Effect of breed on growth performance and carcass composition of Aberdeen Angus, Charolais, Hereford and Simmental bulls

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ABSTRACT: Breed effects on live weight gain, slaughter characteristics and carcass composition were compared in Aberdeen Angus, Charolais, Hereford and Simmental bulls. The experiment extended over 2 years and involved totally 96 animals. The target slaughter live weights were determined 550 kg for earlier maturing breeds Aberdeen Angus and Hereford and 630 kg for later maturing breeds Charolais and Simmental. Charolais and Simmental gained more rapidly ($P < 0.05$) than Aberdeen Angus while Hereford were intermediate. Hereford had lower ($P < 0.05$) dressing percentage than the other breeds. Percentages of grade I meat were significantly higher ($P < 0.05$) in Charolais and Simmental. The highest percentage of separable fat was recorded in Hereford ($P < 0.05$). Charolais and Simmental had lower ($P < 0.05$) thickness of subcutaneous fat over MLLT than Aberdeen Angus and Hereford. The later maturing bulls generally tended to achieve higher live weight gains during the experiment, produced less fat and had higher percentage of meat from high priced joints in comparison with earlier maturing animals.

Keywords: beef cattle; bulls; breeds; growth; carcass composition

There are totally 12 beef breeds currently kept in the Czech Republic. Of them, Aberdeen Angus, Charolais, Hereford and Simmental included in this experiment are the four most frequently used breeds representing approximately 84% of purebred beef cows (Šeba, 2004). Breed differences in production traits are important genetic resources for improving beef production and carcass composition. No single breed excels in all traits that are important for beef production (Wheeler et al., 1997, 2005).

Differences between individual beef breeds in growth and carcass traits were evaluated by Gregory et al. (1994a,b). Cross et al. (1984) investigated the influence of age, breed and sex on carcass traits and meat palatability of Charolais, Simmental, Hereford and Aberdeen Angus steers. Numerous reports have been published on carcass characteristics of different sire breeds compared in extensive crossbreeding trials in Great Britain (Kempster et al., 1982, 1988), New Zealand (Everitt et al., 1980; Morris et al., 1990) and in the United States (Koch et al., 1982; Wheeler et al., 1996, 2005). Breed differences between crossbred bulls sired by different beef breeds in the Czech Republic were described by Voříšková et al. (1998), Šubrt et al. (1999) and Polach et al. (2004).

Growth performance, carcass composition and beef quality of purebred Hereford and Simmental steers fed two diets with different energy contents and slaughtered at similar backfat thickness were compared by Mandell et al. (1998). Hereford gained more rapidly and more efficiently in this study while Simmental had heavier and leaner carcasses. Growth performance and carcass quality of steers from six beef breeds were compared at a target level of 3.5% intramuscular fat by Chambaz et al. (2001).

The objective of the present study was to evaluate growth performance and carcass characteristics

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of bulls of the four currently most numerous beef breeds in the Czech Republic.

MATERIAL AND METHODS

Ninety-six bull calves of four breeds Aberdeen Angus (AA), Charolais (CH), Hereford (HE) and Simmental (SI) were purchased from farms in the Czech Republic after weaning at approximately 8 months of age. Two separate fattening trials were conducted in two years (year 1 and 2), each involving 48 animals (12 per breed). The animals were born between 1st January and 30th April and were the progeny of 28 sires used in natural service or in the system of artificial insemination. Throughout the experimental periods, the bulls were housed in 4 pens (12 animals per pen) with straw bedding.

The animals were fed a mixed diet available *ad libitum* and based on maize and lucerne silage and concentrates. Its composition was adjusted during the fattening period as the live weight of animals increased. The diet contained approximately 42% dry matter (DM), 0.145 kg crude protein/kg DM, 0.085 kg protein digestible in the small intestine (PDI-N)/kg DM and 7.01 MJ net energy for growth (NEV)/kg DM. The bulls were weighed once a month to determine daily live weight gain. The target slaughter live weights were determined 550 kg for earlier maturing breeds AA and HE and 630 kg for later maturing breeds CH and SI. After a fasting period of approximately 18 hours, individual slaughter weights were taken on the day of slaughter immediately before transport to the abattoir.

The animals were slaughtered either in the experimental abattoir of the Research Institute of Animal Production (year 1) or in a commercial abattoir (year 2). The carcasses were uniformly dressed and split into two sides by sawing down the centre of the vertebral column. Hot carcass weights and weights of internal fats (kidney and rumen fat) were recorded. Dressing percentage was calculated as the proportion of hot carcass weight from slaughter weight, carcass gain was obtained as the ratio of hot carcass weight and days of age at slaughter. In year 2, the carcasses were visually assessed by trained operators for conformation (6-point scale) and fatness (5-point scale) according to the EU beef carcass classification scheme (Anonymous, 1991).

