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Sources of variation of health claimable long chain omega-3 fatty acids in meat from Australian lamb slaughtered at similar weights

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ABSTRACT

The sources of variation of health claimable omega-3 polyunsaturated fatty acids (eicosapentaenoic acid, EPA + docosahexaenoic acid, DHA) in 2000 Australian lambs were investigated using 98 sires (Merino, maternal or terminal breeds) that were mated to about 5000 Merino or crossbred (Border Leicester × Merino) ewes. Pasture was supplemented with feedlot pellets, grains or hay as necessary, when the availability of quality green pasture was limited. Lambs were grown at 8 sites across Australia and when slaughtered the *longissimus lumborum* muscle was collected. Site and kills within sites were the major sources of variation for health claimable fatty acids. These environmental effects are likely to be driven by dietary background. The sire variance differed from about one twentieth to a half of the residual lamb within dam variation, depending on site and kill. This is the first comprehensive study to investigate on-farm sources of variation of long chain omega-3 polyunsaturated fatty acid content of lamb meat.

1. Introduction

Fats in the human and animal body provide structure and energy for work, act as a media for transporting nutrients (vitamins and carotenoids), and act to regulate reproduction and health (Mattos, Staples, & Thatcher, 2000; Palmquist, 2009; Sampath & Ntambi, 2005). Research from the last two decades has shown that long chain omega-3 polyunsaturated fatty acids, such as eicosapentaenioc acid (EPA) and docosahexaenoic acid (DHA), have beneficial effects over other fatty acids present in diets for the maintenance of long term health (McAfee et al., 2010; Simopoulos, 1999). In some countries, such as Australia and New Zealand, it is legal to make claims that foods with higher levels of EPA and DHA offer health benefits (Anonymous, 2012; Food and Drug Authority, 2011). Red meat, including lamb, is a dietary source of EPA and DHA, but there is considerable variability in the reported concentration of these fatty acids in red meat (Droulez, Williams, Levy, Stobaus, & Sinclair, 2006; Enser et al., 1998; French et al., 2000; Ponnampalam et al., 2010; Scerra et al., 2011; Scollan et al., 2006). Thus, there is a need to identify those on-farm factors that cause variation in the levels of EPA and DHA in lamb.

The Australian Sheep Industry Co-operative Research Centre is currently running the sheep Information Nucleus Flock programme, with the aim to estimate genetic parameters for new traits, to undertake a large-scale whole-genome study and to enhance the breeding values of animals in commercial studs (van der Werf, Kinghorn, & Banks, 2010). In a preliminary report, the large differences in EPA + DHA between flocks (sites) and kills (different slaughter dates) at the same site, for the 2007/2008 cohort were reported, although this reporting did not include a full consideration of all sources of variation (Pannier et al., 2010). The present study describes an analysis of all detectable sources of variation using the 2008/2009 cohort.

In brief, this study investigated the sources of variation for the health claimable long chain omega-3 polyunsaturated fatty acid content of Australian lamb, at similar carcass weights. Approximately 2000 lambs from 8 sites across Australia, covering a wide range of sheep genetics and production environments, were included.

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2. Materials and methods

2.1. Details of animals and management

The data were recorded on animals born in the second year (2008/2009 cohort) of the Information Nucleus Flock programme of the Australian Sheep Industry Cooperative Research Centre. The detailed analysis of all observable sources was restricted to one year so as to reduce the complexity of the statistical analysis, although preliminary analyses of other years indicate similar outcomes. The 2008/2009 cohort was chosen as this was the first year of the study to include all study sites.

Details of sire types, dam breeds, experimental locations, breeding and measurement programmes for this flock are given elsewhere (van der Werf et al., 2010). At each site lambs were slaughtered across several slaughter dates so as to achieve a target carcass weight of approximately 21.5 kg. As is the common practice in Australia, lambs were grown under extensive grazing systems with the provision of supplementary feeds during times when the availability of quality pasture is low (Table 1). Post weaning, with the exception of the Katanning site at some periods, all lambs at a site were managed as a single mob. Large differences in environment and pasture/feeding management led to large differences between sites in the slaughter ages of lambs (~150 to 500 days, Table 2). The target carcass weight was approximately achieved at most slaughters across all sites (flocks) (Table 2).

