THE FATTY ACID COMPOSITION OF MUSCLE TISSUE OF SIMMENTAL BABY-BEEF

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SUMMARY

In this work, the fatty acid (FA) composition of muscle tissue of baby-beef cattle was researched with regard to its nutritional value. Twenty- six Simmental cattle of both sexes produced under the intensive conditions of housing and feeding were slaughtered at the age of one year and final weight of 489.6±46.5 kg. The portion of muscle (m.longissimus dorsi) was taken for the chemical analysis at the level of the 8th rib on cooled halves 24 h post mortem. Muscle fat content was determined by Foss-Let apparatus after extraction of lipids with tetrachloroethylene. The fatty acid composition was determined by gas liquid chromatography using in situ transesterification method and given as % of total weight of fatty acids. The average muscle fat content was 18.96 g/kg (95% CI 14.09-23.83). The average proportions of saturated FA (SFA), monounsaturated FA (MUFA) and polyunsaturated FA (PUFA) in muscle tissue were 43.03 (95% CI 42.19-43.87), 43.05 (95% CI 40.74-45.36) and 13.08 % (95% CI 10.96-15.19), respectively. The indicators of nutritional quality of fats like ratios of PUFA to SFA (PUFA/SFA) and n-6 PUFA to n-3 PUFA (n-6/n-3), as well as the atherogenicity index (AI) in muscle were 0.31 (95% CI 0.25-0.36), 13.51 (95% CI 12.59-14.43), and 0.60 (95% CI 0.58-0.63), respectively. These results suggest a need for the improvement of nutritional value of baby-beef fats through the modifications of its FA composition, primarily through n-3 PUFA enrichment.

***Key words**: baby-beef, muscle tissue, fatty acids, nutritional value*

INTRODUCTION

Meat obtained from the intensively fed Simmental older calves of both sex slaughtered at the age of 12 months is very appreciated among Croatian consumers. Because of its favorable sensory properties (color, texture and taste) this so-called ¨baby-beef¨ is highly demanded on local market and it is also selling abroad. In European Union, the quality of meat from this category of bovine animals is clearly distinguished on the market from veal meat obtained from animals aged up to 8 months as well as from beef obtained from animals older than 12 months (*Council Regulation*, 2007). For example, in Italy this class of meat is marketing as ¨*carne di vitellone*¨, in Austria and Germany as ¨*Jungrindfleisch*¨, in Ireland as ¨rosé Veal¨, and in Slovenia as ¨*meso starejših teleti*¨. Recently, Croatia also adopted the new labelling system for bovine carcasses and distinct category for animals aged at slaughter from 8 to 12 months (¨starija telad¨) is established as well (*Anon, 2009.*).

Aside from the eating quality, the contribution to healthy lifestyle is becoming an increasingly important aspect of meat quality in the mind of consumers (Becker, 2002). Meat is traditionally considered as highly nutritious and valued food associated with good health and prosperity. However, that positive image was disturbed when high consumption of red meat has been linked with increased frequency of chronic diseases such as coronary heart disease and some types of cancer (Higgs, 2002; Wood et al., 2003; Biesalski, 2005). That was mainly due to its fat content and fatty acid (FA) composition and in particular beef has been criticized for being too high in saturated FA (SFA) and low in polyunsaturated FA (PUFA) and thus potentially unhealthy for consumers (Scollan et al., 2006). Moreover, in grain-fed beef the concentration of PUFA and beneficial n-3 PUFA tends to be lower than in grass-fed beef (Moloney, 2002). Baby-beef cattle are usually feed with corn-based concentrates and corn grain silage with addition of some fodder, typically in the form of corn stalk silage and hay or straw. It could be assumed that such predominantly grain-based diet may results in nutritive less valuable FA composition of beef fats. Thus, the aim of this work was to investigate the FA composition of muscle tissue of Simmental baby-beef, especially in the terms of its nutritional value.

