The evaluation of growth and selected carcass and meat quality parameters in fattening bulls fed a diet based on concentrates or maize silage

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ABSTRACT: The aim of the study was to evaluate the growth rate and selected carcass and meat quality parameters in bulls fed a high-grain diet and to compare the results with those obtained in bulls fed a diet based on preserved roughage. The trial included 18 Czech-Pied bulls fed a diet with a high proportion of concentrated feed and 18 Czech-Pied bulls fed a diet based on maize silage, used as a control group. The trial was launched after the weaning of calves. During the fattening period, live weight and average daily weight gain were monitored. The bulls were slaughtered at the live weight of 550–600 kg, the mean age at slaughter was 473 days for the high-grain diet group and 474 days for the control group. The carcasses were classified to SEUROP quality grades, and carcass gain and dressing percentage were calculated. Samples of *m. longissimus pars thoracis* were taken from five bulls in each group to examine selected meat quality parameters. In the period from weaning to slaughter the high-grain diet bulls and the control bulls achieved the average daily weight gain of 1.29 kg and 1.21 kg, respectively. Differences between the groups were not significant. The high-grain diet group showed higher average carcass weight and higher carcass weight gain, differences between the groups were not significant, either. As to meat quality parameters under study, a significant difference was found only in meat lightness (L*), with the mean value in the high-grain diet group being significantly ($P \le 0.01$) lower than in the control group. The other meat quality parameters did not show any significant differences between the groups. In this study, the high-grain diet gave similar performance as the maize silage-based diet in fattening bulls. The high-grain diet group and control group showed comparable average daily weight gain and selected carcass and meat quality parameters.

Keywords: Czech-Pied bulls; high-grain diet; weight gain; carcass weight; *m. longissimus*

In the Czech Republic, the fattening of beef cattle with high-grain diets is used the most frequently in so called baby-beef production (fattening to lower slaughter weights). This type of fattening was studied by Chládek et al. (1998) and Chládek and Ingr (2001a,b) in Holstein bulls slaughtered at live weight of 305–480 kg. Much less information is available on the use of high-grain diets at the fattening to higher slaughter weight. Most researchers reported higher average daily weight gain, higher carcass weight and higher intramuscular fat content, as compared with roughage-based diets (Mandell et al., 1998; Keane and Fallon, 2001).

The carcass composition and slaughter traits are affected especially by the cattle breed, as documented Bartoň et al. (2006) and Bartoň et al. (2007).

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Czech-Pied is a dual-purpose cattle breed and its meat production is more efficient in comparison with dairy breeds. In the study of Bartoň et al. (2003), Czech-Pied bulls had a higher proportion of total meat, lower bone proportion in the carcass, lower internal fat production and separable carcass fat proportion in comparison with Holstein bulls. Bartoň et al. (2007) reported no significant effect of the diet on carcass weight, dressing percentage and carcass classification. The intensive diet only increased carcass weight gain and production of internal fat. From meat quality parameters, high-grain diets mainly influence the content of intramuscular fat. A higher intramuscular fat content in cattle fed high-grain diet, compared with roughage-based diet was reported for instance by Mandell et al. (1998). However, French et al. (2000) did not observe any effects of the diet type on intramuscular fat content in beef cattle fed grain-based or forage-based diets. Morris et al. (1997) and French et al. (2000) reported that feeding grain-based or forage-based diets influenced neither pH value nor water-holding capacity. But Muir et al. (1998) indicated that grass-fed steers had higher ultimate pH values than grain-fed steers.

