Performance and carcass quality of Czech Fleckvieh, Charolais and Charolais × Czech Fleckvieh bulls fed diets based on different types of silages

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ABSTRACT: A total of thirty-four Czech Fleckvieh (CF), Charolais (CH) and Charolais × Czech Fleckvieh (CH × CF) bulls with an average weight of 284 kg were included in the experiment and fed *ad libitum* two mixed diets: MS (based on maize silage) and LCS (based on legume-cereal and lucerne silages) with different concentrations of dietary energy until slaughter at the target live weight of 600 kg. The CF bulls consumed more dry matter (DM) of feed daily than the CH bulls ($P < 0.05$) and gained weight less efficiently than the CH × CF and CH animals ($P < 0.01$) during the entire experiment. The killing-out percentage was lower in the CF than in the CH × CF and CH ($P < 0.05$). The CH bulls received a higher score for carcass conformation and a lower score for carcass fatness ($P < 0.01$) than the CF bulls, had lower proportions of kidney and cod fat ($P < 0.01$) than the CH × CF and CF bulls, and produced the highest percentage of high-priced meat ($P < 0.05$) and the lowest percentage of separable fat ($P < 0.001$). The bulls on the MS diet were younger than the others at the end of the experiment ($P < 0.01$), gained weight more rapidly ($P < 0.001$), consumed less DM ($P < 0.001$) daily, utilized nutrients more efficiently over the entire experimental period ($P < 0.001$), and had a higher proportion of internal fat than the LCS bulls. It can be concluded that purebred CH bulls were superior to the other breed groups in most of the traits observed. The intensive diet based on maize silage increased average daily gains, reduced the time needed to achieve the target slaughter weight, and improved the feed efficiency of bulls.

Keywords: cattle; crossbreeding; feeding intensity; growth; carcass quality

Beef currently produced in the CR mostly comes from dairy and dual-purpose cattle breeds (mainly Holstein and Czech Fleckvieh, respectively) with only a smaller part originating from beef breeds or beef × dairy crosses. Over the last decade, however, the stock of beef cattle has been continually increasing. At present, Charolais is the beef breed with the most numerous purebred animals in the CR (Kvapilík et al., 2006).

Crossing of Czech Fleckvieh cows with beef bulls is a frequently used method to exploit heterosis and improve performance and carcass characteristics in the resulting progeny. A number of studies compared the effects of crossing Charolais as a popular terminal sire breed with Czech Fleckvieh females (e.g. Frelich et al., 1998; Šubrt et al., 1999; Polách et al., 2004). Fattening performance and carcass composition of Charolais-sired and purebred Fleckvieh were also tested in Germany (Kögel et al., 2000a,b). Little information, however, is available on the performance and carcass quality of purebred Czech Fleckvieh and Charolais bulls compared to crosses of the same breeds.

The objective of this study was to evaluate growth performance and carcass composition of Charolais, Czech Fleckvieh and Charolais × Czech Fleckvieh bulls fed two diets based on different types of silages.

MATERIAL AND METHODS

Animals and diets

Thirty-four Czech Fleckvieh (CF), Charolais (CH) and Charolais × Czech Fleckvieh (CH × CF) bulls with an average weight of 284 kg were included in

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the experiment. At least four different sires were used within each breed group. The animals were loose-housed in pens with straw bedding. The pens were equipped with electronically controlled feeding troughs (Insentec, Marknesse, The Netherlands) allowing the recording of individual daily feed intakes. After a 2-month adaptation period, bulls from each breed group were assigned according to live weight and age to two similar dietary groups: MS (a more intensive diet based on maize silage) and LCS (a more extensive diet based on a legume-cereal mixture silage and lucerne silage). Both mixed diets were offered *ad libitum*. As the live weight of the animals increased during the fattening period, the composition of the diets was slightly adjusted on the basis of chemical analysis of regularly collected samples of the diet ingredients. The feeds were air-dried at 105°C to a constant weight. Crude protein, fat and fibre contents were determined using the Kjeltec AUTO 1030 Analyser, Soxtec 1043 and Fibertec 2010 (Tecator Comp., Sweden) instruments, respectively. The average ingredient and chemical composition of the diets is given in Table 1. Four animals (3 CH × CF and 1 CF) had to be removed from the experiment due to injuries and severe lameness.

