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Carcass characteristics and meat quality of Hungarian Simmental young bulls fed different forage to concentrate ratios with or without linseed supplementation

Abstract

In total, 30 Hungarian Simmental bulls were reared to 300.07±43.78 kg initial live weight and 274.57±19.73 d of age. Animals were distributed into three feeding groups with different maize silage to concentrate ratios (670:330=F/HC; 750:250=F/LC 1; 800:200=F/LC 2) based on dry matter. The low concentrate groups (F/LC 1 and F/LC 2) received linseed supplemented concentrate during the fattening period. Feeding high concentrate (F/HC) caused the significantly highest daily gain. The slaughter weights, dressing (%), lean (%) and fat (%) did not show any significant differences between feeding groups. Carcass conformation of all groups was assessed mainly as U. Bulls of group F/LC 2 had the lowest amount of kidney fat. Bone proportion of the carcasses was affected by the diet (F/HC: 18.65%; F/LC 1: 18.41%; F/LC 2: 17.91%). The tendon proportions were lower in groups F/LC 1 and F/LC 2 but not significantly (F/HC: 1.15%; F/LC 1: 1.1%; F/LC 2: 1.08%). The intramuscular fat content varied between the three muscles investigated. *Psoas major* muscle contained the highest fat concentration in all three feeding groups. The mineral content of muscles (iron [Fe], copper [Cu], zinc [Zn]) was only affected by muscle type, but not by diet. In linseed supplemented groups (F/LC 1 and F/LC 2) the palmitic acid and palmitoleic acid proportion was decreased ($P<0.05$) in all muscles and the linolenic, eicosapentaenoic and the sum of *n*-3 fatty acid ($P<0.05$) was increased compared to the F/HC group. The beef from groups F/LC 1 and F/LC 2 bulls showed a lower *n*-6 to *n*-3 fatty acids ratio ($P<0.05$). The relative and absolute concentration of CLA*cis*-9,*trans*-11 was unaffected by diet but muscle type caused changes.

Keywords: forage to concentrate ratio, linseed, fatty acids, minerals, muscle, bulls

Zusammenfassung

Titel der Arbeit: **Schlachtkörperzusammensetzung und Fleischqualität von Ungarischen Fleckvieh Bullen, die mit unterschiedlichen Raufutter-Konzentrat-Rationen mit und ohne Leinsamenzusatz gefüttert wurden**
30 Ungarische Fleckvieh Bullen wurden bei einem Lebendgewicht von 300.07±43.78 kg und einem durchschnittlichen Alter von 274.57±19.73 Tagen auf drei Fütterungsgruppen aufgeteilt, die jeweils ein unterschiedliches Verhältnis von Maissilage und Kraftfutter (670:330=F/HC; 750:250=F/LC1; 800:200=F/LC2) basierend auf Trockenmasse aufwiesen. Die beiden Fütterungsgruppen mit niedrigem Kraftfutteranteil (F/LC 1 und F/CL 2) haben während der Mast zusätzlich Leinsamenschrot erhalten. Die Fütterung mit einem hohen Konzentratanteil (F/HC) erhöhte signifikant die täglichen Zunahmen der Bullen. Die Schlachtgewichte, die Schlachtausbeute (%), der Fleischanteil (%) und der Fettanteil (%) wurden nicht von der Fütterung beeinflusst. Die Einstufung der Schlachtkörper der Bullen erfolgte für alle Gruppen in die Klasse U. Die Bullen der F/LC 2 Gruppe wiesen den geringsten Nierenfettanteil auf. Der Knochenanteil der Schlachtkörper war signifikant beeinflusst durch die Fütterung (F/HC: 18.65%; F/LC 1: 18.41%; F/LC 2: 17.91%). Der Sehnenanteil war nur tendenziell niedriger in den beiden Gruppen F/LC 1 (1.1%) und F/LC 2 (1.08%) im Vergleich zur Gruppe F/HC mit 1.15%. Der intramuskuläre Fettgehalt variierte in den drei Muskeln unabhängig von der Fütterung. Der *M. psoas major* wies den höchsten Fettgehalt in allen drei Fütterungsgruppen auf. Der Mineralstoffgehalt (Fe, Cu, Zn) war in den drei untersuchten Muskeln signifikant different, aber unabhängig von der Fütterung. In den mit Leinsamen angereicherten Rationen war der relative Palmitin- und Palmitoleinsäuregehalt ($P<0.05$) niedriger und der Linolen- und Eicosapentaensäuregehalt sowie die Summe

der *n*-3 Fettsäuren (P<0.05) signifikant höher in allen Muskeln im Vergleich zur F/HC Gruppe. Im Fleisch der F/LC1 und F/LC2 Bullen war das Verhältnis von *n*-6 und *n*-3 Fettsäuren (P<0.05) günstiger. Die relative und absolute Konzentration von CLA*cis*-9,*trans*-11 wurde durch den Muskeltyp beeinflusst, aber nicht durch die Fütterung.

