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The influence of sires selection index on the intramuscular fat fatty-acid profile of their progeny

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ABSTRACT

The nutritional value of beef meat is related to its fatty acid composition and the amount of intramuscular fat (IMF). In a two-year experiment, 50 steers, sired by five Simmental sires with different selection indices (SI), were used to evaluate the effects of the sire on carcass characteristics and fatty acid composition. To test the variability in the measured parameters between the fattening bulls, they were divided into three groups according to their EUROP conformation class and EUROP fat grade. The protein content of the longissimus dorsi (LD) linearly increased with increasing SI, while LD fat decreased. All important fatty acids (FA) varied significantly between the different sires; nevertheless these differences were not related to sire SI. Live weight, cold carcass weight, C18:1n9, monounsaturated fatty acids (MUFA) and 18:1/18:0 ratio increased with increasing EUROP conformation score, while C20:4n6 and saturated fatty acids (SFA) decreased. A higher EUROP fat grade was related to an increase in cold carcass weight,% of total lean meat, C18:1n9, MUFA and C18:1/C18:0 and a decrease in% total bone, SFA, C18:3n3 and C20:4n6. Polyunsaturated fatty acid content was positively correlated to LD protein content and negatively correlated to MUFA content. Principal component analyses revealed that polyunsaturated fatty acids (PUFA) and n6/n3 ratio are directly opposite to MUFA content. Parameters that represent a negative impact on health are independent and in opposition to PUFA and MUFA content. These results suggested a genetic variation in FA synthesis and IMF content among the progeny of different sires, which may enable us to select for increased PUFA content and decreased health lipid indices, and potentially atherogenic fatty acids.

Key words: fatty acid, chemical composition, genetic variation, beef, sire

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Introduction

Meat fat content and particulary fatty acid profile is receiving substantial attention due to its impact on human health (RESURRECCION, 2004). Monounsaturated fatty acids (MUFA) and the polyunsaturated fatty acids (PUFA), particularly the n3 PUFAs, eicosapentaenoic acid (20:5 n3) and docasahexaenoic acid (22:6 n3), can have an important beneficial health effect, such as being hypocholesterolemic (BONANOME and GRUNDY, 1988), and anti-inflammatory (BELLUZZI, 2002), in cardiovascular disease prevention, and being anti-cancerogenic and anti-obesity (WHO, 2003; SCOLLAN et al., 2006).

Beef has an important role as a source of protein and micronutrients, but over the last decade these positive attributes have been overshadowed due to the high content of saturated fat. According to nutritional guidelines from the World Health Organization in relation to fat in human nutrition, it is recommended that total fat, saturated fatty acids (SFA), n6 PUFA, n3 PUFA and *trans* fatty acids intake should contribute to <30%, <10%, 5-8%, <1-2% and <1% of the total energy intake, respectively (WHO, 2003). Beef fat quality may be influenced by many factors, including diet (CORAZZIN et al., 2012), breed (ZAPLETAL et al., 2009), genotype (CUVELIER et al., 2006), age, live weight (LAKE et al., 2005) and gender (MONTEIRO et al., 2006).

The effect of the breed is an important factor responsible for the variations in FA composition, because fat deposition varies between breeds or lines, crosses and even animals of the same breed (DE SMET et al., 2004). A great deal of information on the fatty acid composition of the intramuscular fat of different beef breeds is widely available, (ITOH et al., 1999; RAES et al., 2003; ENGLE and SPEARS, 2004), but comparison of these data is complex because of the differences in experimental designs. Individual sires within a breed may influence the genetic, production and carcass traits of their progeny, including the fatty acid composition (XIE et al., 1996; ELIAS CALLES et al., 2000).

Simmentals are a dual purpose beef and dairy breed, but the breeding goal is to obtain the highest income from meat production, and therefore bulls are fattened up to A and B category, according to EUROP system. The fatty acid profile of ruminant tissue may be modified by a dietary manipulation (WOOD et al., 1999), nevertheless, modification of fatty acids by selective breeding may be also effective (HUERTA-LEIDENZ et al., 1993).

By identifying the natural variations in the fatty acid profile of beef, producers could significantly improve meat quality with a combination of nutrition and selection. Therefore, we studied the variations in selection values in fattening bulls of frequently used sires. Additionally, we tested the influence of the EUROP conformation score and fat grade on the fatty acid profile of fattening bulls, as well as which factors lead to the highest n3/n6 ratio.

