The Effect of Production System on Fatty Acid Composition in Beef Meat of Cika Young Bulls

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Summary

The aim of the study was to determine chemical and fatty acid composition in meat of Cika bulls fattened in two production systems. Eight bulls were semi-intensively fattened with a total mix ratio (TMR), while ten were grazed without cereals supplementation. Housed bulls were slaughtered at the age of 20.0 months while grazed bulls were slaughtered at the age of 23.5 months. Samples of *M. longissimus dorsi* located between the 7th and 8th rib were used to determine the chemical and fatty acid composition. Data were analysed using the GLM procedure of the SAS/STAT. Model 1 was used to test the effect of production system on the chemical composition of meat. Model 2 was used to test the effects of production system and the intramuscular fat content nested within the production system as linear regression on the fatty acid composition. Significant differences were determined in intramuscular fat (14.54 *vs.* 8.57 g/kg, $P = 0.015$) and in dry matter content (231.85 *vs.* 239.49 g/kg, $P = 0.032$) in beef meat of TMR fed and in grazed bulls, respectively. Beef meat of grazed bulls contained significantly lower palmitic acid (19.87 *vs.* 21.03 wt.%, $P = 0.002$), oleic acid (26.18 *vs.* 30.01 wt.%, $P = 0.007$) and MUFA (29.88 *vs.* 33.80 wt.%, $P = 0.010$) and higher α-linolenic (3.33 *vs.* 1.45 wt.%, $P = 0.014$), EPA (1.40 *vs.* 0.57 wt.%, $P = 0.002$), DPA (1.84 *vs.* 1.06 wt.%, $P = 0.001$), PUFA (21.42 *vs.* 19.43 wt.%, $P = 0.047$) and n-3PUFA (6.80 *vs.* 3.24 wt.%, $P = 0.001$) compared to TMR fed bulls.

Key words

Cika cattle, production system, intramuscular fat, fatty acids

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Aim

The autochthonous Cika cattle were traditionally kept for milk production. However, due to low milk yield, Cika is today most frequently used in the cow-calf systems for beef meat production. Farms keeping Cika in Slovenia are mainly located in the marginal places, especially in the Alps where beef production systems are based on grazing during the summer time and forage with no cereals supplementation during the winter time. Simčič et al. (2010) reported how production system affected carcass and beef meat quality of Cika young bulls, but at that time no information about the quality of meat fat were provided. According to our best knowledge, little information about bull's meat fatty acid composition of autochthonous breeds is available in literature. Nowadays, it is widely known that fatty acid composition in meat has an implication on the human health. Consumers are even more interested in the fat content as well as fatty acid composition of meat due to the relationship between high-fat diets and heart diseases (Scollan et al., 2006). In addition, fatty acid composition affects the sensory traits of beef meat (Oliver et al., 2006). However, the production system is considered a factor which can influence the fatty acid composition of meat and it is considered a tool to improve the nutritional value of meat for the consumer.

The production system, including gender, slaughter weight and different diets, is responsible for the variability in fatty acid composition of cattle (Razminowicz et al., 2006). Marmer et al. (1984) reported grass-fed that cattle had greater contents of n-3 PUFA and total monounsaturated fatty acids (MUFA) than grain fed cattle. Different fat content in carcasses could also affect the fatty acid composition in beef meat as reported by Raes et al. (2004). The aim of this study was to determine the fatty acid composition of beef meat originated from Cika young bulls fattened in two different production systems.