Schlüsselwörter: Verhältnis von Rau- und Kraftfutter, Leinsamen, Fettsäuren, Mineralstoffe, Muskel, Bullen

Introduction

The dual purposed Hungarian Simmental breed plays an important role for high quality beef production in Hungary due to their excellent gain, conformation and meat quality characteristics. Nowadays the production of high quality beef is an important tool to ensure consumer satisfaction. Besides the genetic type of animal the rearing and feeding systems also affect beef quality (SAMI et al., 2004; RAZMINOWICZ et al., 2008). Maize silage is a commonly used source of forage in cattle fattening in Hungary. KEADY et al. (2007) investigated the effect of the replacement of grass silage with maize silage on animal performance and meat quality. The authors reported an increased carcass gain and weight due to higher intakes and improved utilization of metabolisable energy. At the same time the meat quality and carcass composition did not alter. JUNIPER et al. (2005) established that the maize silage has the potential to reduce finishing time of beef animals to achieve slaughter weight with no apparent detrimental effects on subsequent meat quality. SAMI et al. (2006) reported no effect between fibrous (grass silage) or starch diet (maize silage) on the main meat quality traits. However, the high fibre diet improved the fatty acid composition of beef (REICHARDT et al., 2002). Feeding of maize silage, hay and moderate concentrate diet caused undesirable fatty acid composition of beef due to high *n*-6 fatty acid proportion (HOLLÓ et al., 2001). According to human guidelines an enhancement of *n*-3 polyunsaturated fatty acids (PUFA) is desirable (PFEUFFER, 2001). Linseed is the vegetable fat source with the highest amount of the α-linolenic acid (more than 50% of the total fatty acids). The α-linolenic acid is the precursor of *n*-3 fatty acids *de novo* synthesis. The effect of the different forms of linseed supplementation in diet was analysed in cattle (RAES et al., 2004; NUERNBERG et al., 2005a; RAMINOWICZ et al., 2008), pigs (NUERNBERG et al., 2005), lambs (BORYS et al., 2004; GRUSZECKI et al., 2006) and goat (PIENIAK-LENDZION et al., 2006).

The PUFA incorporation into tissues is limited by the biohydrogenation process in the rumen (LEIBETSEDER, 1996). Additionally the different dietary carbohydrates (cereals *vs* sugar beet pulp) induce different fermentation patterns (propionate *vs* acetate) in the rumen with related effects on fatty acids metabolism (CUVELIER et al., 2006). The forage to concentrate ratio had little effect on the flow of unsaturated fatty acids and this may relate to the buffer ability of the rumen (LEE et al., 2006). Previously, TAKENOYAMA et al. (1999) observed that the forage to concentrate ratio affected the conjugated linoleic acid content (CLA) in meat.

The objective of this trial was to investigate the effect of diets differing in the F/C ratio with or without linseed supplementation on animal performance and meat quality in terms of minerals and fatty acid composition using Hungarian Simmental young bulls.

Materials and methods

Animals and management

In this study 30 young Hungarian Simmental bulls (mean body weight: 300 kg, age: 275 d) were used. The animals of each group were homogeneous for body weight and age. The animals were kept in loose housing system at the Experimental Unit of Faculty of Animal Science at the Kaposvár University. The three dietary treatments (each n=10) consisted of three target forage/concentrate (F/C) ratios of 660:330, 750:250 and 800:200 g/kg dry matter (DM). The control group received a ration consisting of 33% commercial concentrate and 66% maize silage, whilst the low concentrate and high roughage groups received 75% maize silage and 25 concentrate with 25% linseed (F/LC 1) or 80% maize silage and 20% concentrate with 25% linseed (F/LC 2). The diet of each group also consisted of 10 kg grass hay/day. Each group was fed twice daily, water was supplied *ad libitum*. The chemical and mineral as well as fatty acid composition of the consumed feedstuffs is presented in Table 1. The two concentrates were different with regards to crude fat level and fatty acid composition because of the linseed supplementation. Animal weights were recorded monthly.

Table 1
Chemical and mineral composition and fatty acid profile of feedstuff
(Chemische Zusammensetzung, Mineralstoffgehalt und Fettsäuremuster des Futters)

