EFFECT OF GRASS AND CONCENTRATE FEEDING SYSTEMS ON FATTY ACID COMPOSITION, LIPID AND COLOUR SHELF LIFE OF BEEF LOIN MUSCLE

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*** e-mail***: ian.richardson@bristol.ac.uk* **Key Words:** Beef, Finishing diet, Fatty acid composition, Shelf life

Introduction

In the UK, forage feeding systems based on grass and clover are increasingly important to the beef industry as they benefit from low inputs, are more sustainable and ensure that production costs are kept to a minimum and profitability is maximised. These systems also have the potential to produce beef which is healthier and of a more distinctive flavour (Scollan *et al*., 2006). Grass, relative to concentrate feeding, increases the content of *n*-3 polyunsaturated fatty acids (PUFA) resulting in a low *n*-6:*n*-3 PUFA ratio, however, animals cannot always be finished off grass and may need to be finished with some concentrates. Feeding concentrates high in cereals such as wheat, barley or soya can dilute the n-3 fatty acids with n-6 fatty acids. Ruminally protected plant lipids enhance PUFA content very significantly resulting in beneficial P:S and *n*-6:*n*-3 ratios (Scollan *et al*., 2003) but without extra antioxidant input can lead to lipid oxidation and reduced colour shelf life. This study considered the effects of finishing steers (1) outdoors on grass ± concentrate versus (2) indoors on straw/concentrate ± a protected lipid supplement with one of two levels of vitamin E, on the fatty acid composition, sensory quality and lipid and colour stability of the m. *longissimus thoracis et lumborum*.

Materials and methods

Forty eight Charolais steers (initial live weight 490 kg (s.e.d. 6.7)) were randomly allocated to one of six dietary treatments (each consisting of eight animals) (1) good quality grazed grass; (G) (2) grazed grass plus 2.5 kg concentrate;(GC1) (3) grazed grass plus 5 kg concentrate (GC2) (4) straw + concentrate (C) (5) straw + concentrate + 600g/day ruminally protected lipid supplement (PLS, with an 18:2*n*-6:18:3*n*-3 ratio of 1:1, standard vitamin E, 25 mg/kg) (PLSV1) and (6) diet 5 plus 2000 IU vitamin E/day (PLSV2). Straw was offered *ad libitum*. The grazed animals were maintained on rotational grazed paddocks whilst the high concentrate treatments (4, 5 & 6) were indoors. All animals were fed to achieve a similar rate of carcass gain by either restricting access to grass in the grazed animals or restricting intake of the indoor animals. The conventional concentrate contained barley, molassed sugar beet pulp, megalac and a vitamin/mineral premix.

Animals were slaughtered after 100 days on treatment and samples of m. *longissimus thoracis et lumborum* (LTL) were taken and frozen at 48h post-mortem for fatty acid and vitamin E analysis. Four steaks, 20mm thick, were cut after 10 days ageing, packed in modified atmosphere trays (O_2:CO_2, 75:25) and subjected to simulated retail display (700lux light, 16h a day, 4ºC±1ºC). Colour (L*a*b*) was measured on the surface of 2 steaks at three points, daily with a Minolta Chromameter, the remaining 2 steaks were taken at 5 or 10d of display and analysed for lipid oxidation as thiobarbituric acid reacting substances (TBARS). An ANOVA with diet as the main factor was used to analyse the data. Carotene and skatole were measured in loin steak adipose tissue.

Results

Carcass characteristics. Half carcass weights were higher for the outdoor relative to indoor animals ($P < 0.001$ Table 1), but carcass fatness was similar (not shown).

Muscle fatty acids. Total muscle fatty acids were similar across treatments (Table 1). Increasing concentrate outdoors (GC1 and 2) resulted in higher amounts of 18:2*n*-6 and lower 18:3*n*-3 relative to grass only. There was evidence that EPA was also reduced (GC2 *v*. G). The indoor concentrate diet reduced the n-3 fatty acids and increased the n-6 fatty acids relative to the animals grazing grass. Inclusion of the PLS resulted in large increases in 18:2*n*-6 and 18:3*n*-3, which did not impact on the longer chain C20 PUFA, but resulted in a large increase in P:S ratios (i.e PLSV1 *v*. control). Grass feeding resulted in the lowest *n*-6:*n*-3 ratios.