Material and methods

The study was conducted *in nature*, where 18 Cika weaned calves were included in the fattening trial. Cika calves originated from cow-calf system based on grazing and were weaned at the end of grazing season in the autumn. Eight weaned calves were housed in the Educational and Research Animal Husbandry Centre Logatec (Slovenia) where they were finished with a total mix (TMR) (40% maize and 35% grass silage, 6% corn, 18% barley and 1% vitamin and minerals premix, with 10.6 MJ ME/kg DM and 10.2% CP/kg DM) *ad libitum* till slaughter. Bulls were slaughtered in two days at the age of 20.0 months with hot carcass weight 291.8 ± 39.0 kg. The other ten Cika weaned calves were housed on four farms of origin just during winter time where they were fed with hay. In the spring they were put again on all day grazing with no concentrate supplements. Bulls were taken to the slaughter house in four different days directly from the pasture at the end of grazing season. They achieved hot carcass weight of 232.8 ± 48.9 kg at the age of 23.5 ± 0.7 months.

Samples of *M. longissimus dorsi* located between the 7th and 8th rib were collected from the right carcass side to determine the beef meat chemical and fatty acid composition. Samples represented a 70 g steak without connective tissue epimysium, vacuum-packed and immediately frozen at – 20 °C up to the analysis.

Dry matter was determined by AOAC official method (2000). Nitrogen in beef meat samples was determined using Kjeldahl method (AOAC official method, 2000). Intramuscular fat content was determined using petroleum ether extraction after hydrolysis of sample in 4 M HCl solution according to manufacturer's application note (Foss, Application note AN 3904). Total fat determination includes acid hydrolysis step, in which fat bound polar components are separated and later extracted. In our case, samples were hydrolysed in 4 M HCl in SoxCap 2047 (Soxtec 2050, Foss system, Höganäs, Sweden). After drying, fat from hydrolysed samples was extracted using petroleum ether in Soxtec 2050 (Foss system, Höganäs, Sweden).

Fatty acid methyl esters were prepared according to Park and Goins (1994) using *in-situ* trans-esterification method and analysed using gas chromatograph (6890 series, Agilent, Santa Clara, CA, USA). Fatty acid methyl esters were separated using a capillary column (Varian CP 4720, length 100 m, internal diameter 250 µm, film thickness 0.25 µm). Agilent GC ChemStation was used for data acquisition and processing. Separated fatty acid methyl esters were identified by retention time comparison and results were calculated using response factors derived from chromatographic standards of known fatty acid composition (Nu Chek Prep). The exactness and reliability of the method used was assessed with the certified reference material NIST SRM 1546 Meat Homogenate. The fatty acid composition was expressed as a percentage by weight (wt.%) of the total identified fatty acids.

Data were analysed using the GLM procedure in the statistical package SAS/STAT (SAS Institute Inc., 2001). Model 1 was used to test the effect of production system on the chemical composition of meat. Model 2 was used to test the effects of production system and the intramuscular fat content as covariate nested within the production system on the fatty acid composition.

Results and discussion

Grazed bulls (23.5 months) were in average significantly older at slaughter compared to semi-intensively fattened bulls (20.0 months). Average slaughter weight of fattened bulls was 543.6 kg, while it was not possible to weight grazed bulls before slaughter. Consequently, slaughter weight and dressing percentage could not be recorded. But semi-intensively fattened bulls achieved significantly higher carcass weight (291.8 kg) compared to grazed bulls (232.8 kg). Semi-intensively fattened bulls achieved 53.7% dressing percentage. Net daily gain computed on the basis of carcass weight and slaughter age was significantly higher in semi-intensively fattened compared to grazed bulls (488 *vs*. 330 g/day) (Simčič et al., 2010).

Grazed bulls compared to semi-intensively fattened bulls had significantly higher dry matter and lower intramuscular fat content in *M. longissimus dorsi* (Table 1). Production system had no effect on the crude protein content in meat. As was mentioned above, grazed bulls were older at slaughter, achieved much lower growth rate and had poorer fatness as well as lower percentage of carcass fat compared to semi-intensively fattened bulls. All those facts were probably the main reason for the differences in chemical composition of meat.

