GENOTYPE AND SITE DIFFERENCES IN THE FATTY ACID COMPOSITION OF MUSCLE PHOSPHOLIPIDS IN CATTLE

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SUMMARY

Phospholipid data from the *Longissimus dorsi* (eye muscle) and *M. brachii* (shoulder muscle) of Jersey and Limousin cattle were used to study the effects of genotype, anatomical site and their interactions on fatty acid composition. Results indicated that phospholipids of the two muscles did not differ in total saturated, monounsaturated and polyunsaturated fatty acids. However, they differed in specific fatty acids 18:0 and 22:5. Genotype was a significant source of variation for the individual fatty acids 18:2 and 18-di-methyl-aldehyde (18DMA). Significant genotype by anatomical site interactions were observed in the levels of 18DMA, 18:0, 18:2 and 20:5 fatty acids. It was concluded that the fatty acid composition of phospholipids from biopsy samples of the *L. dorsi* and *M. brachii* muscles were similar, but there were significant differences in some individual fatty acids. Furthermore, attention should be paid to genotype by anatomical site interactions that can exist in some individual fatty acids.

Keywords: Fatty acids, phospholipids, muscle, Limousin, Jersey.

INTRODUCTION

Phospholipids are structural lipids found within muscle membranes. The eye muscle (*Longissimus dorsi*) is the most frequently sampled anatomical site for meat quality traits such as tenderness, flavour and fat content in cattle. This is chiefly due to the high price premium placed on the *L. dorsi* and easy accessibility for carcase sampling. Total lipid extracted from this muscle or subcutaneous fat from the same site has been used to identify genotypes in terms of their fatty acid profiles (Pyle *et al. 1977* and Sinclair and O'Dea 1987). However, the fatty acid composition of intramuscular fat varies not because of intrinsic differences in deposited triacylglycerols, but because breeds differ in the quantity of fat deposited intramuscularly (Siebert *et al.* 1996). These same authors found genotypic differences in phospholipids extracted from this muscle in crossbred cattle raised in a feedlot. The consistency of muscle phospholipid composition is yet to be demonstrated in pure breeds of cattle. In this study, comparisons were made between purebred Jersey and Limousin cattle grazing the same pasture under the same management system. A question that also remains unanswered is whether the fatty acid composition of the *L. dorsi* is representative of the shoulder muscle composition or not. Therefore, we compared the shoulder muscle (*M. brachii*) with the *L. dorsi*. The aim was to investigate the effects of genotype, anatomical site and their interactions on the fatty acid composition of muscle phospholipids.

MATERIALS AND METHODS

Eight Limousin and eight Jersey yearling heifers from the J.S. Davies Bovine Gene Mapping herd in South Australia were randomly chosen from the parental generation comprising of stud animals representing well over seventy sires from each breed. The *L. dorsi* and *M. brachii* muscles were biopsied by a technique described in detail by Malau-Aduli *et al.* (1995). The samples were immediately frozen in liquid nitrogen and transported to the laboratory where they were stored at -20°C until analysed for fatty acids. A detailed description of the phospholipid separation and methylation techniques utilised for the fatty acid analysis has been reported (Siebert *et al.* 1996). For gas liquid chromatography, a BP20 capillary column (50m, 0.32 mm I.D., SGE Melbourne) with hydrogen as the carrier gas (65 kPa head presssure) was used. Fatty acid composition for each sample was determined as the normalised percentage area means from duplicate measures. Least squares analysis of variance was carried out using PROC GLM (SAS 1989). The statistical model included the fixed effects of genotype, anatomical site and the interaction between genotype and anatomical site. The model accounted for 3 degrees of freedom (d.f.) leaving 28 d.f. for testing significance.

RESULTS AND DISCUSSION

Effect of genotype. Phospholipids are structural lipids found underlying muscle membranes. They should be representative of muscle cell membranes throughout the body as unlike depot fat, they are not laid down preferentially and do not differ in lipid content. However, they do appear to differ in fatty acid composition. Differences between Limousin and Jersey genotypes in most of the individual fatty acids were not significant except for 18DMA and 18:2 (Table 1). The intramuscular phospholipid compositions of the genotypes were similar in terms of total saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA). Long-chained polyunsaturated fatty acids (PUFA) constituted a substantial proportion (up to 28%) of muscle phospholipids (Table 2). This is in contrast to less than 10% reported in the adipose tissue (Malau-Aduli *et al.* 1995).

Since 18:2 cannot be synthesised by the animals being an essential fatty acid, its origin must be dietary. Hence differences between the Limousin and Jersey (Table 2) are most likely due to differential amounts of feed consumed, absorption or utilisation rates. Even though 18:2 is the most abundant of all polyunsaturated fatty acids in the muscle, Table 1 clearly shows ($P = 0.83$) that the percentage of total PUFA was not affected by genotype. This is in contrast to the breed difference of 5.2% reported by Siebert *et al.* (1996) in total PUFA values between Jersey x Hereford and Charolais x (Simmental x Hereford) cattle. The disparity could be due to the fact that these crossbred animals were fattened in the feedlot as opposed to the pasture-fed heifers in this study. In a previous comparison of triacylglycerols from the adipose tissues of these two breeds, Jersey cows had significantly more PUFA (3.2%) than Limousin cows (1.5%) grazing the same pasture (Malau-Aduli *et al.* unpublished data).Yearling animals did not exhibit any significant breed difference consistent with the present data set. The same is true for total SFA and MUFA. There is strong evidence to suggest that age is an important contributor to changing trends in these total fatty acids where the level of SFA has been shown to decrease while MUFA increased with age (Malau-Aduli *et al* unpublished data).