Measurements

Animal performance was determined on the basis of individual daily feed intake measurements and weighing of the animals every two weeks at the same time of the day. The target live weight was

Table 1. Ingredient and chemical composition of the diets

	Diet	
	MS	LCS
Ingredient (g/kg)		
Wheat grain	121	144
Soybean meal	39	–
Maize silage	755	–
Legume-cereal mixture silage	–	432
Lucerne silage	–	318
Lucerne hay	66	72
Wheat straw	–	23
Limestone	6	–
Mineral-vitamin mixture	12	10
Chemical composition		
Dry matter (DM; g/kg fresh weight)	469	540
Crude protein (g/kg DM)	141	138
PDIN[a] (g/kg DM)	93	85
PDIE[b] (g/kg DM)	92	85
NEF[c] (MJ/kg DM)	7.73	6.75
Crude fibre (g/kg DM)	165	270
ADF[d] (g/kg DM)	202	288
NDF[e] (g/kg DM)	390	449
Crude fat (g/kg DM)	28	19

[a]Protein digested in the small intestine supplied by rumen-undegraded protein and microbial protein from rumen-degraded protein (Sommer et al., 1994)

[b]protein digested in the small intestine supplied by rumen-undegraded protein and microbial protein from rumen-fermented organic matter (Sommer et al., 1994)

[c]net energy of fattening (Sommer et al., 1994)

[d]acid-detergent fibre

[e]neutral-detergent fibre

set at 600 kg. The performance data were separately analysed for the period from the start to day 112 of the experiment (when the first animals reached the target weight and were slaughtered) and for the entire experimental period from start to slaughter. The bulls selected for slaughter were weighed 3 days before slaughter (final weight used for the calculation of daily live weight gain, feed intake and feed efficiency) and before transportation to the abattoir after approximately 18 h of fasting (slaughter weight used for the calculation of slaughter characteristics).

The animals were slaughtered in the experimental abattoir of the Institute of Animal Science. At slaughter, the bulls were stunned with a captive bolt gun and killed by exsanguination. The carcasses were uniformly dressed according to the EU specification and assessed by trained operators for conformation (an 18-point scale) and fatness (a 15-point scale) according to the EU beef carcass classification scheme with the use of subclasses (Anonymous, 1991). The weights of the hot carcass, the gastrointestinal tract (the sum of the weights of the empty rumen and intestines) and fat depots (kidney, rumen and cod fat) were recorded. The killing-out percentage was calculated as 100 × hot carcass weight/slaughter weight. Carcass gain was obtained as the ratio of hot carcass weight and days of age at slaughter.

After approximately a 24 h cooling period (2°C), cold carcass weights were recorded and the right sides were divided into standardised joints. The joints were separated into lean meat, bones and tendons, and separable fat, and their weights were taken. The total meat yield was calculated as the lean meat from all joints plus the lean trimmings. High-priced meat was determined as the total weight of lean meat from the rump, shoulder, loin and fillet, and low-priced meat as the lean meat from the remaining joints plus the lean trimmings. The *musculus longissimus lumborum et thoracis* (MLLT) area and subcutaneous fat thickness were measured at the section between the 8th and 9th thoracic vertebrae.

Statistical analysis

Data were analysed using the GLM procedure of SAS (SAS, 2001). The model involved the fixed effects of breed group and diet and the interaction of breed group × diet. Differences between breed group means were tested by Tukey's method (level of significance set at 5%). As no significant interactions between breed group and diet were detected, the data in the tables are presented as the main effect least-squares means (LSM) with their respective standard errors (SEM) and significance levels.