Materials and methods

Animals, management and feed. A total of 50 young bulls of the Simmental breed, belonging to five different sires of no genetic relationship, were reared in separate pens with slatted floors, from the age of 120 days until slaughter (420 days). The sires were chosen according to the values of the selection index (SI) which were above the average values for SI 100. The selection index was estimated from a combination of three parameters milk production, meatiness and fitness with default interrelationship proportions 40:30:30. The values of SI ranged from 64-136. They were reared under controlled conditions to exclude variations due to management, feeding, and age at slaughter. The animals were fed by concentrate supplement and meadow hay (Table 1). Water was available ad libitum.

Table 1. Ingredients and chemical composition of the experimental diet ("as fed" basis)

Ingredient g/kg (on "as fed" basis)	Diet
Corn grain	700
Bran wheat	15
Soybean meal	185
Sunflower meal	50
Mineral-vitamin premix[1]	50
Chemical composition[2]	
Dry matter (g/kg)	880
Neutral detergent fibre (g/kg)	369
Acid detergent fibre (g/kg)	198
Crude protein (g/kg)	149
Ether extract (g/kg)	32
Gross energy (MJ/kg DM)	17.6

[1]Mineral vitamin premix comprising per kilogram: vitamin A, 150,000 IU; vitamin D3, 40,000 IU; vitamin E, 500 mg; Ca, 120 g; P, 42 g; Na, 30 g; Mg, 1,000 mg; Se, 2 mg; Cu, 240 mg; Mn, 1,000 mg, Zn, 800 mg, Co, 5 mg; [2]Determined using pooled samples during the experimental period

The feed samples were ground and analysed for dry matter, crude protein and ether extract, according to AOAC procedures (AOAC, 1999). Detergent fibre were analysed according to the methods described by VAN SOEST et al. (1991), with α amylase (Sigma-Aldrich, Inc., USA) added during the NDV extraction. Sodium sulphite was not used.

Animals were fasted for 12 hours before slaughtering, stunned and slaughter at a commercial slaughterhouse on the 420th day of age. Live weight (LWS) and hot carcass weight (HCW) were recorded on the slaughter day. Daily weight gain was expressed as weight gain divided by the number of days on feed. After a chilling period of

approximately 24 hours, samples of the longissimus dorsi muscle were collected (7^{th} - 9^{th} thoracic rib cut). Thoracic rib cuts were anatomically dissected and the share of each tissue was determined (RAKO, 1960). The following day the carcasses were classified for conformation and fat cover by a trained and experienced evaluator, according to the EUROP system, using a scale from 1 to 5 for conformation, and a scale from 1 to 5 for fat cover, with 5 being the thickest fat cover.

Chemical composition. After thawing at room temperature for 4 h, the longissimus dorsi muscle (LD) portion was cut into 2 pieces, homogenized and used for determination of chemical composition.

Protein, ash and moisture contents were estimated according to the methods recommended by the AOAC (1999). Briefly, the moisture content was determined by drying homogenized meat samples at 100 °C until they reached the constant weight. The standard Kjeldahl procedure was employed to determine nitrogen content, and expressed as protein content (nitrogen content multiplied by 6.25). The ash content was determined by burning in a laboratory furnace at a temperature of 610 °C. Muscle fat content was extracted using a chloroform-methanol (2:1, vol/vol) mixture, according to the method of FOLCH et al. (1957).

Fatty acid analysis. The fatty acids were analysed as their methyl esters in duplicate, and transesterification was performed using a 20% solution of boron trifluoride in methanol. The fatty acid methyl esters (FAMEs) were separated by gas chromatography equipped with a flame-ionization detector (Gas Chromatograph GC 2010 Plus, Shimadzu, Japan) using a capillary column ZB WAX (Phenomenex, Torrance, CA, USA) and helium as the carrier gas. The FAMEs were identified by comparing the retention times with those of a standard FAME mixture (Sigma-Aldrich, Steinheim, Germany). The identification was carried out by comparison of sample peak retention times with those of FAME standard mixtures (Sigma-Aldrich, Germany) and calculated as a percentage of each individual fatty acid relative to the total fatty acids.

