EFFECT OF ENCAPSULATED CONJUGATED LINOLEIC ACID ON MEAT QUALITY, CARCASS AND FATTY ACID COMPOSITION OF BEEF STEERS

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Introduction

Dietary supplements of a mixture of CLA isomers have been shown to alter lipid metabolism and reduce body fat accretion in mice (West *et al.*, 1998) and pigs (Ostrowska *et al.*, 1999). Evidence from studies in lactating dairy cows (Baumgard *et al.*, 2000) have shown that the *trans*-10, *cis*-12 isomer is responsible for the anti-lipogenic effects. Shingfield *et al* (2004) demonstrated the potential of rumen protected supplements of a mixture of CLA isomers to reduce milk fat content and improve the energy status of dairy cows during early lactation. The efficacy of calcium salts of a mixture of CLA methyl esters containing *trans*-10, *cis*-12, on milk fat synthesis, is relatively low (Bernal-Santos *et al.*, 2003) which may explain the lack of effect on animal performance of heifers fed a total mixed ration containing (20g/kg) calcium salts of a four isomer CLA (Gillis *et al.*, 2004). The lack of performance responses may also be related to the short duration of CLA supplementation, during the last 32 or 60 days before slaughter, and the relatively low level of *trans*-10, *cis*-12 CLA in the diet (2.04g/kg). The current experiment used a lipid-encapsulated supplement containing equal amounts of *cis*-9, *trans*-11 and *trans*-10, *cis*-12 CLA methyl esters on the performance and carcass characteristics of Limousin steers during a 100d finishing period.

Materials and Methods

Forty Limousin steers at the University of Reading beef unit had *ad libitum* access to a basal diet (forage (equal parts grass and maize silage):concentrate ratio 60:40 on a dry matter basis). On reaching a live weight of 425kg, each steer was allocated at random to one of four experimental treatments in a 2 (grass or maize silage, forage:concentrate ratio 60:40 on a DM basis) x 2 (control or CLA lipid supplement) factorial arrangement according to a complete randomised block design. The lipid-encapsulated CLA supplement was prepared by binding methyl esters of CLA (Luta-CLA 60 supplied by BASF, Germany) to a silica matrix and coating this complex with hydrogenated soyabean oil by Balchem Encapsulates (New Hampton, New York). It was expected that the intake of *trans*-10, *cis*-12 CLA would be *circa* 75g of *trans*-10, *cis*-12 CLA, significantly higher than in earlier studies. Major fatty acids in the CLA mix (g/100 g total fatty acids) were: C16:0, 5.26; C18:0, 4.12; *cis*-9 C18:1, 25.66; C18:2*n*-6, 1.99; *cis*-9, *trans*-11 CLA, 29.32; *trans*-10, *cis*-12 CLA, 29.09.

After 100d on diet steers were transported to Bristol University for slaughter and subsequent analysis. At 48h post-mortem, samples of m. *longissimus thoracis* were removed and blast frozen for fatty acid and vitamin E analysis. Lipid was extracted using chloroform/methanol and separated into neutral and phospholipid. Fatty acid methyl esters were prepared by alkaline hydrolysis followed by methylation with diazomethane and analysed on a CP Sil 88, 100m x 0.25mm ID column (Chrompack, UK). An additional section of muscle was conditioned at 1°C for 12 days in vacuum pack and 4 steaks 20mm thick were cut, packed in modified atmosphere trays (O_2:CO_2, 75:25) and subjected to simulated retail display (700lux lighting for 16h a day, 4°C±1°C). Colour (L*a*b*) was measured on the surface of 2 steaks at three points, daily with a Minolta Chromameter. A further 2 steaks were taken at 10d of display and analysed for lipid oxidation as thiobarbituric acid reacting substances (TBARS).