	Maize silage	Hay	Concentrate	Concentrate with 25% linseed suppl.
Dry matter	32.80	94.40	89.85	89.14
Crude protein	2.80	8.50	15.15	15.10
Crude fat	0.9	1.10	4.21	11.86
Crude fiber	7.30	30.30	11.71	10.90
Crude ash	1.5	6.20	7.00	5.68
Ca	1.5	3.77	0.70	0.75
P	0.82	2.68	0.55	0.42
Mg	0.83	1.13	0.55	0.43
K	3.06	14.66	0.95	0.80
Na	0.01	0.273	0.60	0.55
Mn	9.8	31	56.67	56.67
Cu	1.6	4.40	12.05	12.05
Zn	6.0	19.30	71.98	71.98
Fe	44.0	106	37.90	37.90
Se	–	–	0.29	0.29
C12:0	0.70	3.31	0.02	0.02
C14:0	1.03	2.09	0.19	0.23
C16:0	21.22	38.37	22.46	13.28
C18:0	3.66	6.73	2.68	4.57
C18:1*cis*	19.90	14.81	23.07	22.82
C18:2*n-6*	44.89	13.12	47.18	18.37
C18:3*n-3*	3.45	4.64	2.28	39.45

Slaughter and samples procedure

The animals were slaughtered on average at 580 kg. Slaughtering of the animals was performed at a commercial abattoir after captive bolt stunning. The carcasses were assessed for conformation and fatness according to the EUROP system (EU Rule no. 1208/1981 and EU Rule no. 1026/1991). One hour after slaughter, the dressed carcasses were weighed (hot carcass weight), split into two sides, and were chilled at 4°C for 24 h. The right carcass side was manual dissected into lean meat, bone, fat and tendon. From the right carcass half samples were taken from the *longissimus thoracis* (LD; at 11th rib), *semitendinosus* (ST) and *psoas major* (PM) muscles. All samples were immediately wrapped and frozen at −20 °C until analysis. The laboratory analysis of samples was carried out at the Analytical laboratory, Faculty of Animal Science, Kaposvár University.

Chemical methods

Determination of fatty acid composition

The homogenized muscle samples were weighed into a flask, 8 ml concentrated hydrochloric acid was added and boiled for 60 min. After cooling 7 ml ethanol and 15 ml diethyl ether were added. The mixture was shaken for 1 min. After phase separation organic phase was separated and evaporated under vacuum. Then 4 ml 0.5 M sodium-hydroxide in methanol was added, and boiled on a water bath for 5 min. Then 4 ml 14% boron-trifluoride in methanol was added and boiled for 3 min. After cooling 4 ml *n*-hexane and saturated sodium-chloride solution was added. The organic phases were separated and dried with sodium sulfate.

The fatty acid methyl esters (FAMEs) were separated on a 100 m × 0.25 mm wall coated open tubular (WCOT) CP-SIL 88 column. The identification of FAMEs was obtained with a flame ionization detector (FID) at 270 °C. The temperature of the injector was 270 °C. The carrier gas was helium with the head pressure of 235 kPa. The oven was temperature programmed from 140 °C (10 min) with 10 °C/ min increase up to 235 °C (26 min). The injected volume varied between 0.5 and 2 µl. The instrument was a Chrompack CP 9000 gas chromatograph.

Determination of conjugated linoleic acid content

The muscle samples were homogenised in organic solution mixture (*n*-hexane: i-propanol, 3 : 2, HIP) by using an IKA Ultra-turrax dispersion instrument. The filtration apparatus was rinsed three times with 10 ml HIP. The water was eliminated from the organic phase with the addition of 5 g anhydrous sodium sulphate. The HIP mixture was evaporated to dryness from the lipids and the residue was washed with *n*-hexane into a volumetric flask. The methylation of lipids was accomplished with 4 M sodium methoxide. The reaction was completed at 50 °C for 30 min. The FAMEs were extracted with *n*-hexane and injected into the gas chromatograph (see above). Results are given as follows: CLA content of the sample amount analyzed compared to sample mass and expressed in mg CLA/ 100 g muscle and mg CLA/ g lipid.

Determination of mineral (Cu, Zn, Fe, Se) content

The contents of copper, iron, zinc were determined by using atomic absorption spectrometry (SOLAAR M 6) according to European standard (EN ISO 6869). The Se-content was determined by fluorometry. The determination was based on the method published in Hungarian Food Codex (HFC, 1990).

Statistical analysis

Data were evaluated using the General Linear Model (GLM) procedure of the SPSS 10.0 statistical software. In Tables the least square means and standard error of mean (SEM) are presented. The GLM Type III procedure and least significant difference (LSD) test was used to investigate the effects of individual factors (diet, muscle) as well as interactions (diet × muscle) between factors.

Results

In Table 2 the growth performance of groups is summarised. The average initial body weight was 300 kg. The average daily gain was 1.18, 1.09 and 1.12 kg/d for the F/HC, F/LC 1 and F/LC 2 group, respectively. Only the final age showed a significant difference between groups. Animals were significantly older in F/LC 1 group compared to the other groups. Feed utilisation was most efficient in the control group. The net energy for fattening cattle (NE) was higher in linseed groups, due to more than twice as high a crude fat content of linseed concentrate comparing to conventional concentrate.

