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Characterising production systems of beef using fatty acid composition (#214)

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Introduction

Various feeding and production systems exist for Australian cattle and these are necessary to meet the consumer demand for beef. Currently verification of production systems is solely based on audits which are costly and time consuming. The development of a scientific method for verifying production systems is required to reduce costs. A proposed system is to assess the fatty acid composition of subcutaneous fat as an indicator of the changes in diets. The fatty acid composition of subcutaneous fat has been examined previously, but not to compare production systems. While subcutaneous fat is a low value portion that is trimmed from the carcase, it provides valuable information on the diet of the animal and a study was undertaken to test this hypothesis for cattle from two different finishing systems.

Methods

In this investigation 300 beef carcases were sampled: 150 grass-fed and 150 grain-fed animals. With the grain-fed cattle from a Southern Australian feedlot and grass-fed from seasonal pastures in Southern Australia. All diets were verified through supply chain methods and directly with the producers of sampled carcases. A 30g sample of subcutaneous fat was excised from the brisket and frozen at -20°C for transport and then were stored at -80°C until they were freeze dried, and homogenised using a Foss Knife-Tech® grinder for 15s. Analysis of fatty acids in the subcutaneous fat were completed using a one-step extraction method [1]. Extraction of fatty acids was achieved by using 10mL of chloroform/methanol mixture (2:1v/v) added to the sample, shaken and centrifuged. Once extracted, an aliquot of 80–100 μl was evaporated to dryness under nitrogen gas. Once evaporated, the mixture was methylated using 2mL of methanol/toluene mixture (4:1v/v) containing C13:0 (4μg/mL) and C19:0 (4μg/mL) as internal standards, 200μL of acetyl chloride and 5mL of a 6% potassium carbonate solution. The fatty acids were then identified from 80μL of FAME using an Agilent 6890N gas chromatograph equipped with a SGE BPX70 analytical column.

Statistical analysis was completed using linear mixed effects models, deriving predicted means and standard errors and calculating least significant differences between means (at the P = 0.05)for the fatty acids measured from the carcases of each feed type. To account for any batch effects, day of measurement was included as a random effect, with cattle feed type also as a fixed effect. All statistical analyses were completed in R Core Software using the 'emmeans' package and prospectr package.

Results

As highlighted in Table 1, carcases from grain-fed cattle had significantly higher saturated fatty acid (SFA) concentrations (11.1g/100g) compared to grass-fed cattle (8.3g/100g).

Although, the concentration of total monounsaturated fatty acids (MUFA) in the subcutaneous fat in this study did not differ between carcases from grass and grain finishing systems, individual fatty acids including C15:1n-5, C16:1n-7t, C17:1n-7, C18:1n-7t, C18:1n-9t, C20:1n-9, C20:1n-15 and C24:1n-9 showed significant variation. The omega-6 to omega-3 ratio was found to be significantly lower in grass fed cattle than in grain fed.

Conclusion

There has been extensive research conducted on the effect of diet on the intramuscular fatty acid composition of beef [3]. The total MUFA in the subcutaneous fat in this study did not differ between finishing systems, which disagrees with previous research that has shown consistent differences in MUFA [2].

Given that finishing cattle on grain for both long and short periods can cause a reduction in the total omega-3 concentration [3] and an increase in omega-6 fatty acids within intramuscular fat, it is unsurprising that the omega-6 to omega-3 ratio was found to be significantly different in the subcutaneous fat from cattle finished in grass and grain fed production systems. This difference in composition of fatty acids is due to cereal grains being rich in C18:2n-6, with cattle feed concentrates containing very little lipids and those lipids being storage triglycerides. Conversely most grasses are made up of 55-70% C18:3n-3 [3].

The fatty acid composition of subcutaneous fat is able to be used to determine a difference between grain fed and grass fed production systems and can be used to determine production system and thus verify beef production systems. Further research aimed at collecting samples from cattle across various levels of grain feeding and supplementation will improve the knowledge and potential use in the industry as a random auditing system of beef products.