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MATERIAL AND METHODS

The investigation was carried out on twenty six Simmental baby-beef cattle of both sexes raised under similar conditions of housing (indoor boxes, concrete floor bedded with straw) and diet (maize grain silage *ad libitum*, complemented with about 1 kg of concentrate and hay per animal daily). At slaughter, cattle were around 1 year of age and weighted averagely 489.6±46.5 kg. Slaughtering procedure was described previously by Karolyi et al. (2006). The portion of muscle (*m.longissimus dorsi*) for the chemical analysis was taken at the level of 8th rib on cooled right halves 24 h *post mortem* and stored frozen (-18 °C) until analysis. Crude fat content in longissimus muscle was determined by Foss-Let apparatus after extraction of lipids with tetrachloroethylene (AOAC 1996). Fatty acid composition of muscle (intramuscular fat) was determined by gas liquid chromatography using *in situ* transesterification method (Park and Goins, 1994). The content of FA methyl esters (FAME) was determined using a gas chromatograph Agilent Technologies 6890 N (USA), equipped with a flame ionization detector (FID) and a capillary column Supelco Omegawax™ 320. FAMEs were

Table 1. Fatty acid composition of baby-beef longissimus muscle (% of total weight of FA)
Tablica 1. Sastav masnih kiselina *m.longissimus dorsi* - a starije teladi (% od ukupne mase masnih kiselina)

Fatty acid / Masna kiselina		Mean/ Prosjek	S.D.	Min	Max	C.V.	95% C.I.
Muscle fat / mast u mišiću (g/kg)		18.96	12.05	3.00	48.00	63.55	14.09-23.83
C10:0	Capric	0.084	0.018	0.054	0.123	21.28	0.077-0.092
C12:0	Lauric	0.078	0.012	0.060	0.097	14.93	0.073-0.083
C14:0	Myristic	2.50	0.37	1.95	3.69	14.56	2.36-2.65
C14:1	Myristoleic	0.482	0.120	0.323	0.764	24.84	0.433-0.530
C15:0	Pentadecanoic	0.457	0.077	0.310	0.604	16.82	0.426-0.488
C16:0	Palmitic	23.49	1.32	21.21	26.52	5.60	22.96-24.03
C16:1	Palmitoleic	2.93	0.608	2.07	4.41	20.73	2.69-3.18
C17:0	Heptadecanoic	1.50	0.218	1.06	1.92	14.55	1.41-1.59
C18:0	Stearic	14.81	1.38	11.83	17.19	9.34	14.25-15.37
C18:1	Oleic	39.29	5.31	30.33	50.45	13.52	37.15-41.44
C18:2n-6	Linoleic	8.24	3.51	3.41	15.63	42.67	6.82-9.66
C18:3n-6	γ-linolenic	0.072	0.019	0.033	0.108	26.69	0.064-0.081
C18:3n-3	α-linolenic	0.274	0.089	0.138	0.482	32.46	0.238-0.310
C20:0	Arachidic	0.098	0.016	0.073	0.128	16.32	0.092-0.105
C20:1	Eicosaenoic	0.345	0.101	0.180	0.543	29.21	0.304-0.386
C20:2n-6	Eicosadienoic	0.150	0.065	0.056	0.301	43.35	0.124-0.176
C20:3n-6	Eicosatrienoic	0.568	0.179	0.253	1.06	31.60	0.495-0.640
C20:4n-6	Arachidonic	2.76	1.17	0.819	5.21	42.26	2.29-3.23
C20:5n-3	Eicosapentaenoic	0.156	0.069	0.059	0.291	44.09	0.128-0.184
C22:4n-6	Adrenic	0.389	0.128	0.170	0.668	32.83	0.337-0.440
C22:5n-3	Docosapentaenoic	0.502	0.193	0.250	0.930	38.53	0.422-0.582

