FATTY ACID COMPOSITION OF INTRAMUSCULAR LIPIDS IN VARIOUS BEEF BREEDS AND GENOTYPES

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Background

Fatty acid composition of dietary fats is of great importance in human nutrition and health. Numerous studies (Sadi et al., 1996; Turek et al., 1996; Zhang et al., 1999) have demonstrated that dietary fatty acids with different degrees of saturation exert various effects on human health. Additionally, the state of saturation of the fatty acids influences the meat flavour (Purchas et al., 1979; Wood and Enser, 1997) and the consistency of adipose tissues (Bozzolo et al., 1990; Martin et al., 1999). Increased unsaturation results in greater flavour changes in ruminants, including beef, than in pork (Melton, 1990). Breed- age- and sex-related differences in the fatty acid composition of beef cattle have been widely demonstrated (Eichhorn et al., 1986; Zembayashi et al., 1995; Huerta-Leidenz et al., 1996; Perry et al., 1998; Malau-Aduli et al., 2000; Laborde et al., 2001).

Objectives

The aim of our study was to evaluate the effects of breed and sex on growth performance, carcass characteristics and fatty acid composition attributes of the longissimus muscle in Limousin, Simmental, Red Angus, Belgian Blue x Simmental, Belgian Blue x Limousin, Simmental x Limousin growing finishing bulls and heifers.

Materials and methods

Fifty-seven (25 bulls and 32 heifers) growing finishing beef cattle were fattened. The animals were housed in free-stall barn with an open corral, fed *ad libitum* a diet consisting of maize silage, alfalfa hay (NEm=6.8; NEg=3.2 MJ/kg) concentrate mixture (NEm=4.0; NEg=2.5 MJ/kg) and corn (NEm=6.2; NEg=9.5 MJ/Kg). The proportion of the concentrate was increased from about 30 to 40 % of the DM during the fattening period. Bulls and heifers were slaughtered at age of 554 to 520 days, and weight of 617 to 543 kg, respectively. The left side of each carcass was sampled approximately 24 hours *post mortem*. Muscle samples were excised from the longissimus dorsi muscle at the 12th rib. Each sample, consisting of approximately 10 g of tissues, was stored at –20°C in a small plastic bag until the fatty acids were analyzed.

Total lipid was extracted by the method of Folch, Leeas and Sloane-Stanley (1957). The fatty acid methyl esters were separated and analysed by gas liquid chromatography according to Husvéth, Karsai and Gaal (1982), using an automated gas liquid chromatograph (Carlo Erba HRGC 5300) equipped with a dual flame ionisation detector and a packed glass column. Fatty acids were identified by comparing their retention times to those of known standard mixtures of fatty acid methyl esters quantified by a Shimadzu C-RGA integrator. The results were expressed as a weight percentage distribution of total fatty acid methyl esters. Data were initially recorded and listed as the percentages of individual fatty acids in the samples. The total saturated fatty acids (SFA) were calculated as the sum of C14:0, C16:0 and C18:0. Monounsaturated fatty acids (MUFA) comprised C16:1n-7, C18:1n-9, C18:1n-7, and C20:1n-9, whereas total polyunsaturated fatty acids (PUFA) was calculated as the sum of C18:2n-6, C18:3n-3, C18:3n-6, C20:4n-6, C20:5n-3, C22:4n-6, C22:5n-3, and C22:6n-3 fatty acids. Statistical analysis of the data was performed using SPSS 9.0 for Windows (Statistical Package for the Social Sciences, 1996).

In the first step the effects of sex and breed were examined with General Linear Model (GLM) procedure applying the following equation:

$$yij = \mu + Ai + Mj + AixMj + eij$$

(yij= being the observed value of the ith age and jth muscle type, μ = mean value common to all observations, Ai = fixed effects of sex, Mj = fixed effects of breed, AixMj = interaction between sex and breed, eij= the error term). Treatment means were compared by least significant differences (LSD).

Significant differences between the treatments are reported at $P < 0.05$. Statistical models and factors fitted for least square analysis are shown in Table 1.

