THE EFFECTS OF INCLUDING RUMINALLY PROTECTED LIPID IN THE DIET OF CHAROLAIS STEERS ON ANIMAL PERFORMANCE, CARCASS QUALITY AND THE FATTY ACID COMPOSITION OF LONGISSIMUS DORSI MUSCLE.

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Background

Feeding beef cattle on diets rich in n-3 polyunsaturated fatty acids (PUFA) such as linseed or fish oil will beneficially manipulate the fatty acid composition of beef muscle for human nutrition by raising the level of n-3 PUFA and cis-9, trans-11 conjugated linoleic acid (CLA s) (Enser *et al.*, 1999; Choi *et al.*, 2000; Scollan *et al.*, 2001). However, these studies have been less successful in manipulating the polyunsaturated:saturated (P:S) ratio in muscle since this is influenced by the high levels of ruminal biohydrogenation of dietary PUFA with the result that insufficient PUFA pass through the rumen for absorption. Effective ruminal protection of dietary fatty acids, such as that provided by encapsulation of PUFA in formaldehyde-treated protein developed in Australia, is necessary to change this situation (Scott and Ashes, 1993). This product resists proteolysis in the rumen and thereby protects the polyunsaturated oil droplets against microbial hydrogenation. In the acidic secretions of the abomasum, however, the formaldehyde-protein complex is hydrolysed, thus making the PUFA available for digestion and absorption in the small intestine.

Objective

To evaluate the effects of including a ruminally protected lipid supplement (PLS) in the diet of Charolais steers on animal performance, carcass composition and the fatty acid composition of *longissimus dorsi* muscle.

Methods

Twenty four Charolais steers (initial live weight 528 (s.e. 6.3) kg) were randomly allocated to one of three dietary treatments, each consisting of eight animals. The diets were based on *ad libitum* grass silage plus one of three concentrates in which the lipid source was either Megalac (Mega, rich in palmitic acid; C16:0) or PLS (soya beans, linseed and sunflower oils resulting in a 2:1 ratio of linoleic acid:α-linolenic acid (C18 : 2 n-6 : C18 : 3 n-3)): Concentrate 1, (Mega, control) contained 100g/kg Mega; Concentrate 2, (Mega + PLS) contained 54g/kg Mega with 500 g/d PLS fed separately; Concentrate 3, (PLS) contained no Mega and 1000 g/d PLS fed separately . The PLS was considered as part of the overall concentrate allocation per day in maintaining an overall forage:concentrate ratio of 60:40 on a DM basis. To ensure that total dietary oil and protein intake was balanced across the 3 treatment groups, the 3 pelleted concentrates differed in their formulation and therefore chemical composition (Tables 1 and 2). Total dietary oil was formulated to be approximately 7% of DM of which 4% was the test oil. Daily feed intakes were monitored and the animals were weighed every 30 d on 2 consecutive days to assess liveweight gain. The diets were fed for 90 days after which the animals were transported to Langford for slaughter. Carcasses were classified 24h post mortem (SEUROP, 15 point scale) and muscle samples were obtained from the *longissimus dorsi* muscle 48 h post slaughter. Muscle samples were stored at –20°C until required for analysis. Total muscle lipids were extracted (Chloroform:methanol) and fatty acids were determined by gas-liquid chromatography on a CP Sil 88, 50m x 0.25mm (ID) column (Chrompack, UK).

Results and discussion

Liveweight gain, total concentrate intake, carcass weight and conformation were similar across treatments (Table 3). Fatty acid composition of muscle (mg/100g) is given in Table 4. Total fatty acids were decreased (31%) when feeding PLS compared to megalac ($P < 0.05$). The saturated fatty acids, C14 : 0, C16 : 0 and C18 : 0 were reduced by feeding Mega + PLS and PLS and were on average 38% lower on PLS compared to the Mega diet. In our previous studies feeding ruminally unprotected linseed and fish oil did not reduce saturated fatty acids (Choi *et al.*, 2000; Scollan *et al.*, 2001). Similarly, oleic acid, C18 : 1 n-9 ($P < 0.05$) was lower in animals fed the PLS diet and C18 : 1 *trans* ($P < 0.002$) was lower on Mega + PLS and PLS. On average, feeding PLS doubled the content of C18 : 2 n-6 and C18 : 3 n-3. The percentage of C18 : 3 n-3, 1.96% for the PLS diet, was higher than the 1.4% in our previous work when feeding ruminally unprotected linseed (Choi *et al.*, 2000; Scollan *et al.*, 2001). CLA content decreased with inclusion of PLS in line with the reduction in total fatty acids. Both the content and percentage of the longer chain derivatives of C18 : 2 n-6, for example C20 : 4 n-6, were not changed by feeding PLS. The content of C20 : 5 n-3, eicosapentaenoic acid (EPA), which is synthesised from C18 : 3 n-3, was not affected by PLS, but the percentage of EPA was increased, on average by 15 and 42% in steers fed on Mega + PLS and PLS respectively, compared to those on the Mega diet. The P:S ratio was increased from 0.08 on Mega to 0.19 and 0.28 on Mega + PLS and PLS, respectively, ($P < 0.001$), whereas the n-6 : n-3 ratio was not affected. In contrast to our previous studies, these important changes in P:S ratio suggest that the PUFAs in the lipid supplement were well protected from rumen biohydrogenation.

