SATURATED AND MONOUNSATURATED (OLEIC) FATTY ACID CONCENTRATION OF LAMBS REARED FOR MEAT PRODUCTION IN AUSTRALIA

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Abstract – This study investigated the effect of production system (finishing diet) on major saturated (C12:0, 14:0, 16:0 & 18:0) and monounsaturated (oleic; C18:1cis) fatty acid concentrations in meat from lambs grown at 8 production locations across Australia. Sires were selected from Merino, maternal and terminal meat breeds; whilst the ewes consisted of approximately 80% Merino and 20% crossbred types. Lambs were generally maintained under extensive pasture conditions, but were fed grain, hay or feedlot pellets when the pasture supply was limited. Lambs were slaughtered over three consecutive years (2008-2010), with 28-30 kills per year for a total of 5726 lambs. At 24 h post-mortem, 20 g muscle samples (*longissimus lumborum*: LL) were taken for fatty acid determination. Lambs from some sites had a higher ($P < 0.001$) concentration of major saturated (palmitic and stearic) and oleic acids in meat that is proposed to be associated with those lambs being fed diets higher in cereal grain content. The results demonstrate that the finishing diet type can significantly influence the concentration of major saturated (palmitic, stearic) and/or oleic acids in meat from lambs produced under different production systems in Australia.

Key Words –lamb, muscle, fatty acids.

I. INTRODUCTION

Finishing diet, genetic background and age are the major factors affecting fatty acid (FA) composition in meat [1,2]. Lamb production in Australia is primarily based on extensive finishing systems. The type of feed and nutritive characteristics of feed vary due to seasons and environment, which in turn influences the fatty acid composition of meat. Fatty acids are generally classified as saturated- (SFA), monounsaturated- (MUFA) and polyunsaturated (PUFA) fatty acids according to the number of hydrogen atoms attached to the carbon atoms. The variation in SFA and MUFA composition is mainly due to type and level of fatty acids present in the diet, but the level of the various fatty acids can also be influenced by microbial degradation, hydrolysis and biohydrogenation of dietary fats in the gastrointestinal tract [3]. Genetic background can also influence FA composition, for example the meat from Wagyu cattle breed is known for a higher level of C18:1 (oleic acid) when compared to other breeds.

Saturated fatty acids from meat have been implicated with the development of chronic diseases such as cardiovascular disease, hypertension, obesity and some sort of cancers [4]. Among saturated fatty acids, lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids are considered to be detrimental to human health due to their association with increased blood cholesterol and low density lipoprotein (LDL) cholesterol [5], whereas stearic (C18:0) is considered neutral. On the other hand, the major MUFA found in meat, oleic acid (C18:1cis) is shown to be hypolipidemic in terms of reducing blood cholesterol and triglycerides, while polyunsaturated fatty acids are essential to growth and development, and disease prevention in animals and humans [6].

Meat, oils and dairy products are the major contributors of dietary SFA and MUFA intakes while offering moderate amounts of PUFA. There have been reports on health claimable long chain omega-3 (EPA & DHA) fatty acids [7] and omega-6 and omega-3 fatty acids [8] in Australian lamb. The aim of this study was to investigate the effect of finishing diet on saturated fatty acid

(C12:0, 14:0, 16:0 & 18:0) and oleic acid (C18:1cis) concentrations in meat from lambs grown at 8 different production locations in Australia over three consecutive years (i.e. 2008 – 2010).

II. MATERIALS AND METHODS

For this study, sires were selected from a range of breeds used in the Australian sheep industry (Merino, maternal and terminal meat breeds). The base ewes, depending on the research site usually consisted of approximately 80% Merino and 20% crossbred types. Lambs were generally maintained under extensive pasture conditions, but were fed grain, hay or feedlot pellets when the pasture supply was limited. Extensive information on the nutritional background of the lambs over the three years of production period is given by [7]. The eight production locations are Armidale (Kirby), Trangie and Cowra from state of New South Wales; Rutherglen and Hamilton from state of Victoria; Struan and Turretfield from state of South Australia; and Katanning from state of Western Australia. Lambs were slaughtered between 2008-2010 over approximately 28-30 kills per year at a target carcass weight of 21.5kg across several slaughter dates. Muscle samples, *M. longissimus lumborum* (LL) were taken from 5726 lambs at 24 h post-mortem. The LL samples (~20 g) were freeze dried, ground and a homogeneous 0.5 g sample was used for fatty acid extraction, methylation and quantification by gas chromatography as described by [8]. Fatty acid peaks were identified using a reference standard (Supelco C4-C24 mix, Sigma Aldrich Pty Ltd, NSW 2154, Australia) and fatty acid concentrations are reported in mg/ 100 g meat.