Results and Discussion

Overall, the total amount of lipid in subcutaneous fat was reduced by the protected CLA supplement but only significantly so for the maize diet (not shown), a non-significant but similar trend being seen in muscle total fatty acids. Feeding CLA increased total tissue levels of *trans*-10, *cis*-12 CLA 10 to 16-fold in muscle (Table 1) and 11 to 12-fold in adipose tissue. Concentrations of *cis*-9, *trans*-11 CLA were increased up to 2-fold in muscle and 1.5-fold in adipose tissue. The former is much higher than achieved with diet alone in previous studies, but the latter is less than typical on high concentrate diets. For the MUFA C16:1*n*-5, C18:1*n*-9 and C18:1*n*-11 decreased whilst *trans*-C18:1 increased. As expected there was more C18:2 in the meat and adipose tissue of maize silage-fed animals and this decreased with CLA supplementation, whilst there was less C18:3*n*-3 in tissues of maize silage-fed animals which was less affected by CLA. The total CLA increased more with protected CLA feeding on grass-silage based than maize-silage based diets. There was no effect of grass versus maize silage or the addition of the protected CLA in the diet on carcass composition except for a small but significant reduction in the deposition of adipose fat around the kidney (kidney knob and clod fat) and, in a forelimb sample joint dissection, the total and % fat content was reduced non-significantly in animals fed CLA.

Table 1: Selected fatty acids in total lipid of m. *longissimus thoracis*, weight (mg/100g) and % composition, of steers fed a grass or maize silage diet with or without CLA supplementation and measures of meat stability.

Diet	Grass	Maize	Grass +CLA	Maize +CLA	sed	sig	Grass	Maize	Grass +CLA	Maize +CLA	sed	sig
weight							%					
14:0	81	89	121	72	15.3	*	2.4	2.5	3.2	2.6	0.18	**
16:0	903	978	1033	716	140.9	ns	27.2	27.3	26.9	25.7	0.69	ns
18:0	490	515	623	453	81.1	ns	14.8	14.3	16.4	16.2	0.60	**
t-18:1	53	64	110	89	12.4	***	1.6	1.8	2.9	3.2	0.18	***
9c18:1	1174	1287	1278	934	185	ns	35.1	36.0	33.3	33.8	0.72	**
11c18:1	45.7	48.8	45.6	36.8	5.3	ns	1.44	1.40	1.20	1.36	0.083	*
18:2n-6	119	124	93	94	6.7	***	3.4	3.7	2.6	3.6	0.41	**
18:3n-3	13.7	8.7	15.2	7.5	1.27	***	0.44	0.26	0.22	0.28	0.042	***
9c11tCLA	9.7	11.7	19.3	15.2	2.06	***	0.29	0.33	0.51	0.55	0.029	***
10t12cCLA	0.42	0.58	6.97	5.75	0.66	***	0.01	0.02	0.19	0.20	0.015	***
20:3n-6	11.5	12.8	8.9	7.5	0.8	***	0.39	0.39	0.24	0.29	0.049	**
n-6:n-3	5.8	8.0	4.3	6.9	0.63	***						
Chroma d7	21.8	21.1	22.0	20.6	1.1	ns						
Chromad11	17.3	17.4	20.6	17.8	1.5	ns						
TBARS*	1.9[a]	3.5[b]	1.5[a]	2.2[a]	0.46	***						
Vitamin E*	2.2[b]	1.6[a]	2.3[b]	1.9[a]	0.25	*						

* mg/kg muscle fresh weight.

No additional Vitamin E was fed in these trials and the concentration of vitamin E in the meat was lower than the 3-3.5mg/kg meat required for optimum stability. This was expected for the maize silage, but good quality grass silage usually results in higher concentrations of vitamin E than found here, although it was still significantly greater than for the maize silage. Feeding protected CLA did not affect vitamin E concentrations. Colour stability, as measured by saturation, was good after 7 and 11 days simulated retail display, despite the lower concentratrion of vitamin E, but TBARS were higher than in previous trials, being worst on the maize diet. Feeding protected CLA appeared to give some protection against lipid oxidation, but only significantly so for the combination of maize silage with CLA. It has been suggested that CLA is preferentially oxidised and may thus spare other fatty acids from oxidation.

Conclusions

The CLA was protected to a sufficient extent to produce high levels of incorporation, in particular of the *trans*-10, *cis*-12 isomer, into beef meat and adipose tissue. This had no significant effect on body fat accretion, but reduced total fatty acids in adipose tissue, mainly to the detriment of mono- and poly-unsaturated fatty acid content. There was some indication that CLA improved lipid stability.

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