S.D. - standard deviation / standardna devijacija, Min. - minimum, Max. - maximum, C.V. - coefficient of variability / varijacioni koeficijent (%), 95% C.I. - 95% confidence interval / interval povjerenja

determined by the comparison with the retention times of those in standard mixture (Nu-Check Prep, Inc, Elysian, USA). The same standard mixture was used to determine the response factor (Rf) for each FA. The weight proportion (%) of each FA in the sample was determined using the Rf and the factor of conversion of FA from FAME content. The nutritional value of fat was assessed by the ratios of PUFA to SFA (PUFA/SFA) and n-6 PUFA to n-3 PUFA (n-6/n-3) as well as by the index of atherogenicity (AI) (Ulbricht and Southgate, 1991). Descriptive statistics (mean, standard deviation, coefficient of variation, minimum, maximum) and interval estimates of the mean (95% confidence interval) for FAs and ratios were calculated by UNIVARIATE Procedure of SAS Statistical program (SAS Institute, 1999).

RESULTS AND DISCUSSION

Descriptive statistics for intramuscular fat content and its FA composition in Simmental baby-beef is presented in Table 1.

The average fat content in baby-beef meat was 18.96 g/kg (95% CI 14.09-23.83) and varied markedly (CV=63.6). As analyzed beef samples were originated from both, bulls and heifers, the observed variability could be explained by sex-related difference in overall capacity for fat deposition which normally exists in young slaughter cattle (De Smet et al., 2004). High carcass fatness of baby-beef heifers was reported previously (Karolyi et al., 2006). Regarding muscle FA composition (%), the most abundant FAs were C18:1 (39.3; 95% CI 37.15-41.44), C16:0 (23.5; 95% CI 22.96-24.03), C18:0 (14.8; 95% CI 14.25-15.37) and C18:2n-6 (8.2; 95% CI 6.82-9.66). The proportion of C17:0, C14:0, C20:4n-6 and C16:1 was between 1.5 and 3 %, while the percentage of other FA was below 1 %. In comparison with beef FA profile reported in literature (e.g. review of Muchenje et al., 2009) the observed FA values in baby-beef chiefly correspond with reported ranges. However, the proportion of major n-3 PUFA (C18:3n-3) of 0.27 (95% CI 0.24-0.31) founded in baby-beef was at lower margin of reported ranges (Muchenje et al., 2009).

The nutritional value of intramuscular FA composition of baby-beef is given in Table 2.

In total, the proportions of SFA (43.03; 95% CI 42.19-43.87) and monounsaturated FA (MUFA, 43.05; 95% CI 40.74-45.36) were similar, while the proportion of total PUFA was 13.08 (95% CI 10.96-15.19), with averages of n-6 and n-3 PUFA totals of 12.16 (95% CI 10.18-14.15), and 0.91 (95% CI 0.77-1.05), respectively. The PUFA/SFA ratio has been widely used as an indicator of dietary fat quality in relation to atherogenicity in humans. The recommended value for this ratio is ≥0.4 (Higgs, 2002). In beef the PUFA/SFA ratio is generally low due to ruminal biohydrogenation of unsaturated FA and it decreases with fatness (De Smet et al., 2004). The PUFA/SFA ratio of 0.31 (95% CI 0.25-0.36) founded in baby-beef was close to the threshold recommended for human diet and more favorable than PUFA/SFA ratios in concentrate-fed Simmental cattle of higher carcass weight and/or intra-

Table 2. Nutritional value of baby-beef intramuscular fat (*m.longissimus dorsi*)
Tablica 2. Nutritivna vrijednost intramuskularne masti (*m.longissimus dorsi*) starije teladi

	Mean/ prosjek	S.D	Min.	Max.	C.V.	95% C.I.
Σ SFA (%)	43.03	2.08	37.79	46.75	4.84	42.19-43.87
Σ MUFA (%)	43.05	5.71	33.02	54.50	13.27	40.74-45.36
Σ PUFA (%)	13.08	5.24	4.99	24.40	40.05	10.96-15.19
Σ n-6 PUFA (%)	12.16	4.92	4.75	22.89	40.43	10.18-14.15
Σ n-3 PUFA (%)	0.91	0.35	0.24	1.64	38.14	0.77-1.05
PUFA/SFA	0.31	0.13	0.12	0.65	41.98	0.25-0.36
n-6/n-3	13.51	2.27	9.34	19.46	16.83	12.59-14.43
AI	0.60	0.06	0.50	0.79	10.60	0.58-0.63

