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SEASONAL PATTERNS IN FATTY ACID COMPOSITION OF BEEF SUBCUTANEOUS FAT

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Background:
Fatty acid composition and subsequent fat texture has implications for both processing efficiency and for some market specifications for Australian beef (Yang *et al.* 1999). Previous studies have suggested environmental factors, such as feed quality and ambient temperature may affect fatty acid composition in cattle (eg. Ishida *et al.* 1988; Kruk *et al.* 1997a; Kruk *et al.* 1997b). These factors generally oscillate on an annual basis and can be modeled using the sine function. The advantage of using sine curves is that the seasonal pattern can be described in three descriptive parameters, namely frequency, amplitude and phase shift of the oscillation, which can then be related to oscillations in causative factors. If the frequency of a seasonal oscillation is assumed to be annual (ie 365 days), the sine function can be re-parameterised and fitted in a linear model.

Objectives:
The objective of this study was to test for seasonal changes in fatty acid composition of subcutaneous fat from steers finished on grain or grass in a temperate environment.

Methods:
Experimental animals; Subcutaneous fat samples were collected at the 12/13th rib site from 1051 carcasses as part of the Cattle and Beef Industries Co-operative Research Centre straight-breeding program. Robinson (1995) has described the experimental design and management of the cattle in more detail. Briefly, pedigreed calves were purchased from commercial herds at weaning and grown out and finished in a temperate environment (Glen Innes, Armidale and Warialda, NSW). Animals were grown to three market slaughter live weights; 400 kg (Domestic), 520 kg (Korean) and 640 kg (Japanese). Within each market category, 435 were finished on pasture and 617 on grain for approximately 60, 100 and 150 days for the domestic, Korean and Japanese markets, respectively. There were 21 slaughters of grain fed animals and 12 of pasture fed animals.
Chemical Analysis: A 20g sample of subcutaneous fat was collected at boning and stored at –20°C. Gas chromatography (Shimadzu GC17, Kyoto, Japan) was used to analyse for 14 fatty acids using the method of Smith *et al.* (1998).
Statistical Analysis; C16:0, C16:1, C18:0, C18:1c9, C18:1t11, and C18:2,c9,c12 acids were expressed as proportions of the total fatty acid extracted. If the frequency of an oscillation is assumed to be annual (ie 365 days), the sine curve $Y = A.sin((t*c) + \theta)$, where A = amplitude of the sine oscillation, t=julian day of slaughter, θ= phase shift in radians and c = annual frequency $(2\pi/365)$, can be re-written in the form $Y = yo + a.sin(t*c) + b.cos(t*c)$ (Greer and Hancox 1977), where, $A=\sqrt{(a^2+b^2)}$ and $\tan^{-1}\theta=-b/a$ and the two parameters $u = cos(t*c)$ and $v = sine(t*c)$ can be fitted as independent terms in linear models. The sine curve was fitted separately to the data from the grain and pasture fed animals in linear mixed models containing terms for the following effects; year, breed(year), sex(market), herd(year.market), hot carcass weight(market) u, v and sire(breed.year). Sire(breed.year) was fitted as a random effect. The significance of the sine curve was assessed as the combined F ratio for u and v.

Results and discussions:
Fatty acids with sine oscillations after adjustment for fixed effects are shown in Table 1. For pasture finished animals the oscillations in C18:0 (1.39%) and C18:1t11(0.39%) appeared in phase. These peaks were largely offset by reductions in C18:1c9 (0.99%), C16:1c (0.42) and C16:0 (0.92%). For grain fed animals, seasonal changes in C16:0 and C18:0 were not significant ($P>0.05$), although oscillations in the other fatty acids shown in Table 1 were significant ($P<0.05$) and were of a similar amplitude and phase as in the pasture fed animals. Seasonal oscillations in C16:0 and C18:0 present in pasture fed animals were minimised by finishing on grain (Figure 1). This infers that oscillations in these acids in pasture fed animals were due to changes in pasture quality as was suggested by Kruk *et al.* (1997).

After adjustment for fixed effects the oscillations were similar in pasture and grain finished animals for C16:1, C18:1c9, C18:1t11 and C18:2,c9,c12. Given that the literature indicates that C18:1t11 and C18:2,c9,c12 cannot be synthesised by the animal but must come from an exogenous source, it is interesting to speculate how they can oscillate with a similar amplitude and phase in both pasture fed and grain fed animals. As grain fed animals were on a similar diet throughout the year it may have reflected changes in endogenous production, or perhaps an oscillation in an exogeneous source (such as the rumen flora).

Ishida *et al.* (1988) removed the seasonal fluctuation in feed quality by grain feeding and still found seasonal differences in fatty acid composition. Ishida *et al.* (1998) and Kruk *et al.* (1997) both found that unsaturated fatty acids were higher in the winter period in contrast to our results which peaked in summer with increases in unsaturation starting to occur in late autumn and early summer. However, the previous studies may have been confounded with animal fatness. In our study cattle were slaughtered throughout the year and subcutaneous fat composition adjusted to a common carcass weight, hence this confounding was minimised.

Conclusions:
This study showed that, after adjustment for fixed effects, there was seasonal variation in subcutaneous fatty acid composition. By contrasting the seasonal patterns in grain finished and pasture fed cattle in the same environment, the results suggested that the differences were a function of both climatic and nutritional effects. These results show that there may be changes in fat hardness through the year.