Results and discussion

Intramuscular lipid content and fatty acid composition of the longissimus muscle in growing finishing bulls and heifers are shown in Table 2. Breed and sex had significant effect on MUFA and PUFA content. With respect to SFA, sex and breed effect was significant ($P<0.05$) only in case of stearic acid (C18:0). Belgian Blue x Simmental bulls had the highest, while heifers of this genotype had the lowest, C18:0 percentages. This difference suggests that sex had a high impact on stearic acid content of the muscles. Dietary intake of SFA has been attributed to elevate serum cholesterol level and increased risk of cardiovascular disease in humans (Hegsted et al., 1965). In the MFA group only the oleic acid (C18:1n-9) content of the longissimus muscle differed significantly ($P<0.001$) in all models. Limousin heifers had the highest oleic acid level in their muscles, while Belgian Blue x Limousin crossed bulls had the lowest percentage. Most of the significant differences were found in polyunsaturated fatty acids such as C18:2n-6; C18:3n-3 and C18:3n-6. From a nutritional and dietetic point of view, enhanced PUFA content of beef is advantageous as it increases flavor and decreases cardio-vascular risks, which translate to a more healthful product. Belgian Blue x Limousin bulls had the highest percentage of PUFA the lowest values being detected in Limousin bulls. The opposite results were found in SFA percentages. The longissimus muscles of Belgian Blue x Limousin crossed bulls had the lowest values of SFA the highest proportions being detected in Limousin bulls. SFA and MUFA proportions were higher in heifers, whereas PUFA content of the longissimus muscle was superior in bulls.

Conclusions

Both sex and breed had significant ($P<0.05$) effect on the intramuscular TL content and on fatty acid composition with the exception of saturated fatty acids (SFA). Belgian Blue x Limousin crossed animals had the lowest proportion of SFA and monounsaturated fatty acids (MUFA), and consequently, the highest level of polyunsaturated fatty acids (PUFA). The highest SFA and the lowest PUFA contents were found in Limousin breed.

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Table 1. Significance of factors and models

Fatty acids	Sex	Breed	Sex × Breed
Intramuscular Total Lipid	***	**	**
C14:0	**	NS	NS
C16:0	***	*	**
C16:1 *n-7*	**	NS	NS
C18:0	***	*	***
C18:1 *n-9*	***	***	***
C18:1 *n-7*	NS	NS	NS
C18:2 *n-6*	***	***	***
C18:3 *n-6*	NS	***	***
C18:3 *n-3*	***	***	***
C20:1 *n-9*	NS	NS	NS
C20:4 *n-6*	**	**	**
C20:5 *n-3*	NS	NS	NS
C22:4 *n-6*	NS	NS	NS
C22:5 *n-3*	*	*	NS
C22:6 *n-3*	NS	NS	NS
Saturated FA[1]	NS	NS	NS
Monounsaturated FA	***	***	***
Polyunsaturated FA	***	***	***

NS: not statistically significant; *: P<0.05; **: P<0.01; ***: P<0.001; FA[1]: Fatty Acids

Table 2. Intramuscular total lipid (ITL) content (g/kg wet wt) and fatty acid composition (wt%) in heifers and bulls of different genotypes