Health lipid indices useful for evaluating nutritional quality and healthiness of lipid profile were determined as follows (ULBRICHT and SOUTHGATE, 1991):

$$\text{Atherogenic index (AI)} = [(C12{:}0 + 4 \times C14{:}0 + C16{:}0)/(\Sigma MUFA + \Sigma (n\text{-}6) + \Sigma (n\text{-}3))]$$

$$\text{Thrombogenic index (TI)} = [(C14{:}0 + C16{:}0 + C18{:}0)/(0.5 \times \Sigma MUFA) + 0.5 \times \Sigma (n\text{-}6) + 3 \times \Sigma (n\text{-}3) + \Sigma (n\text{-}3)/\Sigma (n\text{-}6)]$$

Statistical analysis. The statistical analysis was performed using STATISTICA software (StatSoft Inc., 2010). One-way ANOVA analysis was applied to study the differences between all animal groups. When analysis of variance gave a significant difference between the groups, the Tukey HSD test was applied. Pearson's correlation

coefficient was used to test parametric correlations. Principal component analysis was used to determine the relationship between different variables.

Results

With the exception of total carcass fat, all other carcass traits and LD chemical composition varied significantly among the progeny of the five different sires with selection indices (SI) varying from 111 to 119 (Table 2). The protein content of LD linearly increased with increasing SI, while LD fat decreased. Other factors varied independently of the sires' SI. All important fatty acid profiles varied significantly among different sires (Table 3), nevertheless these differences were not related to sire SI.

Table 2. Influence of sire selection index on carcass traits and chemical composition of the m. longissimus dorsi of the fattening Simmental bulls[1]

	111[2] (n = 10)	112 (n = 10)	113 (n = 10)	117 (n = 10)	119 (n = 10)
Live weight (kg)	588.0 ± 25.6^{b}	584.0 ± 24.3^{b}	570.0 ± 37.6^{a,b}	576.5 ± 30.7^{b}	526.0 ± 64.0^{a}
Average daily gain (kg)	1.4 ± 0.06^{b}	1.39 ± 0.06^{b}	1.35 ± 0.09^{b}	1.37 ± 0.07^{b}	1.25 ± 0.05^{a}
Dressing percentage (%)	58.11 ± 1.71	59.95 ± 1.51	58.99 ± 1.28	59.6 ± 1.46	59.94 ± 2.55
Cold carcass weight (kg)	334.1 ± 20.2^{a,b}	344.5 ± 18.8^{a}	328.8 ± 23.8^{a,b}	335.2 ± 18.2^{a,b}	307.9 ± 38.6^{b}
Hot carcass weight (kg)	341.8 ± 19.61^{a}	350.2 ± 19.4^{a,b}	336.3 ± 24.54^{a,b}	343.5 ± 18.76^{a,b}	315.0 ± 39.5^{b}
EUROP conformation[3]	3.50 ± 0.53^{a}	3.50 ± 0.53^{a}	3.20 ± 0.63^{a}	3.80 ± 0.79^{a}	2.40 ± 0.52^{b}
EUROP fat grade[4]	2.20 ± 0.42^{b}	2.90 ± 0.32^{a}	2.20 ± 0.42^{b}	2.90 ± 0.32^{a}	2.20 ± 0.42^{b}
% total carcass lean	61.45 ± 3.83^{b}	65.54 ± 2.75^{a,b}	63.87 ± 1.56^{a,b}	66.71 ± 4.82^{a}	61.92 ± 2.02^{b}
% total carcass fat	14.55 ± 2.13	13.39 ± 3.14	12.86 ± 2.03	12.38 ± 3.30	13.34 ± 2.14
% total carcass bone	23.49 ± 2.49^{b}	20.71 ± 1.79^{a}	22.62 ± 1.10^{a,b}	20.45 ± 2.47^{a}	24.11 ± 2.23^{b}
Longissimus dorsi composition					
Dry matter %	25.22 ± 1.13^{a}	25.05 ± 0.91^{a}	23.78 ± 0.49^{b}	24.58 ± 0.49^{a,b}	24.63 ± 0.48^{a,b}
Protein %	19.57 ± 1.43^{a}	19.66 ± 1.16^{a}	20.78 ± 0.70^{a,b}	20.75 ± 1.11^{a,b}	21.25 ± 0.44^{b}
IMF[5] %	4.49 ± 2.11^{a}	4.28 ± 1.67^{a}	1.92 ± 0.87^{b}	2.75 ± 1.11^{a,b}	2.29 ± 0.73^{b}
Ash %	1.17 ± 0.03^{b}	1.12 ± 0.03^{a,b}	1.08 ± 0.03^{a}	1.08 ± 0.07^{a}	1.09 ± 0.02^{a}