In the cattle fed high-grain diets, lighter meat colour is often observed that is associated mainly with an increased fat content. Bennett et al. (1995) reported darker muscle in forage-fed cattle in comparison with concentrate-fed animals. However, Muir et al. (1998), French et al. (2000) and French et al. (2001) did not find any effects of the diet type in the finishing phase on meat colour if animals with same carcass weight and the same intramuscular fat content were compared. Neither did Ingr et al. (1996) demonstrate any significant differences in meat colour between bulls fed concentrate-based diets and those fed conventional, roughage-based diets. Some researchers observed that a grain-based

Table 1. The composition of diets for the high-grain diet and control groups

High-grain diet group	Diet after weaning	Transitional diet	Experimental diets by live weight (kg)			
			300	350	450	550
Age (days)	114–176	176–194	194–261	261–332	332–402	402–472
Concentrates in dry matter (%)	83.00	82.30	83.60	81.30	77.40	75.00
Feed	dry matter (kg)					
COT L	4.49	1.79	–	–	–	–
Meadow hay	0.92	1.09	1.37	1.65	2.29	2.75
Cereals	–	2.59	5.61	5.82	6.47	6.90
BK 1	–	0.69	1.36	1.36	1.36	1.36
Control group	Diet after weaning	TMR by live weight (kg)				
		200	300	350	450	550
Age (days)	115–180	180–195	195–262	262–333	333–403	403–473
Concentrates in dry matter (%)	51.00	34.70	34.70	34.70	34.70	34.70
Feed	dry matter (kg)					
COT L	1.35	–	–	–	–	–
Maize silage	2.67	5.17	5.99	6.52	6.95	7.30
Cereals	1.01	1.96	2.27	2.47	2.63	2.76
BK 2	0.39	0.75	0.86	0.94	1.01	1.06
Ground calcite	0.03	0.05	0.06	0.06	0.07	0.07

COT L – pelleted calf starter

Cereals – mixture of crushed cereals, wheat:barley = 1:1

BK 1 – protein concentrate for the HG group, ingredients – 45% rapeseed meal, 20% soybean meal, 10% sulphite yeast, 7% urea, 3% $NaHCO_3$, 7.6% ground calcite, 2.5% monocalcium phosphate, 2.9% NaCl, 2% mineral and vitamin supplements

BK 2 – protein concentrate for the control group, ingredients – rapeseed meal, cereals, forage meals, mineral and vitamin supplements, 13% urea

(TMR = total mixed ration)

diet increased the tenderness of meat in comparison with roughage-based diets. According to Mitchell et al. (1991) the forage-finishing of cattle has been shown to decrease the tenderness of meat when compared to grain finishing. However, Mandell et al. (1998) and French et al. (2001) did not observe any differences between high-grain and roughage-based diets in Warner-Bratzler shear force. The tenderness is also affected by slaughter weight of cattle. According to Cerdeńo et al. (2006) the bulls with a higher slaughter weight had lower shear force values and higher sensory tenderness. The chemical composition and sensory characteristic of beef can also be influenced by the cattle breed, as documented e.g. by Bureš et al. (2006).

The aim of the study was to evaluate growth rate and selected carcass and meat quality parameters in fattening bulls fed a high-grain diet to 550–600 kg of live weight and to compare the results with those obtained in bulls fed a maize silage-based diet.

MATERIAL AND METHODS

A trial was conducted under field conditions on a selected farm. The trial included 18 Czech-Pied bulls fed a cereal-based diet. The proportion of grains in the diet on dry matter basis was 75.0%–83.6%. As the control, 18 Czech-Pied bulls were used, fed total mixed ration based on maize silage, routinely used on the farm. The trial was launched just after weaning, the mean initial age was 114 days in the high-grain diet (HG) group and 115 days in the control (C) group. The mean weaning weight was 139.78 kg and 138.56 kg in the HG and C groups, respectively.