S.D. - standard deviation / standardna devijacija, Min. - minimum, Max. - Maximum, C.V. - coefficient of variability / varijacioni koeficijent (%), 95% C.I. - 95% confidence interval / interval povjerenja, SFA - saturated fatty acids / zasićene masne kiseline, MUFA - monounsaturated fatty acids / jednostruko zasićene masne kiseline, PUFA - polyunsaturated fatty acids / višestruko zasićene masne kiseline, AI = atherogenicity index / aterogeni indeks = (C12:0 + 4 x C14:0 + C16:0) / (n-6 PUFA + n-3 PUFA + MUFA), Ulbricht and Southgate (1991).

muscular fat (Nuernberg et al., 2005; Kraft et al., 2008). Another measure of nutritional quality of dietary fats is atherogenicity index (AI), proposed by Ulbricht and Southgate (1991). The AI is considered particularly useful as it includes MUFA and puts emphasis on C14:0, which is considered to have the most harmful cardiovascular effect (Higgs, 2002). Data about AI in beef are rare. Ulbricht and Southgate (1991) reported an AI of 0.72 for raw minced beef, while Žlender et al. (2001) reported AI from 0.49 to 0.51 in different muscles of Simmental and Brown bulls. In present study, the AI of baby-beef was 0.60 (95% CI 0.58-0.63). More favorable, lower AI values were reported in other meats, e.g. broiler meat (Polak et al., 2002). For the prevention of diet-related chronic diseases, it is also suggested that intake of n-3 PUFA should be increased relative to n-6 PUFA, with optimal n-6/n-3 ratio in the diet less than 4 (Higgs, 2002). As mentioned previously, the proportion of total n-3 PUFA relative to n-6 PUFA in baby-beef was low and corresponding result for n-6/n-3 ratio in baby-beef of 13.5 (95% CI 12.59-14.43) was quite beyond the dietary recommendations. Feeding grass can increase the n-3 PUFA and other beneficial FA like conjugated linoleic acid in beef, as it was also shown in Simmental bulls (Nuernberg et al., 2005; Petrič et al., 2005). However, for the potential enrichment of n-3 PUFA in beef under the intensive production, the supplements rich in the n-3 PUFA, like some oilseeds should be include in rations. In this regard, methods to protect supplementary lipids from ruminal degradation are under on-going investigations.

CONCLUSIONS

This research showed that typical corn-based diet in baby-beef production can lead to less favourable FA composition of meat. That was particularly noted through the low proportion of beneficial n-3 PUFA. The PUFA/SFA ratio in baby-beef was slightly lower than optimal threshold for human diet, while n-6/n-3 ratio was considerably higher than dietary recommendations. The index of atherogenicity in baby-beef was also high. The observed indicators of nutritional value of fats imply a need for feeding strategy that could enhance the n-3 PUFA content in baby-beef.

SAŽETAK

SASTAV MASNIH KISELINA MIŠIĆNOG TKIVA SIMENTALSKE STARIJE TELADI (BABY-BEEF)