Table 2
Growth performance (Wachstumsparameter)

	Control	Linseed supplemented groups		SEM
		Forage to concentrate ratio		
	660:330 F/HC	750:250 F/LC 1	800:200 F/LC 2	
Initial body weight (kg)	303.30	298.50	298.40	20.26
Final body weight (kg)	625.00	616.90	617.20	16.93
Fattening day	250.70	269.30	256.90	11.80
Final age, day	533.40[a]	565.70[b]	552.30[a]	9.76
Average daily gain (kg/d)	1.18[a]	1.09[b]	1.12	0.04
Food intake*				
Dry matter kg per animal	2542.10	2701.08	2607.54	
Dry matter kg/d	10.14	10.03	10.15	
FCR kg dry matter intake/kg gain	7.78	8.38	8.01	
NE MJ/kg dry matter	10.56	11.26	11.15	

a, b = significant difference between feeding groups ($P \leq 0.05$); *statistics were not possible due to group feeding

The slaughter weight varied between 577 and 585 kg (Table 3). All slaughter and dressing data were not significantly different.

Table 3
Slaughtering and dressing traits (Schlachtkörpermerkmale)

	Control	Linseed supplemented groups		SEM
		Forage to concentrate ratio		
	660:330 F/HC	750:250 F/LC 1	800:200 F/LC 2	
Slaughter weight (kg)	584.70	581.40	576.80	13.36
Kidney fat (kg)	7.42	7.19	7.65	1.05
Kidney fat (%)	1.28	1.23	1.32	0.18
Four feet weight (kg)	12.01	11.95	11.85	0.34
Four feet weight (%)	2.06	2.06	2.06	
Head (kg)	15.41	15.66	15.16	0.43
Head (%)	2.64	2.70	2.63	
Hide (kg)	52.60	52.01	51.70	2.42
Hide (%)	8.98	8.94	8.96	
Hot carcass weight (kg)	342.72	341.96	339.84	9.22
Dressing percentage (%)	58.62	58.82	58.93	0.79
Cold right side weight (kg)	169.37	168.38	166.95	4.64
Lean (%)	71.68	71.85	71.81	1.01
Bone (%)	18.65[a]	18.41	17.91[b]	0.41
Fat (%)	8.58	8.65	9.23	1.00
Tendon (%)	1.15	1.10	1.08	0.10

a, b = significant differences between feeding groups at $P=0.087$

The control group tended to have the highest slaughter weight, four feet weight (kg), hide, hot carcass and cold right side weight as well as highest proportion of bone and tendon. The F/LC 2 group tended to accumulate the most kidney fat.

Table 4
Carcass fat and conformation grading characteristics (Einstufung nach Fett- und Fleischmerkmalen)

	Control	Linseed supplemented groups	
	Forage to concentrate ratio		
	660 : 330 F/ HC	750 : 250 F/ LC 1	800 : 200 F/ LC 2
Fat grading (no. of bulls)			
1	–	2	2
2	9	6	7
3	1	2	1
mean	2.00 ± 0.67	2.10 ± 0.32	1.90 ± 0.57
Conformation grading (no. of bulls)			
E	1	–	–
U	6	10	8
R	3	–	2
mean	3.80 ± 0.63	4.00 ± 0.00	3.80 ± 0.42

*conformation scores converted to number values as follows: 4=class U, 3=class R, 2=class O, 1=class E

Similarly to carcass data the EUROP grading results did not show any differences (Table 4). All animals of F/ LC 1 group were assessed as U, most animals from the other groups were also ranked as U. Comparing the real meat and fat proportion to the EUROP classes, the conformation classes can be adapted to real data, but the ranking of fat classes of groups did not follow the real fat level.

Concerning minerals, the diet had no significant influence (Table 5). Muscle type affected the mineral content, except Se level. The descending order of iron, copper and zinc content of muscles is the following: PM, LD and ST.

Table 5
Mineral concentrations (Fe, Cu, Zn, Se) in different muscles (mg/ kg)
(Mineralgehalt [Fe, Cu, Zn, Se] in unterschiedlichen Muskeln [mg/ kg])

	Muscle	Control	Linseed supplemented groups		SEM	Sign. effect P≤0.05
		Forage to concentrate ratio				
		660:330 F/ HC	750:250 F/ LC 1	800:200 F/ LC 2		
Fe (mg/ kg)	LD	14.16	15.34	14.35	0.91	M, D (0.054)
	ST	12.73	14.12	14.86	0.91	
	PM	16.64	18.41	17.13	0.91	
Cu (mg/ kg)	LD	0.48	0.58	0.48	0.09	M
	ST	0.39	0.55	0.56	0.09	
	PM	0.71	0.81	0.51	0.09	
Zn (mg/ kg)	LD	32.26	34.45	32.68	1.54	M
	ST	32.94	32.98	34.62	1.54	
	PM	28.61	29.76	28.71	1.62	
Se (mg/ kg)	LD	0.07	0.07	0.07	0.004	
	ST	0.07	0.07	0.07	0.004	
	PM	0.06	0.07	0.07	0.004	

