty acids level were small, but statistically significant ($P < 0.001$). In general the provision of feedlot or grain diets at greater amounts prior to slaughter, during periods of low availability of quality pasture further reduced the levels of the parent and its longer chain omega-3 fatty acid derivatives. Overall, the results for eicosapentaenoic acid (EPA, 20:5n-3) plus docosahexaenoic acid (DHA, 22:6n-3) indicate that Australian lamb can be classified as a source of omega-3 fats (32 mg/135 g serve) for those who consume lamb in their regular diet. These are the first national data showing a snap shot of the omega-3 content of lamb covering sire lines, genotypes and major production systems in Australia.**

***Index Terms*— Lamb, environment, feed, genotype, omega-3 polyunsaturated fatty acids.**

I. INTRODUCTION

Current consumers are health conscious and they prefer to eat foods rich in vitamins, minerals, antioxidants and essential fatty acids (Bermingham, Roy, Anderson, Barnett, Knowles & McNabb, 2008). Red meat intake in Australian adults is 6 times higher than fish intake and an updated national nutrition survey on fatty acid composition showed that red meat contributed almost as much as seafood to the long-chain omega-3 polyunsaturated intake (Howe, Buckley & Meyer, 2007). Newly introduced nutrient reference values indicate that most Australians need to increase their intake of the long chain omega-3 polyunsaturated fatty acids so as to reduce the risk of chronic disease (Howe et al., 2007). These fatty acids include eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and docosapentaenoic acid (DPA), but DPA cannot currently be included in the nutrient content claim for omega-3 under the Food Standards Code (FSANZ, 2005).

There can be variation in fatty acid composition and the levels of health claimable fat (EPA plus DHA) in lamb due to variation in feed types, genotypes, length of feeding, age at slaughter, gender or birth type. It is apparent that nutritional manipulation can be used to alter the levels of EPA and DHA found in muscle (Sinclair, 2007). Genetic manipulation is another potential approach to increase muscle omega-3 levels (De Smet, Raes & Demeyer, 2004). This large study, using approximately 2000 lambs from 7 sites covering a wide range of sheep genetics and environments across Australia, investigates the environmental variation on long chain omega-3 polyunsaturated fatty acid content of lamb, slaughtered at similar carcass weights.

II. MATERIALS AND METHODS

Details of sire types, dam breeds, experimental locations, breeding program and genetic parameters for traits measured are given elsewhere (Fogarty, Banks, van der Werf, Ball & Gibson, 2007). In brief 4500 ewes at 7 locations were joined to 94 selected sires of Merino, maternal and terminal sires over the summer/autumn of 2007/2008. The sites used were at Armidale (New South Wales), Cowra (New South Wales), Rutherglen (Victoria), Hamilton (Victoria), Turretfield (South Australia), Struan (South Australia) and Katanning (Western Australia). Lambs were maintained under extensive grazing systems with the provision of supplementary feeds during times of poor availability of quality pasture. Lamb progeny from Cowra were fed mainly on quality perennial pasture (mainly lucerne), those at Rutherglen and Struan mainly on annual pasture, however at Rutherglen it also included pellets and at Straun grains such as beans and barley with straw were offered prior to slaughter for kill groups 3-5 due to senescing pasture. Hamilton, Turretfield and Kataning lambs were mainly fed on grains such as lupins, barley, oats with grass hay and oaten hay, triticale or barley grass. At each site lambs were slaughtered at several kill dates so as to achieve a target slaughter weight of approximately 21 kg. On average, lambs from the Cowra site took the shortest time to reach the target weight and those at Hamilton took the longest time and others sites had similar finishing times (Figure 1).

Statistical analysis

Parsimonious REML models, after an appropriate transformation, were developed for the fatty acids and combinations of fatty acids. Effects examined included sire, dam, flock, kill within flock, sire type, sire breed, dam breed, birth type, rearing type, age at kill, age of dam, lamb gender, calculated intramuscular fat and separate residual variation of lambs between flocks and kills. Intramuscular fat was calculated as the sum of individual fatty acids level as quantified from the GC and used in the model. The Kirby site was excluded from the analysis because, for several fatty acids, the values follow a mixture distribution and the application of REML models is inappropriate.

III. RESULTS

A wide range of mean values for the parent fatty acid alpha-linolenic acid (ALA, 18:3n-3) and the longer chain derivatives such as EPA+DHA and EPA+DPA+DHA were observed between sites. The major effects found in the analysis for causing variation in ALA and the longer chain derivative EPA, DPA, DHA content were flock (site, $P < 0.001$) and slaughter date (kill group, $P < 0.001$) within flock (Figures 2 - 4), which is a reflection of different types and levels of nutrition. Sire effects were small, but statistically significant ($P < 0.001$). Other factors such as sire type, sire breed, rearing type, birth type, dam breed, calculated IMF, gender, age of dam or age at slaughter had a minor or no effect. An age effect was not significant after allowing for slaughter day.