Predicted means of a range of fatty acids for various production locations were generated using restricted maximum likelihood (REML) mixed model analyses with production location (Flock) as a fixed effect and sire and dam as random effects. The Wald F-tests were used to determine the overall significant difference among the predicted means, whereas the difference between two predicted means was judged to be significant if it was at least 2 times the average standard error of difference.

III. RESULTS AND DISCUSSION

Among the SFA the concentration of lauric acid (C12:0) was found to be the smallest, palmitic and stearic were greatest and myristic was at a modest level. Oleic acid was the major MUFA, and is found in the greatest quantity among all FA found in meat (Table 1).

Production sites had significantly different effects on all SFA ($P < 0.001$, Table 1). Although small in magnitude, lambs from Hamilton and Turretfield had the lowest concentration of lauric acid and ranged from 3.4-3.8 mg/100 g of muscle LL. Kirby, Trangie, Struan and Katanning had a moderate concentration of lauric acid and ranged from 4.1-4.5 mg/100 g of muscle LL. Whilst, Rutherglen and Cowra had highest concentration of lauric acid and ranged from 4.8-5.1 mg/100 g of muscle LL (see Table 1). Myristic acid concentration was greatest in lambs produced from Cowra, Rutherglen and Katanning, lowest in lambs produced in Trangie and Turretfield and modest in lambs produced at other sites. Palmitic and stearic acid were greatest in lambs produced from the Kirby, Hamilton and Katanning sites and lowest in lambs produced from Trangie, Cowra and Struan and moderate at the Rutherglen and Turretfield sites. Oleic acid was also significantly different between production sites with highest ($P< 0.001$) concentration found in lambs produced from Kirby, Hamilton and Katanning, lowest in those from Trangie and Struan and moderate at other sites.

There was a clear indication of significant effects of finishing diet on major SFA and MUFA (oleic acid) in lamb meat. As reported in other studies for sheep [9,10], lauric and myristic acids were present in smaller concentrations while palmitic and stearic acids were present in greater concentrations in meat. Lambs grown at Kirby, Hamilton and Katanning produced the highest palmitic (C16:0) and stearic (C18:0) acid concentrations, which might have been contributed by the background diet during the finishing period. Lambs from these sites were predominantly fed a feedlot ration or oat/barley grains with lupins due to the unavailability of green pastures. Further details of the diets used and the feeding

Table 1. Effect of production sites on major saturated (lauric, C12:0; myristic C14:0, palmitic C16:0 and stearic C18:0), monounsaturated (Oleic, C18:1) and total saturated fatty acid (SFA) concentration (mg/ 100 g meat) of muscle <u>*longissimus lumborum*</u> from lambs grown in eight production sites of Australia

Fatty acid	Kirby	Trangie	Cowra	Rutherglen	Hamilton	Struan	Turretfield	Katanning	SED	*P-Value*
C12:0	4.1^{b}	4.1^{b}	5.1^{d}	4.8^{d}	3.4^{a}	4.4^{c}	3.8^{b}	4.5^{c}	0.15	0.001
C14:0	70^{b}	61^{a}	75^{c}	76^{c}	67^{b}	69^{b}	63^{a}	77^{c}	2.1	0.001
C16:0	741^{d}	530^{a}	602^{b}	662^{c}	714^{d}	587^{b}	600^{b}	738^{d}	13	0.001
C18:0	491^{c}	420^{a}	442^{b}	494^{c}	520^{d}	443^{b}	457^{b}	633^{e}	9.3	0.001
C18:1	1404^{g}	899^{a}	1005^{b}	1164^{d}	1281^{e}	979^{b}	1062^{c}	1328^{f}	23	0.001
SFA	1360^{d}	1064^{a}	1178^{b}	1296^{c}	1354^{d}	1156^{b}	1171^{b}	1507^{e}	23	0.001