U ovom radu istraživan je sastav masnih kiselina mišićnog tkiva Simentalske starije teladi (baby-beef) s posebnim osvrtom na njihovu nutritivnu vrijednost. Analizirano je dvadeset i šest grla oba spola koja su proizvedena u intenzivnim uvjetima držanja i hranidbe i zaklana u dobi od godine dana pri završnoj masi od 489.6±46.5 kg. Za kemijske analize korišten je uzorak mišićnog tkiva (m.longissimus dorsi) uzet u razini 8 rebra s ohlađenih desnih polovica 24 sata post mortem. Sadržaj masti u mišiću određen je Foss-Let aparatom nakon ekstrakcije lipida s tetrakloroetilenom. Sastav masnih kiselina određen je plinskom kromatografijom metodom in situ transesterifikacije i prikazan kao % od ukupne mase masnih kiselina. Prosječni sadržaj masti u mišiću iznosio je 18,96 g/kg (95%IP 14,09-23,83). Prosječni udio (%) zasićenih, mononezasićenih i poinezasićenih masnih kiselina u mišićnom tkivu bio je 43,03 (95%IP 42,19-43,87), 43,05 (95%IP 40,74-45,36) i 13,08 (95%IP 10,96-15,19). Pokazatelji nutritivne vrijednosti masti, kao što su omjer polinezasićenih i zasićenih masnih kiselina (P/Z) i omjer n-6 i n-3 polinezasićenih masnih kiselina (n-6/n-3), kao i aterogeni indeks (AI) u mišićnom tkivu, iznosili su redom 0,31 (95%IP 0,25-0,36), 13,51 (95%IP 12,59-14,43) i 0,60 (95%IP 0,58-0,63). Dobiveni rezultati ukazuju na potrebu poboljšanja nutritivnu vrijednosti masnoća baby-beef mesa kroz modifikaciju sastava masnih kiselina, poglavito kroz povećanje sadržaja n-3 polinezasićenih masnih kiselina.

***Ključne riječi**: baby-beef, mišićno tkivo, masne kiseline, nutritivna vrijednost*

ZUSAMMENFASSUNG

ZUSAMMENSETZUNG DER FETTSÄUREN IM MUSKELGEWEBE DER ÄLTEREN SIMMENTALKÄLBER (BABY-BEEF)

In dieser Arbeit ist die Zusammensetzung der Fettsäuren im Muskelgewebe der älteren Simmentalkälber (baby-beef) mit besonderer Rücksicht auf ihren nutritiven Wert untersucht. Es wurden sechsundzwanzig Stücke beiden Geschlechtes analysiert, die in intensiven Haltungsbedingungen und Fütterung gezüchtet und im Lebensalter von einem Jahr bei einer Endmasse von 489.6±46.5 kg geschlachtet wurden. Für die chemischen Analysen ist das Muster des Muskelgewebes (m. longissimus dorsi) genommen in der Höhenlage der 8 Rippe aus den gekühlten rechten Hälften 24 Stunden post mortem genutzt. Der Fettgehalt im Muskel ist mit Hilfe des Foss-Let Apparates nach der Extraktion des Lipoids mit Tetrachloräthylen bestimmt. Die Zusammensetzung der Fettsäuren ist durch die Gaschromatographie Methode in situ Transesteriphykation bestimmt und als % von der Gesamtmasse der Fettsäuren dargestellt.Der durchschnittliche Fettinhalt im Muskel betrug 18,96 g/kg (95%IP 14,09-23,83). Der durchschnittliche Anteil (%) der gesättigten, monoungesättigten und poliungesättigten Fettsäuren im Muskelgewebe war 43,03 (95%IP 42,19-43,86), 43,05 (95%IP 40,74-45,36)

und 13,08 (95%IP 10,96-15,9). Die Indikatoren der nutritiven Fettwerte, wie das Verhältnis der poliungesättigten und gesättigten Fettsäuren (P/Z) und das Verhältnis n-6 und n-3 poliungesättigten Fettsäuren (n-6/n-3) und der atherogene Index (AI) im Muskelgewebe betrugen der Reihe nach 0,31 (95%IP 0,25-0,36), 13,51 (95%IP 12,59-14,43) und 0,60 (95%IP 0,58-0,63). Die bekommenen Resultate zeigen, dass ein besserer nutritiver Wert der Fette im baby-beef-Fleisch nötig ist, u.zw. durch die Modifikation der Zusammensetzung von Fettsäuren, besonders durch die Vergrößerung des Gehaltes n-3 poliungesättigter Fettsäuren.

Schlüsselwörter: *baby-beef, Muskelgewebe, Fettsäuren, nutritiver Wert*

LITERATURE

Anonymous (2009): Pravilnik o kakvoći goveđih trupova i polovica, NN 02/2009.