M= significant effect of muscle type, D= significant effect of diet at P≤0.05

In Table 6 the main fatty acids of muscle samples are summarized. Significant effects of muscle type were detected for several fatty acids (C14:1, C16:1, C17:0, C18:0, sum C18:1*trans*, C18:1*cis*, C20:3*n*-6). PM contained more (P<0.05) saturated fatty acids (SFA) and lower (P<0.05) monosaturated fatty acids (MUFA) compared to the other two muscles. The desaturase activity was significantly lower in PM compared to the other two muscles. This resulted in a lower proportion of C14:1, C16:1 and C18:1*cis*-9 in PM. The sum of C18:1*trans* isomers were significantly higher in PM than LD and ST. The proportion of C18:1*trans* isomers was significantly affected by muscle type, whilst CLA changed only at a level of significance P=0.06. The P/ S ratio and *n*-6/ *n*-3 ratio were not different between muscles.

Table 6
Effect of diet on fatty acid composition (g/100 g FAME) in different muscles of Hungarian Simmental bulls (Einfluss des Futters auf die Fettzusammensetzung [g/100g FSME] in unterschiedlichen Muskeln von Ungarischen Fleckvieh Bullen)

%	Control			Linseed supplemented groups						SEM	Sign. effect
	Forage to concentrate ratio										
	670:330 F/HC			750:250 F/LC 1			800:200 F/LC 2				
	LD	ST	PM	LD	ST	PM	LD	ST	PM		P≤0.05
C12:0	0.06	0.05	0.05	0.07	0.04	0.05	0.06	0.05	0.05	0.01	
C14:0	1.93	2.01	1.97	1.82	1.77	1.86	2.16	1.94	2.04	0.12	
C14:1	0.26	0.29	0.20	0.25	0.22	0.17	0.32	0.26	0.23	0.03	M
C16:0	24.13	24.43	23.45	22.46	22.79	22.08	23.67	23.38	23.03	0.49	D
C16:1	2.57	2.46	1.74	2.14	1.87	1.44	2.43	2.04	1.81	0.17	D, M
C18:0	18.73	18.94	22.66	19.90	21.03	24.17	19.60	20.64	23.31	0.85	M
Sum of C18:1*trans*	5.23	5.25	6.36	5.76	6.03	6.71	5.46	5.58	6.63	0.33	M
C18:1*cis*-9	35.18	35.07	32.12	34.71	34.22	31.33	35.54	34.65	32.38	1.01	M
C18:2	6.71	5.98	6.28	6.50	6.03	6.23	5.29	5.66	5.25	0.75	
C20:0	0.09	0.08	0.11	0.15	0.16	0.17	0.11	0.12	0.12	0.03	
C20:1	0.19	0.21	0.19	0.17	0.15	0.14	0.19	0.19	0.17	0.02	D
C18:3*n*-3	0.45	0.36	0.40	1.18	1.01	1.05	0.95	0.91	0.91	0.13	D
CLA*cis*-9,*trans*-11*	0.82	0.76	0.68	0.90	0.77	0.83	0.88	0.67	0.71	0.08	
C20:3*n*-6	0.43	0.56	0.41	0.32	0.38	0.31	0.29	0.41	0.27	0.06	D, M
C20:3*n*-3	0.11	0.16	0.11	0.17	0.13	0.10	0.12	0.14	0.09	0.03	
C20:4*n*-6	1.44	1.54	1.21	1.51	1.29	1.13	1.06	1.35	0.93	0.24	
C20:5*n*-3	0.05	0.02	0.02	0.19	0.14	0.13	0.21	0.13	0.09	0.05	D
SFA	46.45	47.20	50.17	46.05	47.54	50.21	47.20	47.87	50.41	1.08	M
MUFA	43.42	43.28	40.60	43.03	42.49	39.78	43.95	42.72	41.22	1.17	M
PUFA	10.12	9.52	9.22	10.93	9.86	9.91	8.96	9.41	8.38	1.09	
Sum of *n*-3 FA	0.60	0.53	0.53	1.53	1.28	1.27	1.29	1.19	1.09	0.16	D
Sum of *n*-6 FA	8.69	8.22	8.01	8.50	7.81	7.81	6.80	7.55	6.57	1.02	
P/S ratio	0.22	0.21	0.19	0.24	0.21	0.20	0.19	0.20	0.17	0.03	
n-6/*n*-3 ratio	19.78	9.09	7.93	7.04	7.35	7.30	6.63	7.52	7.12	2.28	D
Δ-9 DI (C16:0)	9.55	9.09	6.88	8.73	7.60	6.12	9.25	7.93	7.18		M
Δ-9 DI (C18:0)	65.24	64.90	58.67	63.58	61.82	56.48	64.43	62.59	58.09		M

DI=Desaturase index; M=sign. effect of muscle type, D=sign. effect of diet at P≤0.05; *including CLA*trans*-7,*cis*9 and CLA*trans*-8,*cis*-10

The different diet affected 6 individual fatty acids (C16:0, C16:1, C20:1, C18:3*n*-3, C20:3*n*-6, C20:5*n*-3), the *n*-3 fatty acids and the *n*-6/*n*-3 ratio (Table 6). The higher forage to concentrate ratio and linseed supplementation decreased the palmitic and palmitoleic acid as well as C20:3*n*-6 proportion, linolenic and eicosapentaenoic acid content increased significantly in muscle tissues. The beef from linseed supplemented, low concentrate groups contained more *n*-3 fatty acids.

