Effect of concentrate-finishing on muscle fatty acid composition in genetically lean beef cattle

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Introduction

Concentrate finished beef cattle can be economical due to the high rates of gain achieved by these animals. Intensive diets are higher in energy and animals can deposit considerable levels of carcass fat and marbling. On the other hand, pasture finished cattle normally have lower rates of gain and deposit less fat (i.e., sucbutaneous and intramuscular fat) (Steen and Kilpatrick, 1998). However, extensive feeding can improve muscle fatty acid profiles enabling beef production with a more desirable fatty acid composition for human health. Breed-type can also affect muscle fat quality where variation in fatty acid compositions are mostly related to intramuscular fat levels, and consequently to neutral and polar lipids ratios (Scollan *et al*., 2001).

Current recommendations for human health are to limit intakes of 14:0 and 16:0 and to increase intakes of n-3 fatty acids. Beyond this, fatty acids of current interest are intermediates in ruminal biohydrogenation of polyunsaturated fatty acids. Rumenic acid (9*c*,11*t*-18:2) and its precursor vaccenic acid (11*t*-18:1) accumulate in pasture finished beef and these have purported roles in the prevention and possible treatment of several diseases including diabetes, obesity and some types of cancer (Belury, 2002; Ip *et al*., 2003). On the other hand, some *trans*-18:1 isomers (notably 10*t*-) can accumulate in intensively finished beef and these have been demonstrated to be atherogenic in animal models (Bauchart *et al*., 2007; Roy *et al*., 2007). The objective of this work was to evaluate to what extent intensive and extensive systems can be combined without negatively affecting the fatty acid composition of the meat.

Materials and methods

Twenty-five yearling bulls from "Asturiana de los Valles" (AV) Spanish beef breed (adapted to extensive productions systems and heterozygote for the gene responsible for muscular hypertrophy (*mh*/+)) were reared under grazing conditions (ryegrass and clover pastures) with or without final finishing on *ad libitum* barley-based concentrate (84% barley meal, 10% soya meal, 3% fat, 3% minerals, vitamins and oligoelements, plus barley straw) for either 0 months (n = 7), 1 month (n = 10) or 2 months (n = 8).

Animals were slaughtered commercially at an average weight of 518 ± 12 kg. After dressing carcasses were chilled at 3°C for 24 hours. The rib joint between the 6th and 9th ribs was then dissected and transported to the laboratory. The *Longissimus thoracis* from the 8th rib was cut, vacuum packed and frozen at -80°C for subsequent fatty acid analysis. Meat samples were freeze-dried and lipids were extracted using a mixture of chloroform – methanol (1:1, v/v). Lipid aliquots from each muscle sample were methylated separately using acidic (methanolic HCl) and basic (sodium methoxide) reagents. The fatty acid methyl esters were analyzed using the GC and Ag^{+}-HPLC (Dugan *et al*., 2007; Kramer *et al*., 2008).

The statistical analysis was conducted using the SPSS12.0 for Windows (2003). The effect of finishing was studied by ANOVA analysis.

Results and discussion

All animal groups showed similar live weight at slaughter and cold carcass weight. However, the carcass yield of grass fed animals (52%) was significantly lower in comparison to concentrate fed animals (average of 55.4%, Table 1). Between animal groups with final finishing (1 or 2 months) no significant differences were found in growth and efficiency parameters.

Increasing the finishing time on concentrate significantly increased the total fatty acid methyl ester content of the meat which was reflected in significant increases of saturated, monounsaturated, polyunsaturated and total *trans*-18:1 contents (mg/100g of meat, Table 2). Regarding the intermediates of ruminal biohydrogenation of polyunsaturated fatty acids, pasture finished animals had the best *trans*-18:1 isomer profile with low 10*t*-, 9*t*-, and 6-8*t*-18:1 in absolute contents, while 11*t*-18:1 and CLA with positive health image were unchanged (i.e., 9*c*,11*t*- and 11*t*,13*c*-). However, the content of those CLA isomers with a more negative health image (i.e., 7*t*,9*c*-, 9*t*,11*c*-, and 10*t*,12*c*-) were significantly higher in concentrate finished animals; similar results were found in Canadian beef fat (Dugan *et al*., 2007). Dannenberger *et al*.

(2004) also found a higher 10*t*- but similar 11*t*-18:1 content in muscle from concentrate *vs* pasture fed German Holstein bulls.

When looking at the fatty acid profile in percentages of total fatty acid methyl esters (Table 2), the significant differences found were in accordance with the differences observed in absolute contents. In general, as intramuscular fat content increased (measured as mg FAME per 100g meat) a lower percentage of polyunsaturates was noticed ($P>0.05$) mainly due to a significant reduction in n-3 fatty acids even though this was true only for animals finished on concentrate during the last 2 months before slaughter. As a result, animals finished only on grass or 1 month of concentrate showed the lowest n-6/n-3 ratios although all values (3.1 to 4.6) were in good accordance with the nutritional requirements. However, only grass fed animals showed the most desirable *trans*-18:1 isomer profile with their outstanding low 10*t*- content and consequent high 11*t*-/10*t*- ratio.

Conclusions

Overall, pasture feeding was judged to provide a superior beef fatty acid profile and this was negatively affected mainly with the longer period (2 months) of concentrate finishing. Specifically, concentrate feeding increased levels of detrimental *trans*-18:1 isomers reducing 11*t*-/10*t*- ratio. Pasture finished animals, however, had the lowest carcass yield and fatness, and in the particular case of the lean breed studied (AV *mh*/+) the meat obtained would probably not have enough intramuscular fat to ensure consumer acceptability for sensorial attributes such as juiciness. A final finishing on a diet with a balanced forage to concentrate ratio will, therefore, likely be necessary to maintain high levels of desirable and low levels of undesirable fatty acids while maintaining production efficiencies and improving consumer acceptability of the final beef products.