background over the three years are provided by [7]. At Cowra, Trangie and Struan, when pasture (either green or desiccated) was major portion of the diet during the finishing period, the concentration of palmitic and stearic acid were lower in meat, whilst intermediate concentrations were shown in lambs finished with pasture/hay and different levels of grain supplements. Previous studies conducted in lambs showed lower concentration of palmitic acid with grass finishing [10] when compared to concentrate feeding. The concentration of lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids that are considered detrimental to human health were reported to be lower in lambs finished with pasture compared with those finished on concentrate diets [11]. The latter study indicated that the proportion of palmitic acid was increased with increased levels of concentrate diet, with the lowest concentration found in lambs fed pasture while intermediate concentrations were found in meat from lambs fed a mixture of pasture and concentrate diets. The findings support the findings from this current study. This indicates that the variation in major saturated fatty acids (C16:0, C18:0) found in meat mainly depend on the combination of the diets provided during the finishing stage and selection of diets by the animals.

The effect of diet on myristic acid concentration was not very clear, with Rutherglen, Cowra and Katanning having the highest concentrations, Trangie and Turretfield having the lowest and others being moderate. Lambs finished at the Cowra, Rutherglen and Struan sites were comparatively given more pasture and less feedlot/ grain diets compared to other sites that were provided with more feedlot/grain and less pasture. In the current large scale study, there was no data available on how the animals selected the diets and how much was consumed. Although smaller in magnitude, similar to myristic acid, lauric acid was higher in meat from lambs raised at Cowra, Rutherglen and Struan where feeding contained proportionately better quality pasture or desiccated lucerne hay. Oleic acid (C18:1) is the major MUFA and is found at highest concentration among all FA in meat. It was reported that lambs fed lucerne hay (alfalfa) as a forage diet had significantly lower concentrations of oleic acid than those fed with concentrate diets (formulated mainly with barley, wheat, corn , soybean meal) after a 7 week feeding period [10]. The finding from the current study also indicates that when lambs were provided with more feedlot ration or grain diet during finishing, that the meat contained a higher concentration of oleic acid than those lambs raised at sites where predominantly pasture or other forage diets were consumed.

Saturated fats are the main type of fat found in butter, dairy products, fatty meat, processed meat products and coconut milk. Increasing SFA intake increases total blood cholesterol and LDL cholesterol in the body, which can lead to heart disease and other metabolic disorders [4]. The total energy intake from fats and SFA present in food is recommended to be 30 and 10% of the total energy intake, respectively and the mean SFA intake in Australia has remained steady at around 29-32 g/day calculated using both pre- and post-2007 data. The National Health and Medical Research Council (NHMRC) recommends that *trans* fatty acids (TFA) and SFA combined contribute no more than 8-10% of energy intake. On average Australians and New Zealanders consume 14-16% of their energy from TFA and SFA [12] which is well above the NHMRC guidelines. The mean intake of TFA from all sources in Australia and New Zealand has been documented at 0.6 and 0.7% respectively, which is well below the recommendation that it be less than 1% to total energy intake. According to Standard 1.2.7 – Nutrition, Health and Related Claims [12], any food that contains less than 1.5 g of SFA per 100 g of solid food can be claimed as low in saturated fats. In this context meat derived from the *longissimus lumborum* (or short loin as it is known commercially) of lambs reared at all production sites used in this study can be claimed as low in saturated fats.

IV. CONCLUSION

Production site significantly affected the SFA concentration in meat, which appears to reflect the finishing diets fed to lambs. When animals were finished on mainly pasture or forage diets with none to a small amount of grain, the lambs produced meat with lower concentrations of palmitic and stearic acids. Lambs finished mainly with feedlot or grain had a greater concentration of oleic acid compared with lambs finished mainly with forage based diets. Meat from lambs reared at all production sites in this study can be claimed as low in saturated fats.

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