EFFECT OF FORAGE LEGUMES ON THE FATTY ACID COMPOSITION OF BEEF AND OTHER ASPECTS OF MEAT QUALITY

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Background

Forage based feeding systems, using grass and legumes are very important to the UK beef industry and are essential constituents of sustainable and environmentally friendly production systems. Feeding animals on grass, which is rich in α-linolenic acid and α-tocopherol, enhances the content of n-3 polyunsaturated fatty acids (PUFA) in beef muscle and has important benefits for colour shelf life in comparison with feeding diets rich in grain (Warren *et al.* 2002). Legumes such as white and red clover offer important animal production benefits (increased intake and live weight gain) but their effects on quality of beef such as shelf-life (colour and lipid stability), flavour and human nutritional value, have not been fully addressed. Tissues from lambs finished off swards containing white clover were reported to contain more linoleic and α-linolenic acid and less eicosapentaenoic acid (EPA, 20:5 n-3) (Vipond *et al.*, 1993) compared to animals grazing grass. This study compared the effects of feeding two beef breeds (Welsh Black and Simmental) on grass or grass plus white or red clover on the fatty acid composition of beef and other aspects of meat quality.

Objectives

To determine the forage type (grass, grass and white clover or grass and red clover) on quality of meat from two beef breeds.

Methods

Forty eight pure-bred Welsh Black and Simmental steers, average live weight 270kg, were allocated to each of three forage systems, resulting in 8 animals per breed per treatment. Animals grazed a grass sward, a grass/white clover sward or a grass/red clover sward from May to October in the first year and from May in the second year and received silage prepared from the same forage during the intervening winter. During the summer and winter feeding periods the grass:clover proportions were approximately 60:40 on a DM basis. Animals were slaughtered after a similar time on treatment on average 465 days. Vitamin E (HPLC) and fatty acids (GLC) were analysed on samples of *m.longissimus* removed 48h post-mortem and colour (L*a*b*) and lipid oxidative shelf-life and eating quality were assessed on meat conditioned for 10 days at +1°C and packed in a modified atmosphere (0.75 O_2, 0.25 CO_2) for simulated shelf-life display.

Results and discussion

Higher growth rates in animals consuming legumes resulted in heavier carcasses and higher conformation and fatness scores compared to those fed grass only, after a similar time on each system (Table 1). Conformation scores were higher for Simmentals while the Welsh Black had higher fatness scores. Carcasses from steers eating the grass/red clover were lighter and not as fat as those fed grass/white clover but intramuscular fat contents were not different. The oxidative stability of the meat and colour measurements were not affected by diet or breed. The vitamin E content of the meat was higher in beef produced from grass and grass and red clover compared to grass and white clover. Beef flavour was unaffected by feed or breed (Table 2).

The differences in carcass fatness scores were also reflected by a higher content of total muscle neutral and phospholipid from clover compared to grass (Table 3 and 4). The legumes increased the proportion of C18:2 n-6 and C18:3 n-3 in muscle neutral lipid. In general, the proportions of the longer chain C20 n-6 series were higher on the legumes while C20:5 n-3 was lower. The proportion of C18:2 n-6, C18:3 n-3 and the longer chain C20 n-6 and n-3 series (except C22:5 n-3) were higher in muscle phospholipid from Simmentals compared to Welsh Blacks. Interestingly, the Simmental had a higher proportion of phospholipid in the total lipid compared to the Welsh Black, averaging 0.26 *v* 0.20 (s.e.d. 0.017, $P < 0.001$), respectively. The content and proportion of trans vaccenic acid and conjugated linoleic acid (*cis*-9, *trans*-11 CLA) were also higher for the Simmental. We have previously noted differences in fatty acid composition between Welsh Blacks and Holstein Friesians (Choi *et al.*, 2000) with the former have higher proportions of C18:3 n-3 and C20:5 n-3 in phospholipid resulting in improved P:S and n-6:n-3 ratios (see below).

The ratio of polyunsaturated : saturated fatty acids (P:S) in the muscle total fat and n-6:n-3 ratios, covariate adjusted for total muscle neutral lipid are also given in Table 4. The P:S ratio was beneficially higher on the legumes compared to grass on average 0.12 *v.* 0.10, respectively, reflecting the higher proportions of both n-6 and n-3 PUFA attained when feeding legumes. In contrast, the n-6:n-3 ratio was beneficially lower on grass compared to legumes, although it should be noted that on all treatments the ratio is helpfully less than the recommended target of < 2. It is well recognised that feeding legumes results in higher dry matter intakes and this along with reduced feed retention time in the rumen helps to increase the flow of dietary C18:2 n-6 and C18:3 n-3 to the small intestine and consequently higher contents of these fatty acids in beef muscle. The higher proportions of polyunsaturated fatty acids is in agreement with a previous study by our research groups (Enser *et al.*, 2001) and is highly desirable in terms of human nutrition. However, Enser *et al.* (2001) reported that red clover reduced the oxidative stability of the meat in comparison to grass, which is in contrast to that reported in Table 2. This aspect requires clarification.