RESULTS

Animal performance

The basic characteristics of the experiment, live weight gains, feed intake and feed efficiency are given in Table 2. The bulls from the different breed groups started the experiment at a similar live weight and age, and no significant differences were observed in weight at day 112, final weight, final age, and duration of the entire experimental period. While the average live weight gains were similar in the breed groups in both analysed periods, differences were found in feed intake and feed efficiency. The CH bulls consumed less feed (DM, PDIE, and NEV) daily than the CF bulls in the first part of the experiment ($P < 0.05$) and over the entire experimental period ($P < 0.01$) while the CH × CF bulls were always intermediate. The CF bulls used the diet less efficiently (consumed more feed per kg live weight gain) than the CH bulls ($P < 0.01$) in the period until day 112 and less efficiently than the CH and CH × CF over the entire experimental period ($P < 0.01$).

The bulls on the MS diet were heavier at day 112 ($P < 0.05$), younger than the others (i.e. reached the target live weight earlier) at the end of the experiment ($P < 0.01$), and they gained more rapidly by 21 and 27% in the first ($P < 0.01$) and over the entire experimental period ($P < 0.001$), respectively, than the bulls on the LCS diet. The MS bulls consumed less DM ($P < 0.001$), PDIE ($P < 0.01$), and NEV ($P < 0.05$) daily over the entire experimental period, and utilized nutrients significantly more efficiently in both analysed periods than the LCS bulls.

Slaughter traits

The traits recorded at slaughter are presented in Table 3. While there were no differences in slaughter weight between the breed groups, the hot carcasses of CH × CF tended to be heavier and carcass

Table 2. Animal performance

	Breed (B)						Diet (D)				*P* – value	
	CF (*n* = 11)		CH × CF (*n* = 7)		CH (*n* = 12)		MS (*n* = 15)		LCS (*n* = 15)		B	D
	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*		
Initial weight (kg)	345.4	17.9	346.4	22.6	335.9	17.1	355.0	15.5	330.2	16.1	0.905	0.277
Initial age (d)	325.1	11.7	297.5	14.8	307.7	11.2	314.6	10.1	305.7	10.5	0.325	0.549
Weight at day 112	497.3	18.9	508.5	23.9	497.3	18.0	528.4	16.4	473.7	17.0	0.919	0.029
Final weight (kg)	602.5	7.0	613.1	8.9	599.4	6.7	608.9	6.1	601.2	6.3	0.471	0.390
Final age (d)	536.0	13.8	494.7	17.4	518.1	13.2	489.2	11.9	543.3	12.4	0.199	0.004
Duration (d)	211.1	14.2	197.2	17.9	210.4	13.5	174.6	12.3	237.8	12.8	0.803	0.002
Period from start to day 112 of the experiment												
Daily gain (kg/d)	1.356	0.057	1.447	0.072	1.441	0.054	1.548	0.049	1.282	0.051	0.481	0.001
Feed intake												
DM (kg/d)	9.46[a]	0.26	8.95[ab]	0.33	8.49[b]	0.25	8.70	0.23	9.23	0.24	0.043	0.118
PDIE (kg/d)	0.85[a]	0.03	0.80[ab]	0.03	0.76[b]	0.02	0.82	0.02	0.79	0.02	0.039	0.224
NEF (MJ/d)	68.89[a]	1.92	64.89[ab]	2.43	61.53[b]	1.83	67.69	1.66	62.52	1.73	0.036	0.042
Feed efficiency												
DM (kg/kg gain)	7.22[a]	0.26	6.23[ab]	0.33	6.01[b]	0.25	5.65	0.22	7.33	0.23	0.007	<0.001
PDIE (kg/kg gain)	0.64[a]	0.02	0.56[ab]	0.03	0.54[b]	0.02	0.53	0.02	0.62	0.02	0.007	0.004
NEF (MJ/kg gain)	52.03[a]	1.84	45.01[ab]	2.32	43.32[b]	1.75	43.94	1.59	49.64	1.65	0.006	0.020
Period from start to end of the experiment (3 days before slaughter)												
Daily gain (kg/d)	1.258	0.050	1.376	0.063	1.306	0.047	1.473	0.043	1.154	0.045	0.350	<0.001
Feed intake												
DM (kg/d)	10.40[a]	0.25	9.71[ab]	0.32	9.10[b]	0.24	8.72	0.22	10.75	0.23	0.004	<0.001
PDIE (kg/d)	0.91[a]	0.02	0.85[ab]	0.03	0.80[b]	0.02	0.80	0.02	0.91	0.02	0.009	0.002
NEF (MJ/d)	74.71[a]	1.87	69.80[ab]	2.36	65.27[b]	1.79	67.42	1.62	72.44	1.68	0.005	0.042
Feed efficiency												
DM (kg/kg gain)	8.66[a]	0.32	7.17[b]	0.40	7.32[b]	0.30	5.95	0.28	9.48	0.29	0.007	<0.001
PDIE (kg/kg gain)	0.75[a]	0.03	0.63[b]	0.03	0.64[b]	0.03	0.55	0.02	0.80	0.02	0.007	<0.001
NEF (MJ/kg gain)	61.62[a]	2.18	51.25[b]	2.75	51.95[b]	2.08	45.96	1.88	63.91	1.96	0.005	<0.001