After a chill period of approximately 24 hours, cold carcass weights were recorded and the right sides were divided into primal joints. The joints were separated into lean meat, bones and tendons, and separable fat and their weights were taken. Total meat yield was calculated as lean meat from all joints plus lean trimmings. Grade I meat was determined as the total weight of lean meat from rump, shoulder, sirloin and fillet and grade II meat as lean meat from the remaining joints plus lean trimmings. *Musculus longissimus lumborum et thoracis* (MLLT) area was measured at the section between 8^{th} and 9^{th} thoracic vertebrae. Subcutaneous fat thickness was measured at the same area.

Data from 88 animals were included into the analysis (Table 1). Eight bulls had to be removed from the experiment during the fattening period due to health problems (two CH and two HE in year 1; one CH and three SI in year 2). Statistical analyses were performed using the GLM procedure of SAS (SAS, 2001). Fixed effects of breed and year, breed × year interaction and covariates were included in the initial model for all examined traits except for carcass conformation and fatness where only breed and covariate were involved. Linear regression on the age at the start of the test (overall mean) was used for growth traits. The adjusted means of slaughter and carcass composition traits were evaluated at covariate means specific to each breed group. The covariates were thus used only to reduce residual variances. This calculation method described by Mandell et al. (1997) was applied since it is biologically unrealistic to compare the breeds significantly differing in mature size at a common slaughter weight, carcass weight or side weight. In cases where no covariates were used (probability of their significance less than 0.05), a model with breed, year and interaction was used. Interaction terms not significant at a probability of 0.05 were sequentially removed from the model. The covariates included in the analysis and their values are given in Table 2. Differences between LS means and adjusted means were determined. To test the equality of means adjusted to covariate breed group means, appropriate contrasts were constructed (Littel et al., 2002). Scheffe's procedure (Scheffe,

Table 1. Number of bulls of each breed in different years of the experiment

	AA	CH	SI	HE
Year 1	12	10	12	10
Year 2	12	11	9	12

Table 2. Covariates used in models for different traits

Trait	Used covariates	Values of used covariates			
Slaughter weight, daily live-weight gain, carcass fatness, grade I meat, subcutaneous fat thickness, separable fat, shoulder, rump, sirloin, fillet	no covariates used	–			
		overall mean			
Initial weight, age at slaughter	age at the start of the test (days)	293.0			
		covariate mean specific to each breed			
		AA	CH	SI	HE
Rumen fat, kidney fat, total internal fat	slaughter weight (kg)	562.3	621.0	631.6	540.6
Dressing percentage, carcass gain, carcass conformation	carcass weight (kg)	326.5	361.5	364.3	302.3
Total meat, grade II meat, bones and tendons, separable fat, meat:bones and tendons, meat grade I:grade II, MLLT area	right side weight (kg)	161.0	178.4	180.1	148.8

1953) was used to determine the significance of differences in multiple comparisons.

RESULTS AND DISCUSSION

Adjusted and LS means for all analysed traits are given in Tables 3, 4, and 5. The means for the main effect of breed and their differences are discussed only when no significant breed by year interaction ($P > 0.05$) was present. Adjusted and LS means for breed by year interactions are presented in Table 6 and discussed separately.

In agreement with the experimental design, slaughter weight differed significantly ($P < 0.001$) between early maturing (AA, HE) and late maturing (CH, SI) bulls (Table 3). For daily live-weight gain, CH and SI outgained ($P < 0.001$) AA while HE bulls were intermediate. The significantly lower daily gain of AA bulls in the present study was probably due to their higher initial weight at the beginning of the experiment as a result of their exceptionally high live-weight gains until weaning. Similarly to our findings, SI and CH steers had higher average daily gains than all the other compared breed groups (including AA and HE) after a constant time on feed (Gregory et al., 1991, 1994a,b). On the contrary, medium framed HE steers gained more than large framed SI steers when fed to a common backfat endpoint presumably due to a shorter time on feed and higher efficiency for maintenance and gain (Mandell et al., 1998). Similarly, Chambaz et al. (2001) reported higher gains of AA compared to SI and CH slaughtered at a common target level of intramuscular fat also probably resulting from lower age at slaughter and days of fattening in AA.