Beef meat of semi-intensively fattened Cika bulls contained 5.97 g/kg (63%) more intramuscular fat compared to grazed bulls. Similar difference in the intramuscular fat content (70%)

Table 1. Chemical composition of beef meat from total mixed ratio fed and grazed Cika young bulls

Main components	Content (g/kg)		P-value
	TMR[1] fed ([2]LSM ± [3]SE)	Grazed ([2]LSM ± [3]SE)	Production system
Dry matter	231.85 ± 2.43	239.49 ± 2.17	0.032
Crude protein	213.38 ± 3.13	217.88 ± 2.81	n.s.
Intramuscular fat	14.54 ± 1.62	8.57 ± 1.45	0.015

[1]TMR – total mix ratio, [2]LSM – least square mean, [3]SE – standard error

Table 2. Fatty acid composition in beef meat of TMR fed and grazed Cika young bulls

Fatty acid	Fatty acid composition (wt.%)		P-values	
	TMR fed [1](LSM ± SE)	Grazed [1](LSM ± SE)	Production system	Intramuscular fat content
Myristic (C14:0)	1.79 ± 0.15	1.81 ± 0.11	n.s.	< 0.001
Palmitic (C16:0)	21.03 ± 0.73	19.87 ± 0.54	0.002	< 0.001
Stearic (C18:0)	16.06 ± 0.86	17.20 ± 0.64	n.s.	0.004
Linoleic (C18:2 n-6)	11.52 ± 1.55	9.88 ± 1.15	n.s.	0.001
Oleic (C18:1 cis-9)	30.01 ± 1.48	26.18 ± 1.10	0.007	0.001
α-linolenic (C18:3 n-3)	1.45 ± 0.48	3.33 ± 0.35	0.014	0.004
c9,t11-CLA[2]	0.26 ± 0.03	0.30 ± 0.02	n.s.	n.s.
Arachidonic (C20:4 n-6)	3.33 ± 0.35	3.31 ± 0.26	n.s.	< 0.001
[3]EPA (C20:5 n-3)	0.57 ± 0.17	1.40 ± 0.13	0.002	< 0.001
[4]DPA (C22:5 n-3)	1.06 ± 0.13	1.84 ± 0.10	0.001	< 0.001
[5]DHA (C22:6 n-3)	0.15 ± 0.02	0.16 ± 0.02	n.s.	0.005
[6]SFA	46.77 ± 0.87	48.70 ± 0.64	n.s.	< 0.001
[7]MUFA	33.80 ± 1.70	29.88 ± 1.26	0.010	0.001
[8]PUFA	19.43 ± 2.28	21.42 ± 1.68	0.047	< 0.001
n-3PUFA	3.24 ± 0.57	6.80 ± 0.42	0.001	< 0.001
n-6PUFA	15.94 ± 1.78	14.31 ± 1.32	n.s.	< 0.001
n-6/n-3 ratio	5.02 ± 0.29	2.06 ± 0.22	0.007	n.s.

[1](LSM ± SE) - least square means ± standard error, [2]CLA - conjugated linoleic acid, [3]EPA – eicosapentaenoic acid, [4]DPA – docosapentaenoic acid, [5]DHA – docosahexaenoic acid, [6]SFA – saturated fatty acids, [7]MUFA – monounsaturated fatty acids, [8]PUFA – polyunsaturated fatty acids

was found by De la Fuente et al. (2009) between beef meat of Hereford steers reared under extensive conditions and Fleckvieh x Limousin crossed bulls raised on the pasture and finished on the corn silage *ad libitum*, supplemented with restricted soybean meal and cereal meal during the last six months before slaughter. Likewise, Realini et al. (2004) found higher total extractable fat content (89%) in the beef meat of Hereford steers finished on concentrates compared to grazed ones.

Production system in this study significantly affected percentage by weight of palmitic acid, oleic acid, α-linolenic acid, EPA, DPA as well as MUFA, PUFA, n-3 PUFA and n-6/n-3 ratio (Table 2). Beef meat of grazed bulls compared to TMR fed bulls contained significantly lower wt.% of palmitic acid, oleic acid and MUFA while higher wt.% of α-linolenic, EPA, DPA, PUFA and n-3PUFA. Higher percentage by weight of EPA, and DPA in beef meat of grazed bulls could be the result of higher availability of α-linolenic acid in the grass, which is the precursor of longer n-3PUFA such as EPA and DHA.