Data presented as mean values ± SD; [2]Selection indices; [3]E = 5, U = 4, R = 3, O = 2, P = 1; [4]Class 5 = 5 (very fat),…Class 1 = 1 (very lean); [5]IMF: Intramuscular fat; [a,b]Values in the same row with no common superscript are significantly different. P<0.05

Table 3. Influence of sire selection index on the fatty acid composition of the m. longissimus dorsi of the finishing Simmental bulls[1]

	111[2] (n = 10)	112 (n = 10)	113 (n = 10)	117 (n = 10)	119 (n = 10)
C12:0	0.06 ± 0.003	0.06 ± 0.003	0.04 ± 0.01	0.04 ± 0.01	0.06 ± 0.004
C14:0	2.57 ± 0.10	2.65 ± 0.12	2.45 ± 0.16	2.39 ± 0.10	2.78 ± 0.15
C16:0	24.90 ± 0.51^{a,b}	26.05 ± 0.43^{b}	23.92 ± 0.70^{a}	23.87 ± 0.38^{a}	25.66 ± 0.49^{a,b}
C16:1	3.14 ± 0.15	2.97 ± 0.14	2.83 ± 0.18	2.76 ± 0.14	2.84 ± 0.13
C17:0	1.15 ± 0.06	0.95 ± 0.06	1.15 ± 0.09	1.20 ± 0.09	0.96 ± 0.05
C17:1	0.73 ± 0.05	0.55 ± 0.03	0.63 ± 0.08	0.68 ± 0.05	0.54 ± 0.02
C18:0	18.44 ± 0.61	20.03 ± 0.49	18.59 ± 0.53	20.06 ± 0.74	20.43 ± 0.77
C18:1n9	44.59 ± 0.88^{a}	41.15 ± 0.5^{b}	46.28 ± 0.57^{a}	43.79 ± 0.52^{a}	40.28 ± 0.52^{b}
C18:1n7	0.39 ± 0.10^{a}	0.63 ± 0.14^{a,b}	0.69 ± 0.18^{a,b}	0.45 ± 0.03^{a}	1.04 ± 0.16^{b}
C18:2n6	3.35 ± 0.17^{a,c}	3.82 ± 0.12^{b,c}	3.03 ± 0.25^{a}	4.10 ± 0.08^{b}	4.21 ± 0.10^{b}
C18:3n3	0.16 ± 0.03^{b,c}	0.24 ± 0.02^{c,d}	0.05 ± 0.02^{a}	0.12 ± 0.04^{a,b}	0.26 ± 0.02^{d}
C20:0	0.03 ± 0.02^{a}	0.11 ± 0.01^{b}	0.02 ± 0.02^{a}	0.07 ± 0.02^{a,b}	0.12 ± 0.01^{b}
C20:1n9	0.05 ± 0.03^{a}	0.21 ± 0.02^{b,c}	0.03 ± 0.03^{a}	0.09 ± 0.05^{a,b}	0.23 ± 0.03^{c}
C20:4n6	0.00 ± 0.00^{a}	0.06 ± 0.01^{b}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.07 ± 0.01^{b}
C20:5n3	0.01 ± 0.01	0.02 ± 0.02	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01
C22:6n3	0.01 ± 0.01^{a,b}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.04 ± 0.01^{b}
SFA	47.20 ± 0.86^{a}	49.91 ± 0.50^{b}	46.23 ± 0.57^{a}	47.66 ± 0.60^{a,b,c}	50.07 ± 0.55^{b,c}
MUFA	48.90 ± 0.90^{a,b}	45.51 ± 0.54^{c,d}	50.46 ± 0.45^{a}	47.78 ± 0.62^{b,c}	44.93 ± 0.53^{d}
PUFA	3.90 ± 0.21^{a,b}	4.58 ± 0.020^{b,c}	3.32 ± 0.28^{a}	4.57 ± 0.07^{b,c}	5.01 ± 0.11^{c}
n-6/n-3	6.50 ± 0.53	7.00 ± 1.05	7.25 ± 1.36	7.38 ± 1.00	5.97 ± 0.20
PUFA/SFA	0.08 ± 0.005^{a,b}	0.09 ± 0.004^{b}	0.07 ± 0.01^{a}	0.1 ± 0.002^{b}	0.1 ± 0.003^{b}

[1]Results expressed as a percentage of the total fatty acids. Data presented as mean ± standard deviation. [2]Selection indices; $^{a-d}$ Values in the same row with no common superscript are significantly different. P<0.05.