[a,b,c]Means within a row with different superscripts significantly differ ($P < 0.05$)

gains tended to be higher than in CF. The killing-out percentage was lower in CF than in CH × CF and CH ($P < 0.05$). The overall carcass classification results ranged from E– to O+ for conformation and from 2 to 3 = for fatness. The gastrointestinal tract expressed as a percentage of slaughter weight tended to be heavier in the CF animals than in the CH group ($P = 0.050$). The CH bulls received a significantly higher score for carcass conformation and a lower score for carcass fatness ($P < 0.01$) than the CF bulls, while the CH × CF animals were always intermediate. The CH bulls also had lower proportions of kidney and cod fat and, as a result, a lower proportion of total fat depots ($P < 0.01$) than the CH × CF and CF bulls.

No significant effect of diet was observed on the hot carcass weight, killing-out percentage, carcass classification, or gastrointestinal weight as a percentage of slaughter weight. The bulls fed the MS diet had a higher carcass weight gain ($P < 0.01$) and produced more kidney ($P < 0.001$), cod and total internal fat ($P < 0.01$) expressed as proportions of slaughter weight.

Carcass composition

The composition of carcasses was significantly affected by the breed group (Table 4). Different tissue (meat, separable fat, bones and tendons)

Table 3. Slaughter traits

	Breed (B)						Diet (D)				P – value	
	CF (n = 11)		CH × CF (n = 7)		CH (n = 12)		MS (n = 15)		LCS (n = 15)		B	D
	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*		
Slaughter weight (kg)	585.9	6.5	593.6	8.2	585.1	6.2	593.5	5.6	582.8	5.6	0.686	0.197
Hot carcass weight (kg)	329.7	5.4	350.1	6.9	341.7	5.2	345.1	4.7	335.8	4.9	0.074	0.183
Killing-out (%)	56.3[a]	0.6	59.0[b]	0.8	58.5[b]	0.6	58.2	0.5	57.6	0.5	0.013	0.438
Carcass gain (kg/d)	0.62	0.02	0.71	0.02	0.66	0.02	0.71	0.02	0.62	0.02	0.065	0.006
Carcass conformation[1]	7.5[a]	0.4	8.8[ab]	0.5	9.4[b]	0.4	8.9	0.3	8.2	0.4	0.005	0.127
Carcass fatness[2]	6.8[a]	0.3	6.1[ab]	0.3	5.3[b]	0.2	5.9	0.2	6.2	0.2	0.001	0.343
Gastrointestinal tract and internal fat depots (% slaughter weight)												
Gastrointestinal tract	5.78	0.18	5.18	0.22	5.17	0.17	5.29	0.15	5.46	0.16	0.039	0.443
Kidney fat	1.26[a]	0.06	1.14[a]	0.08	0.92[b]	0.06	1.29	0.05	0.93	0.05	0.002	<0.001
Rumen fat	0.66	0.07	0.69	0.08	0.54	0.06	0.69	0.06	0.56	0.06	0.269	0.128
Cod fat	0.61[a]	0.04	0.53[a]	0.05	0.38[b]	0.04	0.59	0.03	0.42	0.04	0.001	0.003
Total internal fat	2.53[a]	0.13	2.36[a]	0.17	1.84[b]	0.13	2.57	0.11	1.91	0.12	0.003	0.001