Table 7
Effect of diet on intramuscular fat (%) and CLA*cis*-9, *trans*-11 concentrations (mg/100 g) of Hungarian Simmental bulls (Einfluss des Futters auf das intramuskuläre Fett [%] und CLA*cis*-9, *trans*-11 [mg/100g] in unterschiedlichen Muskeln von Ungarischen Fleckvieh Bullen)

	Muscle	Control 660:330	Linseed supplemented groups 750:250	800:200	SEM	Sign. effect P≤0.05
Intramuscular fat (g/100g muscle)	LD	2.00	2.30	2.42	0.43	M, D×M
	ST	1.20	1.62	1.77	0.43	
	PM	3.16	4.11	3.49	0.43	
CLA*cis*-9, *trans*-11* (mg/100 g muscle)	LD	23.69	25.00	28.50	6.37	M
	ST	26.74	20.16	28.66	6.37	
	PM	36.68	48.16	32.40	6.37	
CLA*cis*-9, *trans*-11 (%)	LD	0.82	0.90	0.88	0.08	–
	ST	0.76	0.77	0.67		
	PM	0.68	0.83	0.71		

* including CLA*trans*-7,*cis*9 and CLA*trans*-8,*cis*-10

Table 7 shows the quantitative data of intramuscular fat and CLA*cis*-9, *trans*-11. The muscle type significantly affected the amount of CLA. The intramuscular fat content of muscle was higher in PM muscle. Higher intramuscular fat level lead to higher CLA concentration in PM compared to LD and ST.

Discussion

Animal performance and dressing data

The aim of this trial was to compare the performance, slaughter and meat quality (fatty acid composition, minerals) traits of Hungarian Simmental young fattening bulls fed diets consisting of three maize silage and concentrate ratios supplemented with or without linseed.

The maize silage inclusion comparing to grass or grass silage diet improved the food conversion ratio by increasing the daily gains of carcass (KEADY et al., 2007), fat and lean proportions in the carcass and killing-out percentage (JUNIPER et al., 2005), obtaining high carcass weight, young slaughter age with non excessive fattening score and most tender meat (OURY et al., 2007). POLGÁR (2007) reported a daily gain of 1,116 g/d at 18 months slaughtered Hungarian Simmental bulls by feeding moderate concentrate and maize silage diet. This result is similar to that of F/LC 2 group which achieved 1,118 g/d. But this value is lower compared to the daily gain of 1.49 kg/d in Simmental young bulls reported by ALBERTI et al. (2008). They have been fattened at a higher intensity level compared to the present study.

High forage feeding of cattle is a more effective way to reduce the carcass fat than reducing the energy intake during the finishing period (STEEN and KILPATRICK, 2000). Forage feeding caused lower carcass weight and intramuscular fat content when compared to grain feeding at similar times on feed (MANDELL et al., 1998). Pasture *versus* concentrate feeding influenced the growth rate significantly but no significant effect was investigated in carcass weight when animals were slaughtered at the same live weight (DANNENBERGER et al., 2006). In the present experiment the higher forage to concentrate ratio with linseed supplementation caused significantly lower daily gain and tendentially lower carcass weight. MARINO et al. (2006) recorded higher daily weight gain in high concentrate (60:40) fed Podolian young bulls compared to low concentrate fed (70:30) animals. The authors found also no significant differences between groups for slaughter weight, carcass and right side weight dressing percentage. LOVETT et al. (2003) established that reducing the F/C ratio from 65:35 to 10:90 resulted in significantly increased rates of live weight gain, moreover the oil supplementation (coconut oil) had no effect on animal performance. KREUZER et al. (1995) and AHARONI et al. (2004) reported no differences for daily gain, age and live weight at slaughter between high and low forage diet fed to Friesian young bulls, moreover the oilseed supplementation (rapeseed and crushed linseed, respectively) did not have any effect on performance traits. NOCI et al. (2005) investigated neither the type of silage (grass *vs* whole crop wheat silage) nor sunflower oil supplementation affected final live weight, carcass weight, and daily gain. The inclusion of linseed in maize silage diet did not influence the growth performance (BARTON et al., 2007). Similarly to RAMINOWICZ et al. (2008) supplementing concentrate with or without linseed during the finishing period of grass fed steers the daily gain did not change significantly.