The animals were reared in a calf shed (pre-fattening period) with the same conditions. The calves came from different farms and they did not have the relationship. The bulls were transferred to the fattening house at the mean age of 204 (HG) and 205 days (C). The animals were housed loose by groups in two bedded pens with paddocks. Feed was administered once a day in an outdoor concrete trough. The ratio between the number of places at the trough and the number of animals per group was 1:1. Water was provided by drinkers. Diets were formulated using the software Animal Nutrition – Cattle (Agrokonzulta Žamberk), version 6.029. Nutrient contents in all feed ingredients used were analysed using valid methods, according to Decree No. 124/2001 (2001). Net energy content (NEF) was

Table 2. Nutrient contents of the high-grain and control diets (kg/dry matter basis)

High-grain diet group	Diet after weaning	Transitional diet	Experimental diets by live weight (kg)			
			300	350	450	550
Dry matter (kg)	5.41	6.16	8.34	8.83	10.12	11.01
CP (g/kg)	202.86	194.33	187.71	183.24	173.86	168.61
Fibre (g/kg)	102.03	91.43	80.53	85.71	94.87	100.30
Ca (g/kg)	18.37	12.60	9.12	8.84	8.20	7.85
P (g/kg)	7.45	6.63	6.14	6.03	5.80	5.66
Mg (g/kg)	3.06	2.76	2.54	2.46	2.27	2.17
NEF (MJ/kg)	7.69	7.96	8.22	8.13	7.99	7.91

Control group	Diet after weaning	TMR by live weight (kg)				
		200	300	350	450	550
Dry matter (kg)	5.45	7.93	9.18	9.99	10.66	11.19
CP (g/kg)	153.35	129.57	129.37	129.50	129.44	129.56
Fibre (g/kg)	86.23	120.27	120.27	120.38	120.28	120.31
Ca (g/kg)	10.70	6.96	7.03	6.84	7.05	6.94
P (g/kg)	4.81	3.68	3.68	3.68	3.68	3.68
Mg (g/kg)	2.77	1.94	1.94	1.94	1.94	1.94
NEF (MJ/kg)	7.38	7.08	7.08	7.08	7.08	7.08

CP = crude protein; NEF = net energy for fattening calculated using the equation of the calculation of NEF in ruminant feeds, published by Sommer et al. (1994). The diet components are listed in Table 1, nutrient contents in Table 2.

In order to assess the growth rate, the bulls in both experimental groups were regularly weighed. Based on the live weight values measured, average daily weight gain was calculated for the periods between the weighings and for the whole experimental period – from weaning to the end of fattening. Animals from both groups were weighed eight times within the fattening period. The bulls were slaughtered at the average age of 473 and 474 days in the HG group and C group, respectively. Carcass weight, dressing percentage and carcass weight gain were measured at slaughter. The carcasses were graded according to SEUROP.

From 5 bulls from each group samples of *m. longissimus pars thoracis* were taken from the right half-carcass at the level of the 8th rib. In the muscle tissue collected, pH_1, pH_{24}, pH_{48} and pH_{72}, drip loss and remission 24 hours *post mortem* with 520 nm wavelength were measured. Dry matter, fat, total protein and collagen contents were analysed; in 6 days *post mortem* the colour of raw and cooked meat was measured with a Minolta CM – 2600d spectrophotometer, and in 7 and 8 days *post mortem* the texture was measured with INSTRON 5544 by texture profile analysis (TPA), and Warner-Bratzler (WB) shear force was also measured. Weight losses caused by cooking were determined.

Arithmetic mean (x) and standard deviation (SD) were calculated for all the parameters under study. Student's t-test was used to test the significance of differences in all the parameters under study between the HG and C groups. The homogeneity of variation, required for the use of t-test, was tested by F-test. Calculations were carried out using Excel software (Microsoft Office 97).

RESULTS

Table 3 documents the live weight of bulls at different weighings and average daily weight gain for the different periods. In the starter period, the

Table 3. Mean live weight of bulls at different weighings and average daily weight gain (n = 18)