To test the variability in the measured parameters among the fattening bulls, they were divided into three groups according to EUROP conformation class (low, middle and high), and according to EUROP fat grade they were divided into two groups (low and high). EUROP conformation score significantly influenced seven parameters (Table 4). Live weight, cold carcass weight, C18:1n9, MUFA and 18:1/18:0 ratio increased with increasing EUROP conformation score, while C20:4n6 and SFA decreased. EUROP fat grade influenced 9 parameters (Table 5). Higher EUROP fat grade was related to an increase in cold carcass weight,% of total lean meat, C18:1n9, MUFA and C18:1/C18:0 and a decrease in% total bone, SFA, C18:3n3 and C20:4n6. The significant (P<0.05) correlations between carcass traits and chemical composition of longissimus dorsi and fatty acid content are given in Table 6.

Table 4. Influence of EUROP conformation classes on carcass traits and fatty acid profile of fattening bulls[1]

Parameters	EUROP conformation class		
	Low (2)	Medium (3)	High (4)
Live weight (kg)	498.5 ± 51.0[a]	575.4 ± 31.06[b]	586.6 ± 28.78[b]
Cold carcass weight (kg)	290.9 ± 25.0[a]	331.2 ± 21.41[b]	343.3 ± 20.39[b]
C18:1n9 (%)	39.8 ± 1.65[a]	43.5 ± 2.73[b]	44.2 ± 2.67[b]
C20:4n6 (%)	0.09 ± 0.033[a]	0.02 ± 0.03[b]	0.01 ± 0.02[b]
SFA (%)	50.6 ± 1.88[a]	48.1 ± 2.28[ab]	47.5 ± 2.41[b]
MUFA (%)	44.5 ± 1.83[a]	47.8 ± 2.84[ab]	48.3 ± 2.42[b]
C18:1/C18:0	1.9 ± 0.28[a]	2.3 ± 0.34[ab]	2.4 ± 0.33[b]

[1]Results expressed as percentage of the total fatty acids. Data presented as mean ± standard deviation. [a,b] Values in the same row with no common superscript are significantly different. $P < 0.05$.

Table 5. Influence of EUROP fat grade on carcass traits and fatty acid profile of fattening bulls[1]

Parameters	EUROP fat grade		P value
	Low (Lean)	High (Fat)	
Cold carcass weight (kg)	322.1 ± 29.83	338.8 ± 21.04	0.025
% total lean	62.1 ± 2.95	65.7 ± 3.56	0.000
% total bone	23.5 ± 2.25	20.9 ± 2.00	0.000
C18:1n9 (%)	42.1 ± 2.94	44.4 ± 2.44	0.003
C18:3n3 (%)	0.23 ± 0.07	0.17 ± 0.06	0.017
C20:4n6 (%)	0.04 ± 0.05	0.01 ± 0.03	0.010
SFA (%)	49.0 ± 2.42	47.3 ± 2.19	0.010
MUFA (%)	46.5 ± 2.86	48.5 ± 2.41	0.007
C18:1/C18:0	2.12 ± 0.34	2.38 ± 0.33	0.011

[1]Results expressed as percentage of the total fatty acids. Data presented as mean ± standard deviation. [a,b] Values in the same row with no common superscript are significantly different. $P < 0.05$.

Table 6. Correlation between carcass traits and chemical composition of the longissimus dorsi and fatty acid content[1]

	C18:0	C18:1n9	C18:2n6	C18:3n3	C20:1n9	C20:4n6	SFA	MUFA	PUFA	n3	n6
Live weight	-0.482	0.444	-0.408	-0.499	ns	-0.418	-0.353	0.440	-0.471	-0.498	-0.408
Cold carcass weight	-0.422	0.353	ns	-0.399	ns	-0.328	ns	0.348	-0.369	-0.393	ns
EUROP conformation	-0.345	0.413	ns	ns	ns	-0.501	-0.352	0.365	ns	ns	ns
EUROP fat grade	-0.332	ns	ns	-0.377	ns	ns	-0.324	ns	ns	ns	ns
Total carcass lean	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Total carcass fat	ns	ns	-0.354	ns	ns	ns	ns	ns	-0.384	ns	-0.354
Total carcass bone	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Longissimus dorsi composition											
Protein	ns	-0.400	0.398	0.384	0.464	0.327	ns	-0.361	0.416	0.340	0.398
Intramuscular fat	ns	0.536	-0.399	-0.407	-0.456	-0.413	-0.463	0.521	-0.413	ns	-0.399