The results of slaughter traits are shown in Table 3. For dressing percentage, HE were significantly lower ($P < 0.001$) than the other breeds. Similarly to our findings, dressing percentage for carcasses from

Table 3. LS means and their standard errors for growth traits

Trait	Breed				Pr > F
	AA	CH	SI	HE	
Initial weight (kg)	391.3 (*5.78*)	297.5 (*6.61*)	320.7 (*6.18*)	285.0 (*6.29*)	not examined[+]
Slaughter weight (kg)	562.3[a] (*5.53*)	620.7[b] (*5.91*)	632.4[b] (*5.92*)	540.1[a] (*5.78*)	< 0.0001
Age at slaughter (days)	433.7 (*5.36*)	526.3 (*6.13*)	515.5 (*5.73*)	482.5 (*5.83*)	not examined[+]
Daily live-weight gain (kg/day)	1.170[a] (*0.04*)	1.428[b] (*0.04*)	1.419[b] (*0.04*)	1.315[ab] (*0.04*)	< 0.0001

values with different superscripts ([ab]) differ significantly ($P < 0.05$)

[+]not examined due to presence of breed by year interaction

Table 4. Adjusted and LS means and their standard errors for slaughter traits

Trait	Breed				Pr > F
	AA	CH	SI	HE	
Dressing percentage (%)*	58.0[a] (*0.25*)	58.3[a] (*0.27*)	57.5[a] (*0.27*)	56.0[b] (*01.26*)	< 0.0001
Carcass gain (kg/day)*	0.741 (*0.01*)	0.723 (*0.02*)	0.723 (*0.02*)	0.611 (*0.02*)	not examined+
Carcass conformation[1]*	3.83[a] (*0.10*)	3.27[b] (*0.11*)	3.77[a] (*0.12*)	3.91[a] (*0.10*)	0.0005
Carcass fatness[2]**	2.58 (*0.16*)	2.27 (*0.16*)	2.22 (*0.18*)	2.50 (*0.16*)	0.3509
Rumen fat (% slaughter weight)*	0.79 (*0.07*)	0.59 (*0.06*)	0.72 (*0.10*)	0.84 (*0.09*)	not examined+
Kidney fat (% slaughter weight)*	1.41[b] (*0.05*)	1.17[a] (*0.05*)	1.40[b] (*0.05*)	1.32[ab] (*0.05*)	0.0059
Total internal fat (% slaughter weight)*	2.20 (*0.07*)	1.77 (*0.08*)	2.12 (*0.08*)	2.16 (*0.08*)	not examined+

values with different superscripts ([abc]) differ significantly ($P < 0.05$)
+not examined due to presence of breed by year interaction
[1]evaluated only in year 2 (Scale 1 = S (best) to 6 = P (poorest))
[2]evaluated only in year 2 (Scale 1 (leanest) to 5 (fattest))
*adjusted means (slaughter weight used as a covariate)
**LS means (no covariate used)

HE-sired steers was lower than for carcasses from CH crosses at constant slaughter age (Wheeler et al., 2005). The authors also reported that the carcasses from British sire breeds tended to have lower dressing percentage than Continental Europe sire breeds at common fat thickness and fat trim percent endpoints. The low dressing percentage of HE bulls found in the present study can also be explained by their low average slaughter weight; it was previously established that this trait increased with increasing slaughter weight (Kempster et al., 1988; More O'Ferrall and Keane, 1990).

Visually assessed carcass conformation was significantly better ($P < 0.001$) for CH bulls in comparison with the other breed groups. Although CH and SI tended to have lower carcass fatness scores, the differences between groups were not significant. Similarly to our study, the bulls of CH sires had better conformation scores according to the SEUROP classification scheme than the bulls of AA and HE sires in the breed comparison of progeny after beef sires in test (Polách et al., 2004). The CH animals produced proportionally less ($P < 0.01$) kidney fat than AA and SI while HE were intermediate. No differences in kidney, pelvic and heart fat proportion between AA, CH, SI and HE animals slaughtered at three different age points were reported by Cross et al. (1984).

Means for carcass composition traits are presented in Table 5. Important breed differences were found in total meat proportions ($P < 0.001$) expressed as a percentage of right side weight. The highest value was recorded for SI bulls while the lowest for HE animals. Proportions of meat in higher priced joints (grade I meat) were significantly different ($P < 0.001$) and higher in CH and SI animals. In contrast, CH bulls had significantly lower proportions of meat in lower priced joints (grade II meat). The highest grade I to grade II meat ratio was recorded for CH carcasses followed by SI, HE and AA.