Weighing		Live weight (kg)			t-test P	Average daily weight gain (kg)		t-test P
		age (days)	x	SD		X	SD	
1.	HG	114	139.778	18.672	0.8586	–	–	–
	C	115	138.556	22.046		–	–	
2.	HG	165	211.778	24.602	0.1085	1.412	0.234	**0.0019
	C	166	196.333	31.232		1.133	0.264	
3.	HG	195	261.056	26.991	*0.0156	1.643	0.277	**0.0044
	C	196	234.389	35.334		1.268	0.440	
4.	HG	220	292.222	26.476	*0.0283	1.247	0.159	0.1166
	C	221	269.827	31.923		1.418	0.414	
5.	HG	282	352.667	20.782	0.1504	0.975	0.400	0.3279
	C	283	336.833	40.261		1.081	0.205	
6.	HG	351	459.611	31.290	0.1579	1.550	0.330	0.5420
	C	352	439.667	49.544		1.490	0.244	
7.	HG	421	549.889	40.715	0.1353	1.290	0.227	0.3893
	C	422	525.778	53.049		1.230	0.179	
8.	HG	472	600.944	40.213	0.0902	1.001	0.335	0.4924
	C	473	573.333	53.806		0.932	0.252	
Average daily weight gain after weaning					HG	1.288	0.123	0.0786
					C	1.214	0.121	

HG = high-grain diet group; C = control group; x = arithmetic mean; SD = standard deviation; *$P \leq 0.05$; **$P \leq 0.01$

Table 4. Slaughter weight, carcass weight, dressing percentage and carcass gain

n = 18		*x*	SD	*P*
Slaughter weight (kg)	HG	570.944	40.213	0.1308
	C	543.333	54.166	
Carcass weight (kg)	HG	330.244	20.154	0.1989
	C	318.544	32.084	
Dressing percentage (%)	HG	57.978	3.576	0.5184
	C	58.655	2.565	
Carcass gain (g/day)	HG	699.281	55.420	0.1752
	C	672.102	62.165	

HG = high-grain diet group; C = control group

HG group showed high growth rate when average daily weight gain between the weaning and the 2nd weighing was significantly ($P \leq 0.01$) higher than in the C group. Similarly, in the next period, the HG bulls achieved significantly ($P \leq 0.01$) higher weight gains than the C bulls. Live weight measured at the third weighing was significantly ($P \leq 0.05$) higher in the HG group. In the next period, the HG group showed higher average daily weight gain than the C group; the differences between the groups were not significant. The differences in live weight were not significant at the next weighings, although the HG group always reached higher mean live weight than the C group. Average daily weight gain for the whole trial period (from weaning to end of fattening) was higher in the HG group (1.29 kg) than in the C group (1.21 kg). The difference was not however significant.

Table 4 shows the values of carcass weight and carcass weight gain in the HG and C groups. The HG bulls had higher carcass weight and carcass gain; the differences between the groups were not statistically significant. The HG bulls achieved a little better percentage lean and higher intramuscular fat content than the control bulls in SEUROP quality grading. The U class of meatiness was received by 5 HG bulls and 3 C bulls, R class by 13 HG bulls and 14 C bulls, O class by 1 C bull (Figure 1). 7 HG bulls and 10 C bulls scored degree 2 of carcass fattiness, 11 HG bulls and 8 C bulls scored degree 3 (Figure 2).

Table 5 shows the results of chemical analyses of meat and results of measurement of pH and free water content. Contents of dry matter and total protein were quite balanced among all the meat samples and the values showed a low variation. The differences between the groups were not statistically significant. For the collagen content, no significant differences were found between the groups. pH of *m. longissimus* samples was measured within 1 h (pH_1), 24 h (pH_{24}), 48 h (pH_{48}) and 72 h (pH_{72}) *post mortem*. The differences between the groups

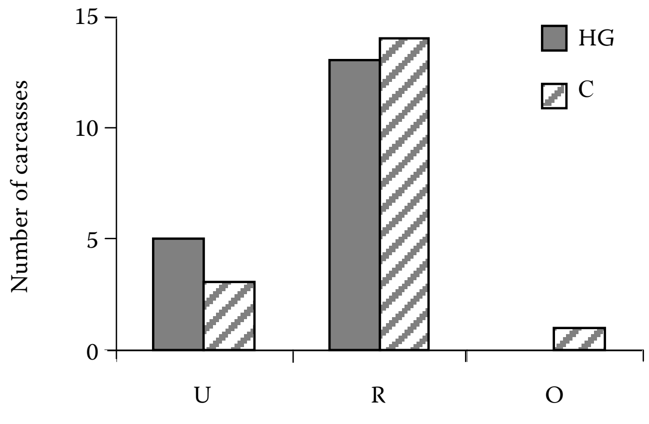

Figure 1. Results of classification of bull carcasses according to SEUROP – classes of meatiness – U, R, O (HG = high-grain diet group; C = control group)