[1]Significant values $P<0.05$. NS not significant

Correlation analyses revealed a positive correlation between PUFA content and LD protein content (Fig. 1A), and a negative correlation between PUFA content and MUFA content (Fig. 1B) and LD fat percentage (Fig. 1C). Principal component analyses of the progeny revealed that PUFA and n6/n3 ratio are directly opposite to MUFA content (Fig. 1D). Parameters that represent a negative impact on health (TI, AI, C12:0, C14:0 and C16:0) are independent and in opposition to PUFA and MUFA content.

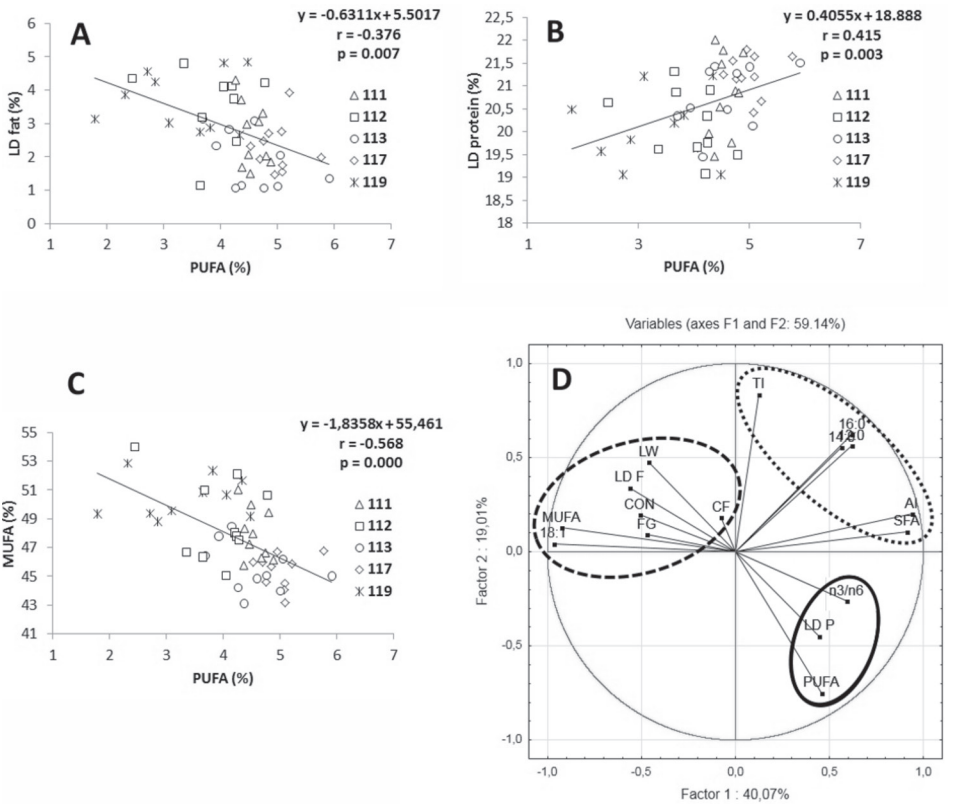

Fig. 1. Correlation scatterplot and Pearson correlation coefficient for PUFA and LD fat content (A), PUFA and LD protein (B) and PUFA and MUFA (C) Principal component analyses showing PUFA, n6/n3 ratio and LD protein (lower right quadrant) in relation to MUFA content, fat parameters, live weight, conformation score and fat grade (higher left quadrant), and with indices related to health (higher right quadrant) (D). MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids; LD P; protein content of the longissimus dorsi; LD F, fat content of the longissimus dorsi; LW, live weight; CON, EUROP conformation score; FG, EUROP fat grade; CF, carcass fat; TI, thrombogenicity index; AI, atherogenicity index

Discussion

The selection indices of the sires were in a narrow range from 111 to 119. Despite that narrow range, almost all carcass traits and the chemical composition of LD varied significantly among the sires. Conformation scores were higher for the progeny of 119 (good conformation) sires compared to all other (average conformation) sires (Table 2).