Figure 1

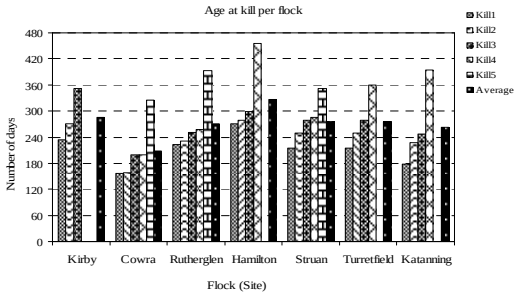


Figure 2

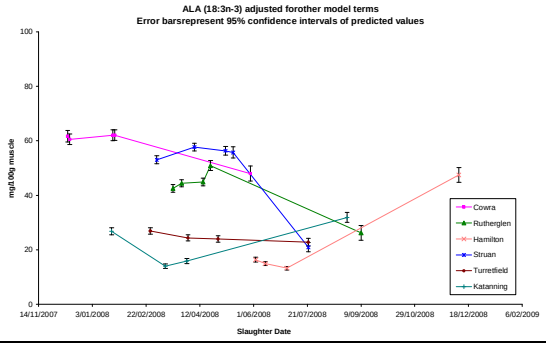


Figure 3

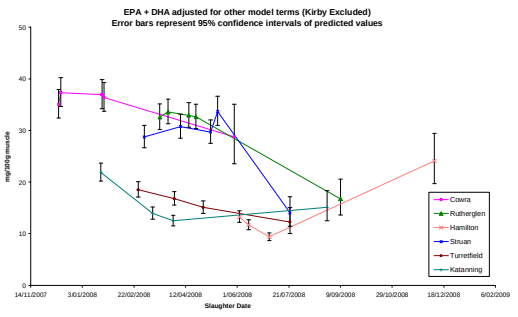
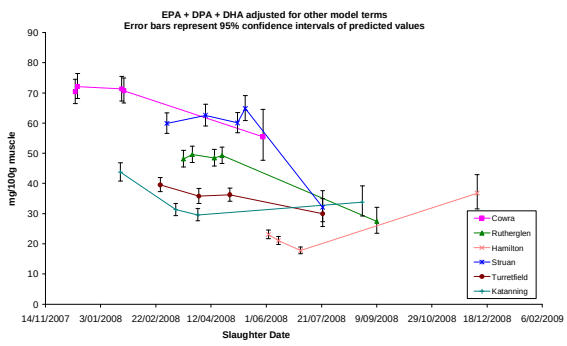


Figure 4



Figures 1-4 show the number of days taken to reach lamb slaughter weight for each kill at each site (Figure 1), and predicted means (mg per 100 g fresh muscle) with 95% confidence intervals for ALA (Figure 2), EPA + DHA (Figure 3) and EPA + DPA + DHA (Figure 4) levels across sites and kill groups.

IV. DISCUSSION

When comparing the EPA, DPA & DHA the results show that those flocks and kill groups that had higher levels of ALA tend to produce greater levels of longer chain derivatives and vice versa (Fig. 2, 3 and 4). Nutrient reference values for Australia and New Zealand (Williams, 2007) indicate that any food containing 30 mg and 60 mg EPA+DHA per serve can be categorised as a "source" and 'good source' of omega-3 fats, respectively. Accordingly, a serve of lamb (135 g portion) from the Cowra, Rutherglen and Struan sites can be claimed as a source of omega-3. Lambs at Hamilton, Turretfield and Katanning have omega-3 levels at about 75% of the level needed for a similar claim.

The national average of EPA plus DHA per 100 g of fresh lamb meat was 24 mg, which was equivalent to a level of 32 mg in a 135 g serve. This was higher than the 30 mg cut-off point required for a 'source' claim for omega-3 (FSANZ, 2005). This is the first national data showing a snap shot of the omega-3 content of lamb which encompasses many recognised sire lines, genotypes and major production systems in Australia. More slaughters are needed from subsequent years to underpin the magnitude of the genetic and seasonal variation in EPA plus DHA content of lamb meat.

V. CONCLUSION

There was a major variation in ALA and the longer chain derivatives EPA, DPA & DHA levels between sites and between kills within each site. Effects of sire type, sire breed and dam breed on ALA or health claimable omega-3 fatty acid (EPA+DHA) levels in muscle were minor. Results demonstrate that the long chain polyunsaturated fatty acids in lamb, including health claimable EPA and DHA levels are highly sensitive to diets from the grazing environment.

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