Conclusions

The results suggest that the protected lipid used, which was rich in PUFA, had a high degree of protection from the hydrogenating action of rumen microorganisms. The content of saturated fatty acids, C14 : 0, C16 : 0 and C18 : 0 were substantially reduced while those of C18 : 2 n-6 and C18 : 3 n-3 were increased on feeding PLS. The content of C18:1 *trans*, a by-product of rumen biohydrogenation, was reduced on feeding PLS, reflecting a reduction in biohydrogenation. The net result was a large shift in P:S ratio 0.28 *v.* 0.08 on feeding PLS compared to megalac, respectively, resulting in beef which is healthier by having a higher content of PUFA and reduced saturated fat.

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Table 1 *Formulation of experimental diets (g/kg fresh)*

	Concentrate type		
	Mega	Mega + PLS	PLS
Barley	504	575	651
Molassed sugarbeet pulp	191	221	251
Molasses	56	65	76
Soya bean meal	127	63	0
Megalac	100	54	0
Premix	22	22	22

Table 2 *Chemical composition of the diets (g/kg DM)*

	Lipid supplement	Concentrate type		
		Mega	Mega + PLS	PLS
Dry matter	920	889	880	868
Organic matter	950	909	917	924
Crude protein	300	147	129	109
Acid hydrolysis ether extract	366	108	65	19

Table 3 *Effect of diet on animal performance and carcass composition*

	Concentrate type				
	Mega	Mega +PLS	PLS	s.e.d.	P
Total dry matter (DM) intake (kg/d)	10.06	9.96	9.62	0.338	NS
Concentrate DM intake (kg/d)	3.98	3.45	2.91	0.120	0.001
Protected lipid supplement DM intake (kg/d)	0	0.46	0.92	NA	NA
Liveweight gain (kg/d)	1.43	1.37	1.39	0.100	NS
Carcass wt. (kg)	359	358	360	8.50	NS
Conformation (1-15 scale)	8.9	9.6	9.9	0.91	NS
Fat class (1-15 scale)	8.8	8.8	7.4	0.73	NS

NA= not applicable

Table 4 *Effect of diet on the fatty acid content (mg/100g muscle) of m.longissimus total lipid*

	Concentrate type				
	Mega	Mega + PLS	PLS	s.e.d.	P
C14:0 myristic	107.5	85.1	64.5	15.24	0.034
C16:0 palmitic	986	843	598	117.8	0.012
C18:0 stearic	508	421	331	61.6	0.03
C18:1 *trans*	73.9	53	38.1	8.47	0.002
C18:1n-9 oleic	1195	1144	759	177	0.044
C18:1 cis vaccenic	38.2	37	26.9	4.81	0.053
C18:2 n-6 linoleic	100.3	194.6	215.1	9.46	0.001
C18:3 n-3 α-linolenic	23.1	45.9	45.8	4.25	0.001
CLA	16.6	14.4	9.9	2.56	0.044
C20:3 n-6	9.53	10.23	8.66	0.656	0.081
C20:4 n-6 arachidonic	28.2	27.2	28.3	2.02	NS
C20:5 n-3 eicosapentaenoic	9.52	9.51	8.93	1.198	NS
C22:4 n-6	2.66	2.01	1.95	0.433	NS
C22:5 n-3 docosapentaenoic	18.8	16.3	14.7	1.13	0.005
C22:6 n-3 docosahexaenoic	2.25	1.66	1.72	0.355	NS
Total fatty acids	3505	3260	2421	430.8	0.049
P:S ratio	0.06	0.194	0.281	0.0289	0.001
n-6:n-3	4.64	4.39	4.74	0.483	NS

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