[a,b,c]Means within a row with different superscripts significantly differ ($P < 0.05$)

[1]Scale 1 = P – (poorest) to 18 = S+ (best)

[2]Scale 1 = 1 – (leanest) to 15 = 5+ (fattest)

weights are shown as percentages of the right side weight. The CH bulls had a higher percentage of high-priced meat ($P < 0.05$), a lower percentage of meat from lower-priced joints ($P < 0.05$) and produced less fat separated during the cutting process ($P < 0.001$) than the other breed groups.

The carcasses of the LCS bulls tended to have a lower percentage of separable fat ($P = 0.093$). Otherwise, no significant effect of diet was found on the carcass composition of the bulls.

DISCUSSION

CF is a dual-purpose breed with a satisfactory potential for both milk and meat production while CH and its crosses are mainly produced for meat. To our knowledge, there are no studies in the literature directly comparing the performance of Czech Fleckvieh and Charolais bulls with the crosses of the same breeds. The growth potential of purebred and crossbred Charolais has been described in a

Table 4. Carcass composition

	Breed (B)						Diet (D)				P – value	
	CF (n = 11)		CH × CF (n = 7)		CH (n = 12)		MS (n = 15)		LCS (n = 15)		B	D
	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*	LSM	*SEM*		
Tissue (% of right side weight)												
Total meat	78.3	0.3	78.6	0.4	78.6	0.3	78.6	0.3	78.4	0.3	0.732	0.6910
High-priced meat	38.9[a]	0.4	39.1[a]	0.5	40.5[b]	0.4	39.9	0.3	39.2	0.4	0.014	0.1660
Low-priced meat	39.3[a]	0.4	39.5[a]	0.5	38.1[b]	0.4	38.7	0.3	39.2	0.4	0.037	0.2960
Separable fat	3.3[a]	0.2	2.7[a]	0.2	2.1[b]	0.2	2.8	0.1	2.5	0.1	<0.001	0.0930
Bones and tendons	18.5	0.3	18.7	0.4	19.4	0.3	18.6	0.3	19.1	0.3	0.100	0.1789
Fat thickness (mm)	4.6[a]	0.3	4.2[a]	0.4	3.0[b]	0.3	4.1	0.3	3.8	0.3	0.007	0.5160
Meat:bones and tendons	4.255	0.081	4.214	0.103	4.073	0.087	4.246	0.070	4.115	0.073	0.261	0.2090
High:low-priced meat	0.992[a]	0.019	0.992[a]	0.024	1.066[b]	0.018	1.033	0.016	1.001	0.017	0.013	0.1800
MLLT area/100 kg slaughter weight (cm^2)	12.25	0.54	12.03	0.68	13.34	0.51	12.93	0.47	12.16	0.48	0.223	0.2610

[a,b,c]Means within a row with different superscripts significantly differ ($P < 0.05$)

number of studies (Andersen et al., 1977; Everitt et al., 1980; Amer et al., 1992; Gregory et al., 1994). In agreement with our results, the CH-sired bulls had slightly higher daily live weight gains than the purebred dual-purpose Fleckvieh bulls and needed 5% less energy per kg gain in the crossbreeding trial with two different feeding intensities (Kögel et al., 2000a). Similarly, the CH-sired bulls had a higher live weight gain during the experimental period than the purebred CF bulls and the other tested beef crosses (Frelich et al., 1998). Intensively finished CH-sired bulls outperformed Aberdeen Angus-sired bulls in terms of live weight gain and feed conversion ratio in the study by Hyslop et al. (2006).