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Table 1. Mean fatty acid proportions in the subcutaneous depot for grain and pasture fed cattle grown a temperate environment, with the parameters of the sine oscillation and F ratio's for individual fatty acids.

	Mean	Grain fed				Pasture fed			
Fatty acid	%	A (%)	θ *(radians)*	Max day	F ratio 2,289	A (%)	θ *(radians)*	Max day	F ratio 2,289
C16:0	28.0	0.23	5.98	109	$.39^{ns}$	0.92	3.55	250	30.71
C16:1c	4.4	0.30	1.00	33	5.05	0.42	2.77	295	5.99
C18:0	13.1	0.15	4.12	217	0.26^{ns}	1.39	5.87	115	10.29
C18:1c9	39.3	1.19	1.46	7	19.70	0.99	1.88	347	9.08
C18:1t11	2.7	0.42	4.30	206	10.84	0.39	5.95	111	9.77
C18:2c9,c12	0.9	0.15	3.33	263	25.97	0.08	2.48	312	15.16

A=amplitude; θ= phase shift; Max day=julian day sine curve reaches its maximum value, ns - not significant; Mean=raw mean

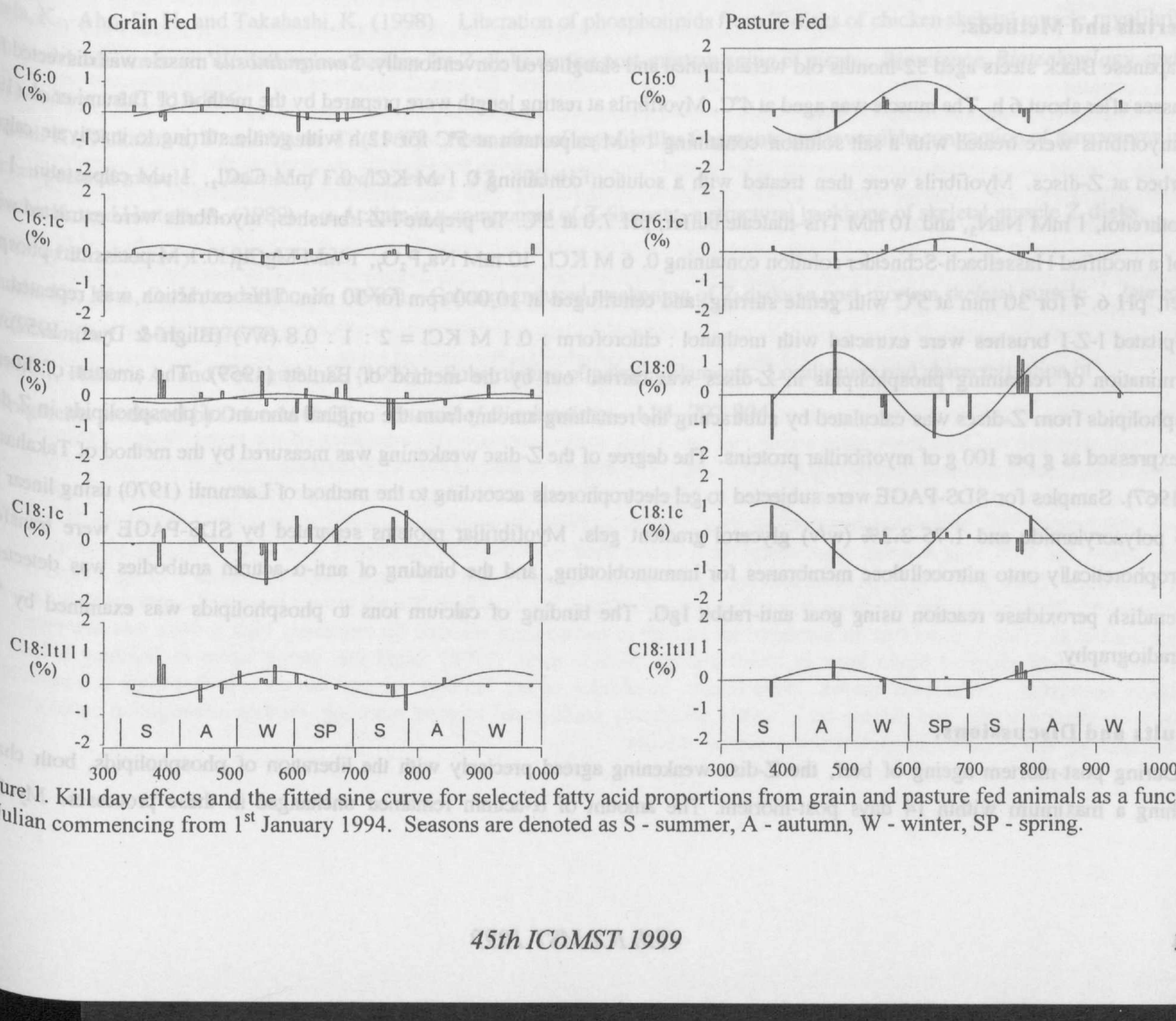

Figure 1. Kill day effects and the fitted sine curve for selected fatty acid proportions from grain and pasture fed animals as a function of Julian commencing from 1st January 1994. Seasons are denoted as S - summer, A - autumn, W - winter, SP - spring.