Vitamin E, colour and lipid oxidative stability As the amount of concentrates in the diet increased so the amount of vitamin E decreased, being almost replenished to that of grass-grazed animals by dietary addition in PLSV2 (Table 2). Reduced vitamin E led to an increased oxidation of lipids, particularly so by 10 days of retail display and when additional PUFA were incorporated into the meat when PLSV1 was fed. The additional vitamin E in PLSV2 virtually produced the same meat stability as that for grass-grazed beef. Colour stability showed similar trends, though differences between diets were small and not statistically significantly different. The carotene content of the subcutaneous adipose tissue over the 10th rib was highest in grass fed animals. That found in the indoor-fed animals may have been residual from the prior dietary regime and appeared to be reduced by the additional vitamin E in PLSV2. Carotene concentration was linearly related to the b* (yellowness) of the fat.

Table 1. Fatty acid content (mg/100g muscle) of m. *longissimus thoracis et lumborum*

	Outdoor			Indoor				
	Grass (G)	GC1	GC2	Control	PLSV1	PLSV2	SED	P
Half CCWT (kg)	161.5	164.6	166.6	157.0	156.8	156.0	2.42	0.001
Fatty acid composition (mg/100 g muscle)								
Total FA	1725	1800	1637	1778	1880	1638	274.5	NS
16:0	405	432	383	435	456	383	73.7	NS
18:0	254	256	225	266	260	234	43.1	NS
18:1*n*-9	567	609	520	546	528	440	100.2	NS
18:1 *trans*	33.0	31.0	32.5	26.5	29.6	28.0	7.01	NS
CLA	8.5	8.2	9.1	6.8	8.0	7.6	2.12	NS
18:2*n*-6	58.4	64.6	77.5	91.2	178.3	171.8	10.01	0.001
18:3*n*-3	27.4	21.3	18.6	14.7	42.2	40.5	3.44	0.001
EPA	14.5	13.2	12.4	11.3	11.9	10.8	1.18	0.039
DPA	19.1	19.7	18.8	16.9	13.5	13.2	1.21	0.001
DHA	1.9	2.6	2.2	1.8	1.7	1.7	0.28	0.017
P:S	0.14	0.13	0.16	0.15	0.30	0.35	0.027	0.001
n-6:*n*-3	1.44	1.83	2.29	2.96	3.10	3.12	0.223	0.001

Table 2 TBARS (mg/100g muscle) and colour saturation of loin steaks of m. *longissimus thoracis et lumborum* during simulated retail display, vitamin E content (mg/100g) of muscle and carotene (mg/100g) content of adipose fat

	Outdoor			Indoor				
	Grass (G)	GC1	GC2	Control	PLSV1	PLSV2	SED	P
mg/100g lean tissue								
Vitamin E	4.51^{c}	3.86^{b}	3.85^{b}	2.72^{a}	2.81^{a}	4.04^{b}	0.40	***
Carotenes adipose tissue	0.65^{c}	0.57^{bc}	0.47^{bc}	0.39^{ab}	0.40^{ab}	0.25^{a}	0.086	***
TBARS d5 §	0.36^{a}	0.40^{a}	0.62^{a}	1.34^{b}	2.07^{c}	0.49^{a}	0.297	***
TBARS d10§	0.66^{a}	0.95^{a}	1.45^{ab}	2.68^{b}	5.70^{c}	1.59^{ab}	0.815	***
Colour saturation day 8§	17.8	18.0	17.5	17.8	16.3	17.9	0.91	NS
Skatole (ng /g tissue)	19.2	20.3	20.3	6.6	4.7	4.6	2.88	***

§ days of retail display

The only difference found by the sensory panel was that the group fed grass and low concentrates produced meat which was significantly ($p<0.05$) tougher than the rest. Skatole, formed as a result of bacterial degradation of tryptophan in the rumen of cattle, was significantly higher in the adipose tissue of steers grazed grass than those indoors on a concentrate diet as seen previously (Young *et al*., 1999) but did not affect meat flavour.

Conclusions

Total fatty acids were relatively low which contributed to higher P:S ratios across all treatments due to acknowledged relationship between total lipid and P:S. Grass feeding resulted in higher levels of *n*-3 PUFA resulting in very favourable *n*-6:*n*-3 ratios. However, these beneficial effects were diluted by feeding additional concentrate outdoors. Protected lipids resulted in large increases in 18:2*n*-6 and 18:3*n*-3 contributing to a very beneficial P:S ratio. Grass grazing produced more yellow fat, due to its carotene content, and a greater meat lipid stability, due to the natural intake of vitamin E with the diet. Improving the P:S ratio by feeding protected lipids caused a severe oxidative challenge in the meat and this was overcome to a great extent by supplementing the diet with vitamin E. Supplementing animals with concentrates whilst grazing over a 100d period reduces the natural vitamin E content of the meat and reduces its stability, though non-significantly.

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