A higher daily dry matter intake in CF may be associated with their heavier gastrointestinal tracts expressed as a percentage of slaughter weight. A similar relationship was suggested by Istasse et al. (1990), who compared the performance of double-muscled Belgian Blue and dairy Holstein bulls. The CF bulls in our study were less efficient in converting feed into live weight gain than the other groups. As reviewed by Herd et al. (2004), several plausible mechanisms exist by which variation in the efficiency of nutrient use may be explained. One of them is the lower energy expenditure for depositing lean compared to fat tissue. This may be the case in this study, as the CF bulls produced relatively more internal fat and separable fat and obtained a higher score for carcass fatness than the CH bulls.

The bulls fed the LCS diet gained more slowly and less efficiently than the bulls on the MS diet as a result of the lower content of dietary energy and higher contents of dietary neutral- (NDF) and acid-detergent (ADF) fibre. The higher feed intake and reduced feed efficiency observed in the LCS group over the entire experimental period were also probably due to a considerably longer time on feed needed to reach the target slaughter weight. In agreement with our study, the average live weight gain and feed efficiency were positively affected by a higher dietary energy concentration in Simmental bulls (Sami et al., 2004). Also, increasing the dietary energy content improved daily live weight gains and feed efficiency in Simmental and Hereford steers (Mandell et al., 1998). Replacing grass silage with maize silage improved the growth rate and feed conversion efficiency of Simmental × Holstein steers, as reported by Juniper et al. (2005).

The observed killing-out percentages of the CH and CF bulls are comparable to those reported in our previous studies (Bartoň et al., 2003, 2006). The values of the killing-out percentage for CH-sired bulls and purebred Fleckvieh bulls presented by Kögel et al. (2000b) are somewhat higher, but the difference (2.7%) is similar to our results.

While the CF bulls were visually classified for conformation on average between R– and R=, the CH × CF bulls obtained an average score approaching R+ and CH between R+ and U–. The lowest score for fatness in CH and the highest score in CF correspond to the differences found in the other recorded fatness traits (internal fat and separable fat proportions, subcutaneous fat thickness). Similar differences in carcass conformation between Fleckvieh and CH × Fleckvieh bulls were reported by Kögel et al. (2000b). However, in contrast to our study, no differences between the groups were observed in fatness score. The superiority of CH-sired bulls over dual-purpose Norwegian bulls in carcass conformation was also demonstrated (Aass and Vangen, 1998).

The CH bulls produced less internal fat as a percentage of slaughter weight than both the CH × CF and CF. In accordance with this, no difference in kidney fat production between CH × CF and CF was found in the breed comparison by Voříšková et al. (1998).

The feeding of MS diet with a higher energy concentration increased the deposition of internal fat and especially kidney and cod fat depots and tended to increase the separable fat content. However, no significant effect of diet was observed on visually scored carcass fatness. In accordance with our results, Juniper et al. (2005) reported that the inclusion of maize silage in the diet of crossbred steers increased the size and rate of internal fat deposition.

The high carcass quality of purebred CH bulls was clearly indicated by the highest proportion of meat of higher-priced cuts and, on the contrary, the lowest proportion of low-priced meat compared to the other breed groups. However, no significant differences in any of the observed carcass composition traits were found between CH × CF and CF. Similarly, no differences between these groups for most carcass composition traits were found by Frelich et al. (1998). Conversely, it was reported that CH-sired bulls had a higher proportion of meat in carcasses than purebred Fleckvieh bulls (Kögel et al., 2000b). Higher percentages of valuable cuts were recorded in CH × German Friesian and purebred CH bulls compared to Angler, German

Friesian, and German Red and White bulls (Guhe et al., 1994).

It can be concluded that purebred CH were superior to the other breed groups in most of the traits observed. The positive effects of crossbreeding CH with CF were apparent only in the feed efficiency and the killing-out percentage, which were higher in the crossbred bulls compared to the purebred CF animals. The intensive diet based on maize silage increased average daily gains, reduced the time needed to achieve the target slaughter weight, and improved the feed efficiency of the bulls. Except for the higher production of internal fat in the intensively fed bulls, no effect of diet was observed on slaughter traits and carcass composition.

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