These results were expected, as young bulls in progeny inherited the paternal musculature and final live weights (XIE et al., 1996; MAHER et al., 2004). Fat scores were mainly 2 and 3 L/VL (EC 1208/1981) and differed significantly between the progeny of the sires (Table 2), even though all the progeny were finished on a similar ration. These differences in our trial were not related to nutrition or management practices, but rather to the genetic variations in the sires. There is therefore a strong relationship between energy intake and IMF (DALY et al., 1999); fattening cattle fed similar diets have low variability in IMF content. Nevertheless, in our experiment significant differences were observed for IMF, as was found by ELIAS CALLES et al. (2000), who reported significant differences in IMF from the progeny of Wagyu sires. Since IMF is linked to the rate of growth and nutrition, conflicting results are the result of cattle production under experimental conditions that differ from those reported in the present experiment. The most obvious variation was observed for LD intramuscular fat, with 2.3 times higher values in sire 111 than in sire 113. Overall, these data imply that genetic variations in carcass traits and the chemical composition of LD exist among frequently used Simmental sires in Croatia. The progeny from 117 was superior to those from 119 and 111 in its ability to produce lean meat with a minimum amount of LD fat.

The predominant fatty acids in the intramuscular fat were C18:1 n9, C16:0, C18:2 n6 and C14:0. This distribution is characteristic for ruminant muscle tissue (SCOLLAN et al., 2006). Consequently PUFA content and n6/n3 ratio were low, which is nowadays connected to potential health problems (RESURRECCION, 2004). The main cause of low n3/n6 ratios in modern fattening cattle is feed with high levels of grains rich in C18:2 n6. In contrast, before modern feeding systems, ruminant rations consisted mainly of grass, rich in C18:3 n3. This change in the diet has led to a drastic increase in the n6/n3 ratio in the meat of ruminants, which has been associated with a negative impact on human health (SIMOPOULOS, 2004). It is interesting that wild ruminants have a higher n3/n6 tissue ratio than domestic ruminants fed exactly the same ration (CORDAIN et al., 2002). This implies that, besides nutrition, which is still the most important factor in the modulation of ruminant tissue fatty acid profile, genes and species could also have a significant influence. Sire genotype had a significant influence on the majority of fatty acids, although the SI were relatively similar. Other authors have suggested that the observed differences in major fatty acid profiles, MUFA and SFA are related to genetic differences among Wagyu sires, indicating that it may be possible to identify and select individuals capable of transmitting their ability to accumulate tissue with less palmitic acid (C16:0), more oleic acid (C18:1) and a high MUFA: SFA ratio, to provide consumers with a healthier beef product (ELIAS CALLES et al., 2000). These genetic differences among sires could be utilized by selective breeding to produce beef cattle with a more desirable fatty acid profile.

Today, the focus has moved from overall fat content to individual fatty acids and the balance in the diet between n-6 and n-3 PUFA. The recommended ratio for humans is less than 4 (WEBB and O'NEILL, 2008). The concentration of important long chain fatty acids from the n3 line (docosahexaenoic and eicosapentaenic fatty acid) is dependent on the intake of either the metabolic precursor α-linoleic acid (C18:3 n3) or the preformed FA. The predominant SFA are 14:0 (myristic acid), 16:0 (palmitic acid) and 18:0 (stearic acid), the latter representing 0.4 of the total SFA. Due to the ruminant physiology (rumen biohydrogenation of unsaturated fatty acids), ruminant edible tissues are characterised by high values of potentially atherogenic saturated fatty acids (C12:0 and C14:0) (SCOLLAN et al., 2006) and low PUFA/SFA ratio, at around 0.1 (CHOI et al., 2000), except for double muscled animals, which are very lean (<1% IMF), where P:S ratios are typically 0.5-0.7 (RAES et al., 2003).