Chemical composition

The intramuscular fat is one of the most important meat quality traits. The intramuscular fat content besides genetic background, is influenced by the energy content of diet (SCHOONMAKER et al., 2004), feeding regime (HOLLÓ et al., 2005; NUERNBERG et al., 2005a; SAMI et al., 2006) and muscle type (PURCHAS et al., 2005; MARINO et al., 2006). Pasture feeding significantly decreased the intramuscular fat level in *longissimus* and *semitendinosus* muscle (DANNENBERGER et al., 2006). Extensive and intensive feeding of Simmental bulls for 100 and 138 days resulted in significant differences in moisture, fat and ash content of *longissimus* muscle (SAMI et al., 2004). The authors did not find effects on beef chemical composition when only the energy content of diet was increased. SAMI et al. (2006) found lower intramuscular fat level in *longissimus* muscle of Simmental bulls fed maize silage to concentrate 65:35 compared to the present experiment. MARINO et al. (2006) detected no significant differences in chemical composition of *longissimus* muscle of Podolian young bulls fed high or low concentrate diets. The intramuscular fat of *longissimus* muscle was not changed by forage level or by linseed supplementation; however the forage and flaxseed interaction was significant (AHARONI et al., 2004). In the present study the diet (concentrate and forage ratio and supplementation) did not significantly alter the fat content of muscles. The type of muscle affected significantly the fat content. PURCHAS et al. (2005) investigated higher level of intramuscular fat of *longissimus* muscle than *triceps brachii* muscle of Angus cross heifers. In the present study PM as an oxidative muscle contained higher intramuscular fat, whilst the other two were considered as glycolytic type with a lower fat level. MARINO et al. (2006) reported similar findings, the fat content of ST was significantly lower than LD.

Minerals

Among the minerals four elements were analysed. The two types of concentrate contained the same amount of the analysed elements. Maize silage contained a high amount of Fe, whilst hay was rich in Zn. Selenium, zinc and iron deficiency are characteristic in most developed countries, thus especially in risk groups (elderly, pregnant woman and growing children) meat consumption is recommended (BIESALSKI et al., 2005). Copper deficiency is less frequent, mainly described in premature infants and children. The interactions among minerals were investigated by CÁMARA et al. (2005), between Fe uptake and Zn transportation, there was a negative interaction. On the other hand the high Fe content can favour Cu absorption. The beef from higher forage to concentrate linseed supplemented (F/LC 1 and 2) groups contained more or equal proportions of all examined minerals, although the differences among groups were not significant. At the same time significant differences emerged between PM and the other two muscles for Fe, Cu and Zn content. The background of this is the different metabolic type of muscle. The Zn and Fe content was the same as established in previous work (HOLLÓ et al., 2007) in intensively fed Hungarian Grey and Hungarian Holstein bulls. The levels of Fe in LD were lower than those reported by PURCHAS and BUSBOOM (2005) in US and NZ heifers finished on pasture. In PM measured copper content was about the same as published by FERRERIA et al. (2008) in beef liver in Brazilian. Concerning the Se content of muscles no significant differences were proved. The opposite trend can be seen among muscles and diet. Previously DAUN et al. (2001) established lower Se concentrations in bovine oxidative PM compared to glycolytic muscle (LD). This is in accordance with results in the control group. A contrary tendency was shown in the linseed low concentrate groups (F/LC 1 and 2) the Se content in oxidative muscles was higher compared to glycolytic muscle.