1 Lepage, G. & C. C. Roy. 1986. Direct transesterification of all classes of lipids in a one-step reaction. Journal of lipid research, 27(1):114

2 Noci, F., F. Monahan, P. French & A. P. Moloney. 2005. The fatty acid

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composition of muscle fat and subcutaneous adipose tissue of pasture-fed beef heifers: Influence of the duration of grazing. Journal of Animal Science, 83(5):1167-1178

3 Ponnampalam, E., N. Mann & A. Sinclair. 2006. Effect of feeding systems on omega-3 fatty acids, conjugated linoleic acid and trans fatty acids in Australian beef cuts: potential impact on human health. Asia Pacific Journal of Clinical Nutrition, 15(1):21-29

	Fatty acid	Grain-Fed		Grass-Fed	
		LSM	s.e.	LSM	s.e.
	C10:0	31.1	2.22	24.3	2.22
	C12.0	25.2	3.54	24.6	3.54
	C14:0	837.4	67.48	682.7	67.41
	iso-C15:0	26.5a	2.02	49.7b	2.02
	anteiso-C15:0	30.9	4.19	45.3	4.19
	C15:0	148.7b	8.65	113.7a	8.63
	C16:0	6355.2b	256.09	4928.3a	255.46
SFA (mg/100g)	iso-C17:0	26.5a	2.02	49.7b	2.02
	anteiso-C17:0	168.2a	7.49	220.6b	7.46
	C17:0	385.4b	21.11	193.7a	21.06
	C18:0	2921.6b	117.28	1872.3a	116.88
	C20:0	18.9b	0.54	14.2a	0.54
	C21:0	39.6	1.89	37.3	1.89
	C22:0	14.7	8.86	2.8	8.74
	C23:0	0.1	0.04	0.1	0.04
	C24:0	1.5	0.30	2.3	0.30
	C14:1n-5	365.9	44.28	430.7	44.23
	C15:1n-5	2.3b	0.26	0.4a	0.26
	C16:1n-7	1328.2	112.42	1557.0	112.26
	C16:1n-7t	21.0b	1.57	12.6a	1.57
	C17:1n-7	36.2a	0.83	42.1b	0.83
	C18:1n-7	474.3	29.18	392.2	29.12
MUFA (mg/100g)	C18:1n-7t	850.9b	39.33	217.0a	39.07
	C18:1n-9	11286.3	441.03	9665.8	439.73
	C18:1n-9t	118.5b	7.98	52.5a	7.90
	C20:1n-9	81.2b	3.80	48.6a	3.80
	C20:1n-15	10.8b	0.66	6.5a	0.66
	C22:1n-9	2.4	0.39	1.6	0.39
	C24:1n-9	0.9b	0.08	0.6a	0.08
	C16:2n-4	6.0a	0.30	7.9b	0.30
	C16:3n-4	3.2b	0.15	2.2a	0.15
	C18:2n-6	356.5b	16.6	203.5a	16.6
	C18:2n-6t	204.2	10.10	195.9	10.06
	C18:3n-3	51.1a	5.65	109.2b	5.65
	C18:3n-4	3.8	0.27	3.6	0.27
	C18:3n-6	6.2	0.54	6.1	0.54
	C18:4n-1	7.0	7.16	17.2	7.16
	C18:4n-3	16.1	2.26	19.8	2.26
	C20:2n-6	7.9b	0.21	4.5a	0.21
	C20:3n-3	3.3a	0.33	5.6b	0.33
PUFA (mg/100g)	C20:3n-6	14.2	0.65	14.8	0.65
	C20:3n-9	3.0a	0.23	4.1b	0.23
	C20:4n-3	3.8a	1.08	11.9b	1.08
	C20:4n-6	10.0	0.29	9.4	0.29
	C20:5n-3	2.9a	0.61	7.1b	0.61
	C22:2n-6	0.9a	0.08	1.4b	0.08
	C22:4n-6	4.7b	0.64	1.2a	0.64
	C22:5n-3	9.0a	1.38	18.6b	1.38
	C22:5n-6	0.1	0.38	1.0	0.38
	C22:6n-3	1.3	0.25	1.4	0.25
	Cis 9 t11CLA	67.8	15.73	110.9	15.71
	Trans 10c12CLA	3.7	0.26	3.4	0.26
	Trans	1.2b	0.05	0.5a	0.05
	CLA	0.1	0.02	0.1	0.02
Totals (mg/100g)	Omega-3	87.6a	10.2	173.7b	10.2
	Omega-6	400.4b	16.91	241.8a	16.83
	Omega-6:omega-3	5.1b	0.51	1.5a	0.51
	PUFA	0.7	0.03	0.6	0.03
Totals (g/100g)	MUFA	13.6	0.57	12.1	0.57
	SFA	11.1b	0.43	8.3a	0.43

Different letters within rows indicate significance between means ($P < 0.05$).

Table 1. Subcutaneous fatty acid composition from 150 grass- fed and 150 grain-fed beef carcases Least square means (LSM) and standard errors (s.e.) of the subcutaneous fatty acid (FA) composition from carcases of 150 grass-fed and 150 grain-fed beef cattle.

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