Fatty acid	Red Angus		Sim x Li		Sim	Limousin		BB. x Sim		BB. x Li	Total
	bulls	heifers	bulls	heifers	Bulls	bulls	heifers	bulls	heifers	bulls	
ITL	1.9±0.9[a]	5.9±2.3[a]	1.7±0[a]	3.7±1.7	1.8±1.3[a]	1.6±0.0	4.3±1.0	1.3±0.8	3.4±1.3	0.8±0.7	2.7±1.2
C14:0	1.7±0.5[a]	2.0±0.3	1.5±0[a]	2.0±0.6	1.6±0.3[a]	2.1±0.2	2.1±0.4	1.7±0.3[a]	2.1±0.5	1.6±0.4[a]	1.9±0.5
C16:0	18.8±2.7[a]	21.3±0.8	18.7±0[a]	21.1±2.1	19.1±1.3[a]	20.7±1.6	21.8±1.5	18.3±1.4[a]	21.1±1.7	15.7±4.1	20.2±2.3
C16:1n7	2.0±0,6[a]	2.9±0.5	2.4±0	2.9±0.6	2.1±0.5[a]	2.2±0.2[a]	2.9±0.8	1.9±0.4	2.2±1.6	1.5±0.1	2.4±0.9
C18:0	12.3±2.0[a]	10.1±0.9	10.0±0	9.3±0.6	12.4±1.6[a]	11.9±0.1[a]	10.0±1.2	12.7±3.3[a]	9.3±1.5	11.3±0.9[a]	10.8±1.9
C18:1n9	25.7±3.2[b]	30.8±2.3	27.9±0[a]	31.3±3.1	26.3±2.4[a]	27.0±0.4[a]	31.6±3.6	25.3±2.2[b]	29.8±1.3	18.0±4.8	28.4±4.1
C18:1n7	0.8±0.1	0.8±0.1[b]	1.2±0	0.9±0.2	1.0±0.1	0.8±0.1	0.9±0.2	1.0±0.2[b]	0.8±0.3	1.0±0.2	0.9±0.2
C18:2n6	6.4±1.7[a]	2.7±0.5[a]	5.8±0[a]	3.8±1.7	8.8±1.8	5.8±1.8[a]	4.3±1.8	7.0±2.7[a]	3.7±1.2	9.8±5.6	5.3±2.7
C18:3n6	25.3±5.0[a]	24.6±2.8	26.0±0[a]	22.8±1.9	18.9±1.7	23.2±1.4[a]	19.6±1.4[a]	23.9±4.1[a]	24.1±2.6[a]	31.5±0.9	23.0±3.9
C18:3n3	0.3±0.1	0.2±0	0.2±0	0.2±0.1	0.6±0.1[a]	0.2±0.1	0.2±0.1	0.3±0	0.2±0	0.5±0.3[a]	0.3±0.2
C20:1n9	0.5±0.2	0.3±0.1	0.7±0[a]	0.3±0.1	0.3±0	0.5±0.2	0.3±0.2	0.4±0.1	0.4±0.3	0.4±0.0	0.4±0.2
C20:4n6	1.3±0.4[b]	0.7±0.2[a]	1.7±0	1.1±0.6	2.1±0.7[a]	1.1±0.7	1.5±0.8[ab]	1.3±0.5[b]	1.0±0.3	1.0±0.1	1.3±0.6
C20:5n3	0.2±0	0.4±0.3[a]	n.d.	0.2±0	0.2±0.2	n.d.	0.2±0	0.1±0	0.1±0	0.3±0	0.2±0.2
C22:4n6	0.3±0.2	0.1±0[a]	n.d.	0.4±0.3	0.2±0.1	0.4±0.2	0.4±0.4	0.8±0.6[a]	0.4±0.4	0.2±0	0.4±0.3
C22:5n3	0.2±0.1	0.2±0.1	n.d.	0.2±0.1	0.4±0.2	0.3±0	0.2±0.3	0.3±0.2	0.2±0.1	0.8±0[a]	0.3±0.2
SFA	32.8±4.4	33.4±1.4	30.2±0[b]	32.4±2.7	33.2±1.9	34.6±1.7	33.9±2.0	32.7±3.0	32.5±1.8	28.6±5.5[a]	32.9±2.7
MUFA	29.0±3.3[a]	34.8±1.9	32.2±0[b]	35.4±3.4	29.6±2.6[a]	30.4±0.5[a]	35.6±3.5	28.6±2.1[a]	33.3±2.2	20.8±4.7	32.1±4.4
PUFA	33.7±6.8	28.6±2.7	33.7±0	28.2±3.8	31.1±3	29.9±0.6	25.8±3[a]	33.4±5.0	29.4±2.5	43.4±6.1[a]	30.3±5.1

Sim: Simmental; Lim: Limousin; BB.: Belgian Blue;
Within a raw and sex, means lacking common letter (a,b) differ significantly ($P<0.05$). Values are means±S.D.
SFA: saturated fatty acids
MUFA: monounsaturated fatty acids
PUFA: polyunsaturated fatty acids