Fatty acid composition
SAMI et al. (2004) reported only a small effect of time on feed compared to feed intensity on the fatty acid composition. The higher feeding intensity by maize silage and concentrate diet caused lower PUFA to SFA ratio and higher MUFA in intramuscular fat of Simmental bulls. MARINO et al. (2006) proved that the higher forage to concentrate ratio caused a significant increase in the unsaturation level of intramuscular fat, the low concentrate group showed higher unsaturated and polyunsaturated fatty acids compared to high concentrate group. The dietary *n*-3 fatty acid supplementation does not affect the P to S ratio, but it is mainly influenced by genetics, in particular the overall fat level of the animal and much less by nutrition (REICHARDT et al., 2002; DE SMET et al., 2004). With increasing content of intramuscular fat, the content of PUFA decreased including C18:3*n*-3 and C22:5*n*-3 fatty acids (SUBRT et al., 2006). The extensive diet with linseed supplementation during the last month decreased the SFA, increased the unsaturated fatty acid proportion in Hungarian Grey and Hungarian Holstein bulls compared to the intensive maize silage diet (HOLLÓ et al., 2005). According to the results of RAZMINOWICZ et al. (2008) the inclusion of linseed concentrate into grass rations significantly changed the MUFA, but no changes were detected for PUFA and SFA. BARTON et al. (2007) did not observed any effect on SFA and MUFA content, but a significantly decreased *n*-6/*n*-3 fatty acid ratio. In the present study neither P to S ratio nor PUFA was affected by diet (different forage to concentrate ratio and linseed supplementation). The same finding was proved by AHARONI et al. (2004). The forage level did not affect the ratios of SFA to MUFA or to PUFA, but total PUFA levels were higher on the flaxseed supplemented groups. In the present experiment the closest value (0.24) to recommended P to S ratio was found in the *longissimus* muscle of F/LC1 group. On contrary to diet the muscle type significantly affected the SFA and MUFA proportion. MARINO et al. (2006) observed also no difference in the concentrations of C18:0 in intramuscular fat in animals fed diets differing in forage and grain levels. The results of the present study confirmed the previous report of AHARONI et al. (2004) according to decreased proportion of C16:0 and C16:1. Similar results were obtained for C18:3*n*-3 and trans fatty acids. In both experiments (in the previously mentioned trial of AHARONI et al. [2004] and in our experiment) a more than 2-fold enhancement of α-linolenic acid was observed. In the present experiment the C18:3*n*-3 in intramuscular fat of F/LC1 group was 2.6-2.8 fold times higher than in the control group.
The present results agreed with PURCHAS et al. (2005) investigation, as the muscle type significantly affected the P to S ratio but not the *n*-6/*n*-3 fatty acid ratio. CIFUNI et al. (2004) reported more saturated fatty acids in *longissimus* than in *semitendinosus* muscle. In the present study PM contained higher SFA than LD and ST.
The level of C18:3*n*-3 and C20:5*n*-3 did not differ between the grass and the grass and linseed concentrate diet, whilst grass feeding with conventional concentrate lowered *n*-3 fatty acids (RAZMINOWICZ et al., 2008). In that study both basal diet

and linseed supplementation contain high level of *n*-3 fatty acids. In the present study linseed supplementation significant enhanced besides α-linolenic acid the level of C20:5*n*-3. Extruded linseed supplementation increased the level of C20:5*n*-3 and C22:6*n*-3 in *longissimus* muscle of Charolais and Limousin heifers (BARTON et al., 2007). In the present study the level of C22:6*n*-3 was not detected in any muscle type. Previously RAZMINOWICZ et al. (2008) established that a higher dietary supply did not led to higher DHA level in beef. Pasture feeding significantly increased the sum of *n*-3 fatty acids, and the *n*-6/*n*-3 ratio in *longissimus* muscle of German Simmental compared to concentrate feeding (DANNENBERGER et al., 2005; NUERNBERG et al., 2005a). SAMI et al. (2006) proved that feeding maize silage significantly decreased the *n*-3 to *n*-6 ratio (0.13, 0.11) due to lower α-linolenic acid and eicosapentaenoic acid content in the beef compared to grass silage plus sugar beet pulp (0.32) based diet. The total CLA content was between 0.82-0.90% agreeing with the values previously reported (DE LA TORRE et al., 2006). In contrast to their findings in the present experiment there were no significant differences of CLA between groups. It seems that besides the supplementation the effect of basal diet should be considered. In this study the maize silage and conventional concentrate were rich in C18:2*n*-6, and linseed supplemented concentrate rich in C18:3*n*-3. Both fatty acids are hydrogenated in the rumen via C18:1*trans*-11 to C18:0. The relative content of CLA in muscle can be enhanced by pasture feeding (DANNENBERGER et al., 2006) and by supplementing the diet with *n*-3 fatty acids (BARTON et al., 2007) or with *n*-6 fatty acids (sunflower oil, NOCI et al. 2005). The diet did not affect the concentration (mg/100 g muscle) of CLA*cis*-9,*trans*-11 agreeing with the findings of DANNENBERGER et al. (2006) measured in German Holstein and Simmental bulls. In the present study higher CLA*cis*-9,*trans*-11 concentration in *longissimus* muscle were measured compared to these results (11.5-13.3 mg/100 g fresh muscle). In the present study the relative and the absolute CLA*cis*-9,*trans*-11 content was not increased in lipids of F/LC 1 and 2 groups similarly to BEAULIEU et al. (2002) results. In this experiment cattle were fed a high concentrate diet supplemented with soybean oil. The present data confirm the results of MORENO et al. (2008) who also show CLA content was affected by the fat content of tissues and by muscle type. Muscles with higher intramuscular fat level contained a higher CLA concentration.

In conclusion, the different forage to concentrate ratios with/without linseed supplementation did not significantly affect the performance and slaughter traits. The muscle type affected the chemical composition and mineral content.

SFA and MUFA were affected by muscle type, *n*-3 fatty acids and *n*-6/*n*-3 fatty acid ratio by diet. The total CLA proportions were not different between feeding groups. The level of CLAcis-9,*trans*-11 (mg/100 g) was affected by muscle type.

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