All sites had Merino × Merino and Maternal (mainly Border Leicester) × Merino lambs. All sites had lambs from terminal sires joined to Merino dams (Terminal × Merino) or terminal sires joined to crossbred dams (Terminal × Border Leicester Merino), or both (Table 2). Ninety one out of the 98 sires in the current study were of the Poll Dorset (a terminal breed), Border Leicester (a maternal breed), Merino, White Suffolk (a terminal breed) or Poll Merino breeds. Other breeds represented were Southdown, Texel, Suffolk, Booroola and Ile de France. Pure Merinos were mostly slaughtered at much later ages, due to their slower growth rates.

About 2000 of the lambs were slaughtered at 5 abattoirs across Australia. At 24 h post-slaughter, a sample of 40 g (loin; m. *longissimus lumborum*) was collected for individual fatty acid and total fatty acid determination. Each muscle sample was cut into small square (1 cm) pieces, freeze dried and used for the analysis.

2.2. Fatty acid analysis

Samples collected from the 8 sites were systematically allocated in order of sample to two laboratories for sample processing and fatty acid determination. Each laboratory followed the same procedures, columns and temperature setup. Calibration was achieved by testing the same pool sample 10 times each year. Variation less than 5% between laboratories was maintained in the current study. A homogeneous sample of freeze dried ground material (0.5 g) was used for the determination of fatty acid composition using a rapid modified procedure developed from the method reported by O'Fallon, Busboom, Nelson, and Gaskins (2007). One hundred μL of nonadecanoic acid methyl ester (C19:0, Sigma Aldrich Pty Ltd, Castle Hill, NSW 2154, Australia) was added to muscle samples as an internal standard dissolved in chloroform (10 mg C19:0/mL $CHCl_3$). The contents were hydrolysed using 0.7 mL of

Table 1
The nutritional history of 2008/2009 cohort lamb progeny used in the study.

Site	Pasture type early post-weaning	Pasture type late post-weaning	Concentrate early post-weaning	Concentrate late post-weaning
Kirby				
Kill 1	Mixture of dried native grass/improved perennial grass/white clover	Dried pasture	No supplement	Finisher pellets
Kill 2				
Kill 3				
Kill 4	Dried pasture	Dried pasture	Finisher pellets plus barley	Finisher pellets plus barley
Trangie				
Kill 1	Mainly native pasture-windmill grass, spear grass, barley grass/some sown pasture (lucerne)	Green 80%/dry 20%	Lucerne hay + oats/pellets	Pellets
Kill 2		Green 20%/dry 80%		
Kill 3		Green/dry 100% 0%		
Cowra				
Kill 1	Temperate perennials-phalaris, sub clover/Lucerne-winter and summer active	Desiccating lucerne and other native pasture	No supplement	No supplement
Kill 2				
Kill 3				
Rutherglen				
Kill 1	Annual green pasture-annual ryegrass, sub clover/lucerne, phalaris	Annual pasture/lucerne	Cereal/canola hay	Cereal/canola hay
Kill 2		Annual pasture/lucerne		
Kill 3		Lucerne/clover 90/10%		
Kill 4		Lucerne/clover 90/10%		
Hamilton				
Kill 1	Perennial pasture-ryegrass	Rape and millet	Barley 3 kg/wk/head	Barley 4 kg/wk/head
Kill 2		Green pasture Ryegrass and tall fescue		
Kill 3				
Kill 4		Green pasture ryegrass and tall fescue	Barley 3 kg/wk/head	Barley 4 kg/wk/head
Struan				
Kill 1	Green pasture followed by pasture senescence and then irrigated pasture (14/11/08)	Irrigated pasture (kills 1 & 2)	No supplement (kills 1 & 2)	No supplement (kills 1 & 2)
Kill 2				
Kill 3		Dry pasture 23/3/09 to 4/5/09 Feedlot 4/5/09	No supplement	Silage/lentils Lentil/barley/silage
Turretfield				
Kill 1	Windrowed ryegrass & wild oats	Dry pasture and barley stubble	0.25 kg/hd/day barley/pea mix	0.50 kg/hd/day barley/pea mix
Kill 2	Windrowed ryegrass & wild oats	Dry pasture and barley stubble	0.25 kg/hd/day barley/pea mix	0.75 kg/hd/day barley/pea mix
Kill 3	Windrowed ryegrass & wild oats	Feedlot	0.4 kg/hd/day barley/pea mix	Ad-lib/hd/day barley/pea mix plus oaten hay
Katanning				
Kill 1	Annual grass and subclover	Mostly green	Lupins, oats grains for 1–3 months	Lupins, oats grains for 1–3 months
Kill 2		Senesced pasture		
Kill 3				
Kill 4				
Kill 5		Annual grass, subclover	No supplement	No supplement