AOAC, (1996): Official Method 976.21, AOAC Inc., Virginia.

Council Regulation (2007): Council Regulation of 11 June 2007 on the marketing of the meat of bovine animals aged 12 months or less, 07/700/EC. In: Official Journal of the European Union, L 161, 22/06/2007, 1-8.

De Smet, S., K. aes D., Demeyer (2004): Meat fatty acid composition as affected by fatness and genetic factors: a review. Anim. Res. 53:81-98.

Becker, T. (2002): Defining meat quality. In: J. Kerry, J. Kerry and D. Ledward (eds.) Meat processing - Improving quality. Woodhead Publishing Ltd., Cambridge, England, 3-24.

Biesalski, H. K. (2005): Meat as a component of a healthy diet – are there any risks or benefits if meat is avoided in the diet? Meat Sci. 70:509-524.

Higgs, J. (2002): The nutritional quality of meat. In: J. Kerry, J. Kerry and D. Ledward (eds.) Meat processing - Improving quality. Woodhead Publishing Ltd., Cambridge, England, 64-92.

Moloney, P. (2002): The fat content of meat and meat products. In: J. Kerry, J. Kerry and D. Ledward (eds.) Meat processing - Improving quality. Woodhead Publishing Ltd., Cambridge, England, 137-153.

Muchenje, V., K. Dzama, M. Chimonyo, P.E. Strydom, A. Hugo, J.G. Raats (2009): Some biochemical aspects pertaining to beef eating quality and consumer health: A review. Food Chem. 112,279-289.

Karolyi, D., M. Đikić, K. Salajpal, V. Čubrić Čurik. I. Jurić (2006): Carcass traits of baby-beef Simmental cattle. MESO 6,346-350.

Kraft, J., J.K.G. Kramer, F.Schoene, J.R. Chambers, G. Jahreis (2008): Extensive Analysis of Long-Chain Polyunsaturated Fatty Acids, CLA, trans-18:1 Isomers, and Plasmalogenic Lipids in Different Retail Beef types. J. Agric. Food Chem. 56,4775-4782.

Nuernberg, K., D.Dannenberger, G. Nuernberg, K. Ender, J. Voigt, N.D. Scollan, J.D. Wood, G.R. Nute, R.I. Richardson (2005): Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of **longissimus muscle in different cattle breeds. Livest. Prod. Sci. 94:137-147.**

Park, P. W., R. E. Goins, (1994): *In situ* preparation of fatty acid methyl esters for analysis of fatty acid composition in foods. J. Food Sci. 59,1262-1266.

Petrič, N., A. Levart, M. Čepon, S Žgur (2005): Effects of production system on fatty acid composition of meat from Simmental bulls. Ital. J. Anim. Sci. 125-127.

Polak, T., , A. Holcman, V. Stibilj, B. Žlender, (2002): The fatty acid composition of broilers from free range rearing. Zb. Bioteh. Fak. Univ. Ljubl., Kmet. Zooteh., 80 ,71-80.

SAS, 1999. OnlineDoc® Software Release 8. SAS Institute Inc., Cary, NC, USA.

Scollan, N., J.F. Hocquette, K. Nuernberg, D. Dannenberger, I. Richardson, A Moloney, A. (2006): Innovations in beef production systems that enhance the nutritional and health value of beef lipids and their relationship with meat quality. Meat Sci. 74,17-33.

Ulbricht, T.L., D.A. Southgate (1991): Coronary heart disease: seven dietary factors. Lancet. 338,985-992.

Wood, J. D., R. I. Richardson, G. R. Nute, A. V. Fisher, M. M. Campo, E. Kasapidou, P.R. Sheard, M. Enser, M. (2003): Effects of fatty acids on meat quality: a review. Meat Sci. 66:21-32.

Žlender, B., L. Gašperlin, T. Polak (2001): Fatty acid composition of intramuscular fat in three muscles of Simmental and Brown bulls, Proceedings of the 47th International Congress of Meat Science and Technology, Kraków, Poland, 190-191.

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