Considering the total lipids of beef, the PUFA n-6/n-3 and PUFA/SFA ratios are important from the nutritional and human health points of view, and they were 7.5-5.9 and 0.08-0.1 respectively (Table 2). The minimum PUFA/SFA ratio set for human nutrition is 0.45, and the recommended ratio of PUFA n-6/n-3 is below 4 (SIMOPOULOS, 2004). CHOI et al. (2000) explained that the PUFA/SFA ratio in beef is often low, because of the hydrogenation of dietary unsaturated fatty acids by micro-organisms in the rumen. Furthermore, difficulty in reaching the recommended PUFA n-6/n-3 ratio has also been reported by other authors (BURES et al., 2006; MACH et al., 2006; CORAZZIN et al., 2012).

The observed MUFA content was comprised mostly of C16:1n7 and C18:1n9. A higher ratio of C18:1 n9 in meat is considered desirable due to its hypocholesterolaemic properties (BONANOME and GRUNDY, 1988). This effect was also visible in our trial with MUFA and C18:1n9, which were directly opposite to the AI and SFA content (Fig. 1D). This result may be explained by the different hydrogenation of C18:1 in the rumen, or by genetic differences in de novo fatty acid synthesis, as suggested by BURES et al. (2006), who also found that the breed influences the level of C18:1 n-9. Nevertheless PUFA content and n3/n6 ratio were also negatively correlated to MUFA content. Animals with a higher EUROP conformation score had lower C20:4n6 content and higher MUFA content, while the animals that were leaner (lower EUROP fat grade) had higher C20:4n6 and C18:3n3 content and lower MUFA content. Consequently, improvement and selection for EUROP fat grades could be interesting as a part of a program for modulation of the ruminant meat fatty acid profile.

Conclusions

These results suggest that the observed differences in fatty acid profiles, MUFA and SFA are related to genetic differences between the Simmental sires. This indicates that it may be possible to identify and select individuals capable of transmitting their ability

to accumulate tissue with high PUFA and decreased TI, AI and potentially atherogenic fatty acid content, to provide consumers with a healthier beef product. Nevertheless, the effectiveness of selecting for more than one fatty acid simultaneously depends on the genetic correlations between these traits, therefore more research needs to be done in order to evaluate genetic variations for these traits.

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MAURIĆ, M., K. STARČEVIĆ, I. ŠTOKOVIĆ, T. MAŠEK: Utjecaj varijacije genetskog profila bika na sastav masnih kiselina i kvalitetu mesa potomstva. Vet. arhiv 86, 753-766, 2016.

SAŽETAK

Nutritivna vrijednost goveđega mesa povezana je s njegovim masnokiselinskim sastavom i količinom mišićne masti. U dvogodišnjem istraživanju procijenjen je učinak bika/oca na značajke trupova i sastav masnih kiselina 50 junaca, sinova pet simentalskih bikova. Da bi se testirala varijabilnost izmjerenih pokazatelja tovni junci bili su podijeljeni u tri skupine prema sustavu EUROP klasifikacije za konformaciju trupa i za zamašćenost trupa. Udio bjelančevina najduljega leđnog mišića (LD) linearno je i pozitivno povezan s povećanjem selekcijskog indeksa (SI), dok je udio masti negativno povezan. Sve bitne masne kiseline varirale su među različitim bikovima, ali navedene razlike ipak nisu bile povezane sa SI bika. Masa žive životinje, ohlađenih polovica, C18:1n9 i omjer 18:1/18:0 rasli su s povećanjem EUROP klase, dok su C204n6 i SFA opadali. Veći stupanj zamašćenosti trupa bio je povezan s povećanjem mase ohlađenih polovica, udjela ukupnog nemasnog mesa, C18:1n9, MUFA i C18:1/C18:0, a smanjenjem ukupnog udjela kostiju, SFA, C18:3n3 i C20:4n6. Udio PUFA bio je pozitivno povezan s udjelom bjelančevina LD-a i negativno povezan s udjelom MUFA. Analiza glavnih komponenti (PCA) pokazala je da je udio PUFA i n3/n6 omjer negativno povezan s udjelom MUFA. Značajke koje ukazuju na negativan utjecaj na zdravlje (TI, AI, C12:0, C14:0 i C16:0) u suprotnosti su s udjelima PUFA i MUFA. Dobiveni rezultati ukazuju na genetske varijacije u sintezi MK i sadržaju intramuskularne masti među potomstvom različitih bikova što nam omogućuje selekciju na povećani udio PUFA i smanjeni TI, AI i potencijalno aterogene MK.

Ključne riječi: masne kiseline, kemijski sastav, genetska varijacija, meso, bikovi