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Table 1. Production performances of yearling bulls from AV breed with 0, 1 and 2 months on concentrate finishing diet after grazing

	0 mo	1 mo	2 mo	sem	sign
LW at slaughter (kg)	525	502	529	12.3	ns
Cold carcass weight (kg)	274	275	298	7.66	ns
Carcass yield (%)	52.1^{b}	54.7^{a}	56.1^{a}	0.35	***
LW at start of finishing (kg)	-	477	472	15.2	ns
Daily gains (kg/d)	^{G}1.21±0.11	0.92	1.04	0.12	ns
Concentrate intake (kg/d)	-	8.25	8.61	0.16	ns
Concentrate to LW conversion index	-	11.1	10.3	1.27	ns

* P<0.05; ** P<0.01; *** P<0.001; ns P>0.05. ^{a,b} Row mean with common superscripts differ significantly at P<0.05. LW, live weight; ^{G} Daily gains during the grazing period.

Table 2. Fatty acid composition (mg/100g of meat & percentages) of muscle fat of yearling bulls from AV breed with 0, 1 and 2 months on concentrate finishing diet after grazing

	0 mo	1 mo	2 mo	sem	sign	0 mo	1 mo	2 mo	sem	sign
Σ FAME/100g meat										
	497^{b}	734^{ab}	948^{a}	57.1	*					
	mg / 100g of meat					**% of total FAME**				
Σ SFA	181^{b}	284^{ab}	396^{a}	28.4	*	36.2	37.2	40.7	0.78	ns
Σ BCFA	8.12	12.6	14.9	1.26	ns	1.60	1.65	1.54	0.06	ns
Σ MUFA	142^{b}	240^{ab}	329^{a}	26.3	*	28.1	31.0	33.3	0.91	ns
Σ PUFA	111^{b}	140^{a}	146^{a}	4.21	**	22.8	21.3	17.1	1.15	ns
Σ *trans*-18:1	19.4^{b}	43.3^{a}	49.5^{a}	4.73	*	3.77^{b}	5.50^{a}	5.01^{a}	0.27	*
6-8*t*-	0.49^{b}	1.21^{a}	1.65^{a}	0.15	*	0.09^{b}	0.15^{a}	0.17^{a}	0.01	*
9*t*-	0.83^{c}	1.64^{b}	2.50^{a}	0.16	**	0.16^{c}	0.21^{b}	0.27^{a}	0.01	***
10*t*-	1.49^{b}	20.4^{a}	20.6^{a}	2.72	*	0.30^{b}	2.67^{a}	2.16^{a}	0.24	***
11*t*-	12.6	14.2	18.5	2.58	ns	2.41	1.71	1.78	0.17	ns
12*t*-	0.42	0.80	0.82	0.10	ns	0.08	0.10	0.08	0.01	ns
13-14*t*-	1.53	2.61	2.60	0.27	ns	0.30	0.34	0.27	0.02	ns
15*t*-	1.20	1.53	1.81	0.17	ns	0.25	0.20	0.19	0.02	ns
16*t*-	0.84	1.00	1.09	0.15	ns	0.17	0.12	0.11	0.01	ns
Σ CLA	4.13	5.21	7.10	0.67	ns	0.78	0.71	0.71	0.04	ns
9*c*,11*t*-	2.32	2.51	3.90	0.48	ns	0.43	0.33	0.38	0.03	ns
7*t*,9*c*-	0.13^{b}	0.30^{a}	0.44^{a}	0.03	**	0.02^{b}	0.04^{a}	0.05^{a}	0.00	***
9*t*,11*c*-	0.14^{b}	0.30^{a}	0.35^{a}	0.02	**	0.03	0.05	0.04	0.00	ns
11*t*,13*c*-	0.26	0.18	0.29	0.05	ns	0.05^{a}	0.02^{b}	0.03^{b}	0.00	*
11*c*,13*t*-	0.05	0.06	0.07	0.00	ns	0.01	0.01	0.01	0.00	ns
10*t*,12*c*-	0.01^{b}	0.28^{a}	0.23^{a}	0.04	*	0.01^{b}	0.04^{a}	0.02^{ab}	0.00	**
12*t*,14*t*-	0.06	0.07	0.07	0.01	ns	0.01	0.01	0.01	0.00	ns
11*t*,13*t*-	0.18	0.22	0.20	0.02	ns	0.04^{a}	0.03^{ab}	0.02^{b}	0.00	*
10*t*,12*t*-	0.06	0.07	0.06	0.01	ns	0.01	0.01	0.01	0.00	ns
9*t*,11*t*-	0.06	0.10	0.12	0.01	ns	0.01	0.01	0.01	0.00	ns
Σ n-6	83.1^{b}	110^{a}	119^{a}	3.62	**	17.1	16.7	14.0	0.91	ns
Σ n-3	27.5	29.9	26.6	1.10	ns	5.66^{a}	4.55^{a}	3.11^{b}	0.27	**
	Ratios									
n-6/n-3	3.07^{b}	3.75^{b}	4.63^{a}	0.17	**					
PUFA/SFA	0.63	0.60	0.44	0.04	ns					
11*t*-/10*t*-	8.12^{a}	0.81^{b}	1.32^{b}	0.26	***					

* P<0.05; ** P<0.01; *** P<0.001; ns P>0.05. ^{a,b,c} Row mean with common superscripts differ significantly at P<0.05. FAME, fatty acid methyl esters; SFA, saturated fatty acids; BCFA, branched chain fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; CLA, conjugated linoleic acids.