Table 1. Least squares analysis of variance and levels of significance for muscle phospholipids

Fatty acid[A]	Genotype	Anatomical site	Genotype x site
16DMA	0.68	0.06	0.08
16:0	0.10	0.46	0.11
16:1	0.92	0.12	0.93
18DMA	0.01**	0.07	0.13
18:0	0.64	0.01**	0.02*
18:1	0.09	0.27	0.29
18:2	0.05*	0.07	0.01**
18:3	0.90	0.39	0.12
20:4	0.07	0.97	0.51
20:5	0.82	0.24	0.02*
22:5	0.20	0.01**	0.38
SFA	0.63	0.89	0.23
MUFA	0.62	0.19	0.24
PUFA	0.83	0.49	0.06

* $P < 0.05$ and ** $P < 0.01$

[A] SFA=Saturated fatty acids, MUFA=Monounsaturated fatty acids, PUFA=Polyunsaturated fatty acids, DMA=Di-methyl-aldehyde (Sinclair and O'Dea 1987)

Effect of anatomical site. Westerling and Hedrick (1979) compared intramuscular and subcutaneous lipids in Hereford heifers to ascertain. They reported significant differences in which subcutaneous fat contained more 16:0 (palmitate) and 18:1 (oleate) and less 18:2 (linoleate) and 20:4 (arachidonate) than intramuscular fat. It is imperative to point out that the fatty acid profile of adipose tissue reflects almost entirely the triacylglycerol composition (Sinclair and O'Dea 1987). In muscle tissue however, the fatty acid profile is largely due to phospholipids. Our data shows that there were anatomical site differences between the phospholipid composition of the *L. dorsi* and *M. brachii* muscles in the levels of 18:0 and 22:5 fatty acids (Table 2). The proportion of 18:0 (stearate) was significantly more in the *M. brachii* (14.5%) than the *L. dorsi* (12.2%) while the level of 22:5 (clupadonate) was significantly more in the *L. dorsi* (2.6%) than the *M. brachii* (2.1%). Jurie *et al.* (1995) reported significant differences in biochemical and biological characteristics between the *longissimus* and *semitendinosus* muscles. Stearate is a major saturated fatty acid that is synthesised *de novo* from palmitate (16:0) by chain elongation. It would imply that the activity of elongase enzyme in the two muscles differs significantly. From a human health perspective, the immediate impression would be that consumption of *L. dorsi* should be preferred to *M. brachii*. However, caution should be taken not to jump to such conclusions because the total saturated, monounsaturated and polyunsaturated fatty acid profiles of both muscles did not differ between anatomical sites (Table 1).

Effect of genotype x site interaction. Significant interactions between genotype and anatomical site were observed in the individual fatty acids 16:0, 18DMA, 18:0, 18:2 and 20:5 (Table 2). It was evident that the *M. brachii* muscle of the Limousins contained more 16:0 (a saturated fatty acid) and less 18:2 and 20:5 (both polyunsaturated fatty acids) than the Jerseys. With regard to 18:0 however, the *M. brachii* of the Limousins contained less than the Jerseys. Since the *de novo* synthesis of unsaturated fatty acids is a function of the desaturase enzyme, the implication is that levels and activities of this enzyme varied in the samples of the two breeds studied.

Table 2. Genotype x site interaction least squares means and s.e. of muscle phospholipids (%)

	L. dorsi		*M. brachii*		
Fatty acid[A]	Jersey	Limousin	Jersey	Limousin	S.E.
16DMA	11.6	9.2	7.6	9.1	1.0
16:0	20.4^{a}	20.4^{a}	17.6^{b}	21.5^{a}	1.2
16:1	2.5	2.4	1.9	1.9	0.3
18DMA	6.8^{a}	5.8^{b}	8.6^{c}	5.9^{b}	0.5
18:0	11.6^{a}	12.8^{ac}	15.4^{b}	13.7^{ac}	0.6
18:1	18.7	20.9	18.7	19.2	0.8
18:2	9.9^{a}	10.5^{a}	12.6^{b}	9.8^{a}	0.5
18:3	2.0	2.6	3.0	2.3	0.4
20:4	6.6	7.2	6.3	7.6	0.6
20:5	2.9^{abc}	3.5^{a}	3.3^{ab}	2.5^{c}	0.3
22:5	2.5^{a}	2.8^{a}	2.1^{b}	2.1^{b}	0.2
SFA	51.2	48.7	49.6	50.7	1.5
MUFA	23.9	23.4	21.8	23.2	0.8
PUFA	24.9	27.9	28.6	26.1	1.2

[A] As in Table 1

Means in the same row with different superscripts differ significantly ($P<0.05$)

CONCLUSION

The fatty acid composition of phospholipids from biopsy samples of the *L. dorsi* muscle is similar to the *M. brachii* muscle composition in cattle since total saturated, monounsaturated and polyunsaturated fatty acids of the two muscles did not differ by genotype, anatomical site and interactions between genotype and site. However, there were significant differences in some individual fatty acids, hence the need to pay attention to genotype by anatomical site interactions that exist in these individual fatty acids.

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