Additionally, the effect of intramuscular fat content affected ($P < 0.05$) the percentage by weight of all included fatty acids except CLA in grazed bulls (Table 2). The percentage by weight of myristic, palmitic, stearic, oleic, SFA and MUFA increased, while the percentage by weight of linoleic, α-linolenic, arachidonic, EPA, DPA, DHA and PUFA decreased with increased intramuscular fat content in beef meat. The effect of intramuscular fat content was less expressed in the beef meat of TMR fed bulls. Nevertheless, the percentage by weight of myristic, stearic and SFA in the beef meat of semi-intensively (TMR) fattened Cika bulls increased ($P < 0.05$), while arachidonic decreased ($P < 0.05$) with increased intramuscular fat content.

A lot of studies (Zembayashi et al., 1995; Realini et al., 2004; Varela et al., 2004; Razminowicz et al., 2006; Cozzi et al., 2010) investigated fatty acid composition of beef meat originated from grazed cattle. Unfortunately, most cases included steers or heifers due to more calm temperament for pasture rearing technology compared to bulls. On the other hand, fatty acid composition of beef meat from stable rearing belongs to bulls' samples. De la Fuente et al. (2009) determined fatty acid composition in beef meat of Fleckvieh x Limousin crossbred bulls, finished on the corn silage *ad libitum* with restricted soy and cereal meal. They found 45.60 wt.% SFA, 46.90 wt.% MUFA and 7.50 wt.% PUFA. Corazzin et al. (2012) determined neutral lipids fatty acid composition in beef meat of Simmental and Holstein bulls fed with the same feeding ratio described before. Simmental beef meat contain more SFA (57.14 wt.%) and MUFA (38.48 wt.%) and consequently less PUFA (4.38 wt.%) compared to Holstein beef meat (54.51 wt.%, 36.81 wt.%, 8.68 wt.%), respectively.

However, beef meat of TMR fed Cika bulls in this study compared to beef meat of the Fleckvieh x Limousin (De la Fuente et al., 2009) as well as Simmental and Holstein bulls (Corazzin et al., 2012) contained considerably less intramuscular fat as well as less or similar SFA, less MUFA and much more PUFA. The reason for the difference could be in extremely low intramuscular fat content and consequently high proportion of phospholipid content in total lipid content. Raes et al. (2003) found 21.7 wt.% of PUFA in Belgian Blue beef meat which contained 8.6 mg/g intramuscular fat whereas Irish beef meat contained 6.93 wt.% of PUFA and 3.7 mg/g intramuscular fat. Likewise, Sargentini et al. (2010) reported the low level of intramuscular fat (0.7%) and high level of PUFA (23.2 wt.%) in the *Longissimus thoracis* muscle of Maremmana bulls.

Warren et al. (2008) reported of as much ten times higher proportion of linoleic and α-linolenic fatty acids in phospholipids compared to neutral lipids in *M. longissimus* of Aberdeen Angus and Holstein steers fed concentrates or grass silage and slaughtered between 14 and 24 months of age. The phospholipid content varied from 0.55 to 0.71 g/g muscle with no difference between two breeds. If we assume similar proportion of phospholipids in Cika beef meat, then most intramuscular fat content belongs to the phospholipids.

Conclusions

Beef meat from grazed Cika bulls significantly differed in the content of some desired fatty acids (α-linolenic, EPA, DPA) compared to beef meat of TMR fed bulls in this study. The positive effect of grazing was determined despite the very low fat content in beef meat from all bulls. Low n-6/n-3 ratio due to higher content of n-3PUFA in TMR fed Cika bulls was due to grass silage included in the total mix ratio what is quite common on Slovenian farms.

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