EFFECTS OF WHOLE LINSEED AND FULL FAT SOYA INCLUDED IN A HIGH CONCENTRATE DIET AND FED FOR 60 OR 90 DAYS ON MUSCLE FATTY ACID COMPOSITION AND MEAT QUALITY IN BEEF STEERS

N.J. Choi[1], M. Enser[2], G.R. Nute[2], R.I. Richardson[2], N.D. Scollan[1] and J.D. Wood[2]

[1]Institute of Grassland and Environmental Research, Plas Gogerddan, Aberystwyth, SY23 3EB, UK; [2]Division of Food Animal Science, School of Veterinary Science, University of Bristol, Langford, Bristol BS40 5DU, UK

Background

The ruminant meats beef and lamb are often criticised on health grounds for having too-high levels of saturated fatty acids and too-low levels of polyunsaturated fatty acids (PUFA) (Enser *et al*, 1996). Despite the hydrogenating effects of rumen microorganisms, diet can modify muscle fatty acids in these species as we have shown in previous research (eg Enser *et al*, 1998). Feeding unsaturated fat sources also increases the production of cis-9, trans-11 conjugated linoleic acid (CLA) which may have additional health benefits to man (Enser *et al*, 1999). In the UK, beef cattle are usually given a high-forage diet which results in extensive PUFA hydrogenation. Feeding the PUFA as part of a high-concentrate diet reduces biohydrogenation and results in higher PUFA tissue levels (Enser *et al*, 1998).

Objective

To evaluate the effects on muscle fatty deposition of whole linseed containing n-3 PUFA and full fat soya containing n-6 PUFA when both are included in a high-concentrate diet. Also to evaluate the effects of these diets on beef flavour following research in lamb showing the importance of the n-3 PUFA for 'grass-fed' flavour (Sanudo *et al*, 2000).

Methods

Twenty eight Charolais cross steers were randomly allocated at an initial live weight of 548kg to diets containing whole linseed or full fat soya to be fed for 60 or 90 days. The diets had a forage:concentrate ratio of 20:80, the forage consisting of equal amounts of grass silage and barley straw on a dry matter basis. The concentrate was based on wheat, molassed sugar beet feed and molasses. It contained 70g/kg oil of which half was from either whole linseed (n-3 source) or full fat soya (n-6 source). Vitamin E was included in both concentrates at 345 mg/kg DM. After 60 or 90 days, cattle were transported to Langford and muscle samples from the loin were obtained for fatty acid composition at 48h post mortem. A loin joint was conditioned for 10 days at 1°C in vacuum pack. Steaks were cut and displayed in oxygen permeable film at 4°C 1000 lux 16h on 8h off for 13 days. Colour was measured daily using a Minolta Chromameter and colour saturation calculated. Lipid oxidation was measured as thiobarbituric acid reacting substances (TBARS) at 10 days of display. The remainder of the loin joint was stored frozen at -20°C prior to sensory analysis by a 10-person trained taste panel . Muscle from steaks grilled to 74°C internal temperature was assessed on 0-100 line scales.

Results and discussion

After 60 days, carcasses were classified as MLC 3/4L and at 90 days they were fatter, on average 4L (Soya) or 4H (Linseed). Results for selected fatty acids are shown in Table 1. In neutral lipid, Soya produced higher levels of 18:2 n-6 and Linseed higher levels of 18:3 n-3, both increasing with TOF. CLA was not significantly affected by diet but increased between 60 and 90 days. In phospholipid, similar trends in 18:2 n-6 and 18:3 n-3 were apparent and CLA was higher on the Linseed diet. Long chain products of 18:2 n-6 were higher on the Soya diet (eg 20:4) and products of 18:3 n-3 except 22:6 were higher on the linseed diet (20:5, 22:5). The proportions of 18:3 n-3 observed here in both lipid classes after Linseed feeding are higher than in the studies of forage-fed cattle reported by Marmer *et al* (1984) and in our previous work in which linseed was fed as part of a diet with a higher ratio of forage:concentrates (60:40) (Scollan *et al*, 2000), suggesting that the high-concentrate diet had resulted in less hydrogenation of 18:3 n-3 (although the results of the 2 studies cannot be directly compared). However the values for 18:2 n-6 on the Soya diet were much lower than those reported for 'barley beef' diets by Enser *et al* (1996). Results for muscle colour during retail display are shown in Figure 1. Colour deterioration was slightly faster in the 90 day groups. Similarly, lipid oxidation was more rapid in the 90 day groups (Figure 2) especially in the Linseed diet. These results show that shelf life was slightly reduced in the more unstable high n-3 PUFA products. Results for sensory analysis of grilled steaks are in Table 2. These were few significant effects. Diet and TOF affected juiciness . Of the flavour descriptive terms, beef flavour was reduced and abnormal flavour increased after 90 days of Linseed feeding. This group also had a high score for fishy. These results are unexpected based on our research in lamb which shows that high 18:3 n-3 concentrations in grass-fed lambs are associated with high species flavour and low abnormal flavour scores (Sanudo *et al*, 2000).