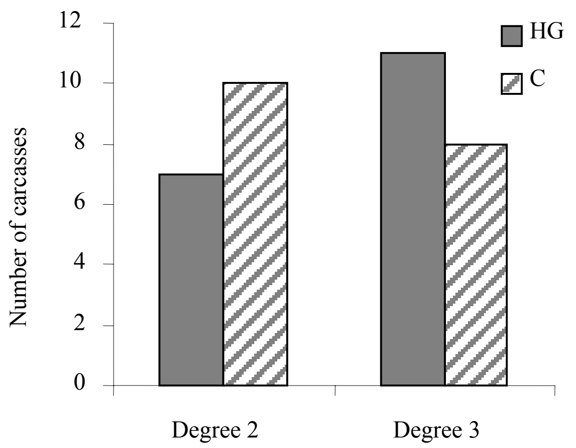

Figure 2. Results of classification of bull carcasses according to SEUROP – degree of fattiness (HG = high-grain diet group; C = control group)

in all the values measured were insignificant. The content of free water determined as drip loss did not show any significant differences between the groups.

Table 6 gives the results of meat colour, meat texture and cooking loss. The HG group showed lower remission values, the differences between the groups were not significant. As for the colour measurement in 6 days *post mortem*, the HG group showed lower lightness (L*) values in raw meat than the C group, the difference between the groups was statistically significant ($P \leq 0.01$). A lower lightness value (L*) was found in the HG group, even in cooked meat, but with a statistically insignificant difference. Meat texture was measured with INSTRON in 7 and 8 days *post mortem*. Somewhat lower cohesion values were found in the HG group by the analysis TPA. Hardness and toughness measured by Warner-Bratzler test showed higher values in the HG group than in the C group. The differences between the groups were insignificant for all the parameters tested. The cooking loss did not

Table 5. Results of the analysis of meat chemical composition, pH measurement and determination of drip loss (n = 5)

		x	SD	P
Dry matter (g/100 g)	HG	25.040	1.120	0.5049
	C	25.796	2.147	
Crude protein (g/100 g)	HG	23.064	0.977	0.2563
	C	22.482	0.186	
Fat (g/100 g)	HG	1.510	0.613	0.0907
	C	3.102	1.747	
Collagen (g/100 g)	HG	0.654	0.088	0.5624
	C	0.612	0.128	
pH_1	HG	6.790	0.114	0.6122
	C	6.830	0.125	
pH_{24}	HG	5.860	0.052	0.3108
	C	5.968	0.205	
pH_{48}	HG	5.740	0.042	0.3883
	C	5.820	0.182	
pH_{72}	HG	5.810	0.074	0.9237
	C	5.820	0.214	
Drip loss (%)	HG	0.542	0.371	0.7798
	C	0.482	0.278	

HG = high-grain diet group; C = control group

Table 6. Results of measurement of meat colour, meat texture, and determination of cooking loss

n = 5		*x*	SD	*P*
Remission (%)	HG	4.900	1.245	0.1268
	C	6.300	1.351	
L* – raw meat	HG	35.908	0.986	0.0029**
	C	39.668	1.734	
L* – cooked meat	HG	39.346	2.892	0.1677
	C	42.61	3.844	
Hardness TPA (N)	HG	54.744	17.667	0.2112
	C	67.854	12.378	
Cohesion TPA	HG	1.264	0.030	0.4669
	C	1.250	0.027	
Hardness WB (N)	HG	231.200	59.523	0.5460
	C	205.178	70.541	
Toughness WB (kPa)	HG	3 073.340	407.323	0.0511
	C	2 289.260	647.361	
Cooking loss	HG	33.436	3.382	0.3690
	C	31.019	4.560	

remission – for 24 h after slaughter at 520 nm; L* = lightness value measured in 6 days *post mortem*; TPA = texture profile analysis in 7 and 8 days *post mortem*; WB = Warner-Bratzler test in 7 and 8 days *post mortem*; HG = high-grain diet group; C = control group

show a significant difference between the groups either.