Conclusions

Feeding legumes resulted in increased deposition of PUFA in beef, resulting in a significant and beneficial improvement in the P:S ratio of the muscle total fat. No deleterious effects on other aspects of meat quality (colour shelf life and eating quality) were noted in this study.

Table 1. Effect of forage and breed on carcass weight and quality

	Forage					Breed			
	Grass	Grass/red clover	Grass/white clover	SED	P	Simmental	Welsh Black	SED	P
Carcass weight (kg)	290.3	334.7	353.9	5.91	0.001	333.0	319.6	4.83	NS
Conformation (1-15)	7.4	8.8	8.7	0.13	0.003	8.6	7.9	0.12	0.05
Fatness (1-15)	4.9	6.7	7.6	0.56	0.001	5.8	7.0	0.45	0.01

Table 2. Effect of forage and breed on meat quality assessments

	Forage					Breed			
	Grass	Grass/red clover	Grass/white clover	SED	P	Simmental	Welsh Black	SED	P
Muscle lipid oxidation†	0.88	0.95	0.99	0.27	NS	0.74	1.14	0.22	NS
Vitamin E (mg/kg)	3.92	4.04	3.27	0.12	0.001	3.84	3.65	0.1	NS
Colour a*	17.8	17.2	17.4	0.21	NS	17.4	17.4	0.17	NS
Saturation	19.4	18.9	19.1	0.17	NS	19.1	19.1	0.14	NS
Beef flavour (1 low - 100 high)	22.8	24.2	23.7	1.54	NS	24.6	22.6	1.26	NS

† mg malonaldehyde/kg meat, measured after 10 d display in a modified atmosphere pack (MAP). * measured after 7 days in a MAP

Table 3. Effect of forage and breed on the fatty acid composition (proportion x 100) of the neutral fraction *of longissimus dorsi* muscle

	Forage					Breed			
	Grass	Grass/red clover	Grass/white clover	SED	P	Simmental	Welsh Black	SED	P
C14:0	2.36	2.68	2.83	0.145	0.007	2.57	2.67	0.118	NS
C16:0	25.8	27.1	27.4	0.58	0.02	25.8	27.7	0.48	0.001
C18:0	17.9	16.3	15.5	0.86	0.02	16.5	16.6	0.70	NS
C18:1 trans	3.16	3.16	3.13	0.38	NS	3.53	2.77	0.31	0.02
CLA	0.67	0.69	0.71	0.057	NS	0.77	0.60	0.065	0.013
C18:1 n-9	36.4	35.0	36.1	0.92	NS	36.0	35.8	0.75	NS
C18:2 n-6	0.57	0.88	0.71	0.038	0.001	0.76	0.68	0.031	0.024
C18:3 n-3	0.70	1.02	0.85	0.06	0.001	0.90	0.81	0.035	0.016
Total fatty acid *	1365	2096	2620	215.3	0.001	1910	2143	175.8	NS

* mg per 100g muscle

Table 4. Effect of forage and breed on the fatty acid composition (proportion x 100) of the phospholipid fraction *of longissimus dorsi* muscle

	Forage					Breed			
	Grass	Grass/red clover	Grass/white clover	SED	P	Simmental	Welsh Black	SED	P
C14:0	0.18	0.24	0.27	0.019	0.001	0.22	0.24	0.015	NS
C16:0	13.7	18.8	13.9	0.27	NS	13.6	14.1	0.22	0.028
C18:0	10.8	10.6	10.6	0.15	NS	10.5	10.8	0.12	0.046
C18:1 trans	0.66	0.75	0.81	0.121	NS	0.85	0.63	0.099	0.03
CLA	0.21	0.24	0.26	0.033	NS	0.25	0.23	0.027	NS
C18:1 n-9	21.7	18.7	20.9	0.67	0.001	19.2	21.6	0.545	0.001
C18:2 n-6	8.5	11.3	10.1	0.393	0.001	10.8	9.1	0.32	0.001
C18:3 n-3	5.55	6.24	5.96	0.276	0.053	6.28	5.54	0.226	0.002
C20:3 n-6	1.05	1.32	1.26	0.050	0.001	1.28	1.14	0.041	0.001
C20:4 n-3	0.87	1.08	1.09	0.049	0.001	1.08	0.95	0.040	0.002
C20:4 n-6	4.77	5.09	4.65	0.177	0.046	5.04	4.64	0.144	0.008
C20:5 n-3	4.34	4.01	3.99	0.152	0.036	4.29	4.00	0.124	0.02
C22:4 n-6	0.21	0.24	0.23	0.014	0.06	0.22	0.24	0.012	0.07
C22:5 n-3	4.42	4.52	4.33	0.100	NS	4.37	4.47	0.082	NS
C22:6 n-3	0.62	0.61	0.51	0.046	0.034	0.63	0.54	0.037	0.017
Total fatty acid *	497	525	575	29.3	0.035	595	469	24.0	0.001
P:S **	0.105	0.132	0.125	0.0097	0.023	0.139	0.103	0.0068	0.001
n-6:n-3 **	1.31	1.45	1.41	0.053	0.028	1.44	1.34	0.037	0.007

* mg per 100g muscle; ** calculated based on relevant fatty acids in both neutral and phospholipid fractions and using total neutral lipid as a covariate.

Pertinent literature

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