Conclusions

Levels of n-3 and n-6 PUFA in beef were modified by feeding whole Linseed or full fat Soya as part of a regime designed to reduce rumen biohydrogenation of PUFA. This was partly successful, increasing 18:3 n-3 to 1.6% of *longissimus* total lipid after 90d on the Linseed diet. CLA was higher after consumption of Linseed and lipid oxidation during retail display following 10d conditioning was greater in the Linseed group at 90 days. There was evidence of poorer flavour in this group, presumably associated with the increased lipid oxidation. The data suggest that it may be difficult to achieve a 'grass-fed flavour' effect by feeding linseed as part of a 'barley beef' diet.

References

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Table 1. Effects of diet and time on feed (TOF) on fatty acid content of *longissimus* neutral lipid and phospholipid (mg/100g muscle).

	Soya		Linseed			Significance		
	60d	90d	60d	90d	s.e.d.	Diet	TOF	Int.
				Neutral lipid				
C18:1 trans	94.3	121.6	117.2	117.7	18.03	ns	ns	ns
CLA	13.7	23.2	21.6	28.6	4.97	ns	*	ns
C18:2 n-6	44.1	66.8	38.6	43.7	8.80	*	*	ns
C18:3 n-3	10.8	13.8	26.5	36.1	4.33	***	*	ns
Total fatty acids	2462	3884	3389	3999	596.3	ns	*	ns
				Phospholipid				
C18:1 trans	4.57	4.56	7.07	5.28	0.961	*	ns	ns
CLA	0.71	0.98	1.38	1.58	0.316	**	ns	ns
C18:2 n-6	83.2	98.1	58.2	71.0	7.71	***	*	ns
C18:3 n-3	10.09	8.84	25.99	33.71	2.757	***	ns	*
C20:4 n-6	23.70	28.48	23.58	21.81	2.318	*	ns	ns
C20:5 n-3	9.72	8.25	14.02	13.93	1.211	***	ns	ns
C22:5 n-3	14.09	15.27	16.78	19.93	1.105	***	**	ns
C22:6 n-3	1.72	1.63	1.67	1.76	0.059	ns	ns	ns
Total fatty acids	415	505	529	528	43.1	*	ns	ns

Table 2. Effects of diet and time on feed (TOF) on sensory characteristics of grilled sirloin steaks (0-100 scale).

	Soya		Linseed			Significance		
	60d	90d	60d	90d	s.e.d.	Diet	TOF	Int.
Toughness	59.8	55.4	55.6	54.3	2.33	ns	ns	ns
Juiciness	40.0	43.9	43.6	46.7	2.17	*	*	ns
Beef flavour	24.0	27.6	26.7	22.0	2.86	ns	ns	*
Abnormal flavour	20.4	16.1	18.0	26.6	3.13	ns	ns	**
Livery	2.0	4.4	3.7	2.4	1.73	ns	ns	ns
Metallic	6.5	5.1	5.5	4.8	1.42	ns	ns	ns
Bitter	6.0	4.3	8.3	7.5	2.40	ns	ns	ns
Sweet	13.3	15.8	13.5	12.2	2.56	ns	ns	ns
Rancid	1.9	1.4	1.6	2.3	0.65	ns	ns	ns
Fishy	2.2	1.2	4.5	9.9	1.67	ns	ns	**
Overall liking	22.9	26.2	24.0	21.8	2.15	ns	ns	ns

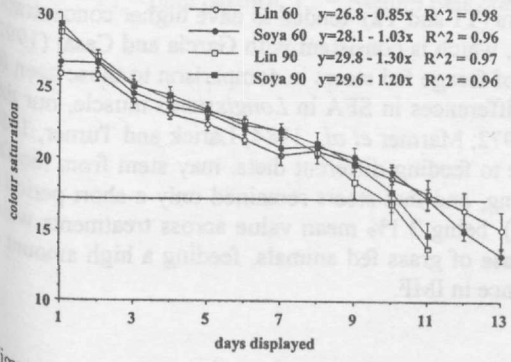

Figure 1. Effects of dietary fat source and time on feed on colour saturation of modified atmosphere packed m. *longissimus* steaks

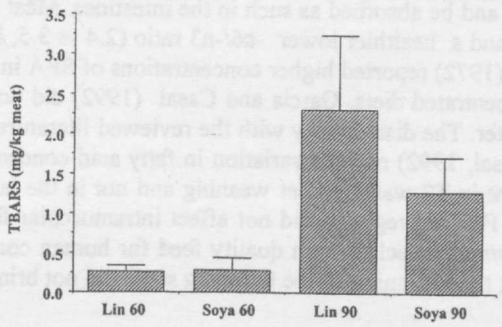

Figure 2. Effects of dietary fat source and time on feed on lipid oxidation (TBARS) in modified atmosphere packed m. *longissimus* steaks at 10 days of display