DISCUSSION

Many researchers (Mandell et al., 1998; Keane and Fallon, 2001) reported significantly higher daily weight gain and higher carcass weight in animals fed cereal-based diets compared with those fed roughage-based diets. In the present study, the HG bulls reached higher average daily weight gain in the period from weaning to slaughter than the C bulls, the difference was not however statistically significant. Significantly ($P \leq 0.01$) higher average daily weight gain and significantly higher ($P \leq 0.05$) average live weight were achieved by the HG bulls in the initial fattening phase. Later they showed a certain drop in the growth rate and the differences between the groups were not statistically significant. Neither in carcass weight nor in dressing percentage values were any significant differences found between the groups, although average carcass weight and carcass gain were numerically higher in the HG group. In SEUROP quality grading, the high-grain diet fed bulls scored a little higher in percentage lean and intramuscular fat content than the C bulls.

Dry matter and total protein contents in *m. longissimus* in the HG and groups corresponded with the values reported in beef by Chládek and Ingr (2001a,b), Bureš et al. (2006) and Cerdeńo et al. (2006). Differences between the groups were insignificant. The literature data have shown that intensive fattening based on cereals usually leads to an increase in intramuscular fat in beef (Mandell et al., 1998). Unlike the latter findings, in this trial the high-grain diet fed animals showed a little lower content of intramuscular fat than the controls, but the difference was not significant. Similarly, French et al. (2000) reported that the type of diet did not influence the content of intramuscular fat in cattle fed grain-based or forage-based diets. Neither in pH_1, pH_{24}, pH_{48} and pH_{72} nor in free water content in meat were any significant differences found. Similar results were obtained by Morris et al. (1997) and French et al. (2000).

Unlike some researchers who found the lighter meat colour in cattle fed a high-grain diet (Bennett et al., 1995), in the HG group in this trial the average remission value was lower than that found in the C group and the lightness (L*) value measured in raw and cooked meat in 6 days *post mortem* with Minolta was lower. Differences between the groups were not statistically significant except for the lightness of raw meat for which the HG group was significantly ($P \leq 0.01$) lower than the C group. Similarly, Ingr et al. (1996) and French et al. (2000) did not find any significant differences in meat colour between the animals fed concentrate-based or roughage-based diets. Muir et al. (1998) reported that the diet type did not influence the meat colour if intramuscular fat contents were the same. As to meat texture parameters, the TPA analysis showed a lower mean value of hardness and somewhat higher mean value of cohesion in the HG group than in the C group, the differences were not however statistically significant. Hardness and toughness measured by the WB test showed higher values in the HG group, the differences between the groups were insignificant. These findings do not correspond with conclusions drawn by researchers who reported that feeding a high-grain diet to cattle lowers the WB shear force value (Mitchell et al., 1991). On the contrary, the results obtained by Mandell et al. (1998) and French et al. (2001) showed that the WB shear force value of meat was not different between the cattle fed a grain-based diet and a roughage-based diet. The present results do not correspond even with conclusions of Cerdeńo et al. (2006), who observed that the bulls with a higher slaughter weight had lower shear force values.

The present study shows that feeding bulls a high-grain diet gives comparable results to feeding a maize silage-based diet. The high-grain diet fed bulls achieved higher average daily weight gain in the period from weaning to slaughter, higher carcass weight and higher carcass weight gain, but the differences in the parameters under study were not significant. No significant differences in the selected meat quality parameters were found between the high-grain diet fed bulls and the maize silage-based diet fed bulls.

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