Similar to our findings, Kempster et al. (1982) reported a lower saleable meat proportion from carcasses of HE-sired steers than from carcasses of AA-, CH- and SI-sired steers compared at 16 months of age. However, they found no significant differences between these crosses in proportions of saleable meat in higher priced joints. Wheeler et al. (1997) found that HE × AA crosses had lower yields of saleable product than CH- and SI-sired steers. Similarly, carcasses from Continental European (including CH ands SI) sire breeds had heavier weights and percentages of retail product at constant carcass weight than carcasses from British sire breeds (AA and HE) (Wheeler et al., 2005). Higher lean yields were also recorded in carcasses from purebred SI compared to HE steers (Mandell et al., 1998) and from purebred SI compared to Red Angus steers (Laborde et al., 2001).

Significant differences were recorded in the proportion of bones and tendons ($P < 0.001$). HE had

Table 5. Adjusted and LS means and their standard errors for carcass composition traits

Trait	Breed				Pr > F
	AA	CH	SI	HE	
Total meat (% side)*	81.18^{ab} (*0.20*)	80.60^{ac} (*0.22*)	81.57^{b} (*0.22*)	80.00^{c} (*0.21*)	< 0.0001
Grade I meat (% side)**	39.19^{a} (*0.23*)	41.04^{b} (*0.25*)	40.25^{b} (*0.25*)	38.76^{a} (*0.24*)	< 0.0001
Grade II meat (% side)*	41.99^{a} (*0.19*)	39.56^{b} (*0.20*)	41.31^{a} (*0.20*)	41.24^{a} (*0.20*)	< 0.0001
Meat grade I:grade II*	0.93^{a} (*0.01*)	1.04^{b} (*0.01*)	0.98^{c} (*0.01*)	0.94^{ac} (*0.01*)	< 0.0001
Bones and tendons (% side)*	17.10^{ac} (*0.17*)	17.73^{c} (*0.19*)	16.86^{ab} (*0.19*)	16.38^{b} (*0.18*)	< 0.0001
Meat:bones and tendons*	4.77^{ab} (*0.05*)	4.56^{a} (*0.06*)	4.86^{b} (*0.06*)	4.90^{b} (*0.06*)	0.0004
Separable fat (% side)**	2.54^{a} (*0.10*)	2.25^{b} (*0.11*)	2.47^{ab} (*0.11*)	3.25^{c} (*0.10*).	< 0.0001
Subcutaneous fat thickness (mm)**	10.4^{a} (*0.51*)	6.5^{b} (*0.55*)	7.2^{b} (*0.55*)	11.2^{a} (*0.54*)	< 0.0001
MLLT area/100 kg slaughter weight (cm^2)*	15.34 (*0.61*)	16.97 (*0.74*)	15.86 (*0.90*)	15.24 (*1.09*)	not examined^{+}
Rump meat (% side)**	22.93^{a} (*0.17*)	24.78^{b} (*0.19*)	23.80^{c} (*0.19*)	22.79^{a} (*0.18*)	< 0.0001
Shoulder meat (% side)**	9.42 (*0.12*)	9.16 (*0.13*)	9.51 (*0.13*)	9.35 (*0.13*)	0.2682
Sirloin meat (% side)**	5.07 (*0.10*)	5.24 (*0.11*)	5.15 (*0.11*)	4.99 (*0.11*)	0.4259
Fillet meat (% side)**	1.77^{a} (*0.03*)	1.86^{a} (*0.03*)	1.80^{a} (*0.03*)	1.61^{b} (*0.03*)	< 0.0001

values with different superscripts (^{abc}) differ significantly (P < 0.05)
$^{+}$not examined due to presence of breed by year interaction
*adjusted means (right side weight used as a covariate)
**LS means (no covariate used)

the lowest, SI intermediate, and AA and CH bulls the highest percentage of bones and tendons. Similar to the present study, no significant differences were found between bone yields of SI and HE bulls and steers (Mandell et al., 1997, 1998) and SI and Red Angus steers (Laborde et al., 2001). Meat to bones and tendons ratios reflected the relationships between the two components in carcasses from different groups. In our study, the highest ratios were found in HE (4.90) and SI (4.86) due to particularly low proportions of bones and tendons in their carcasses while the lowest ratio was recorded in CH (4.56). Contrary to our results, HE- and SI-sired crosses had a lower saleable meat to bone ratio than CH- and AA-sired crosses slaughtered at 24 months (Kempster et al., 1982). No significant differences were, however, observed between lean to bone ratios of CH-, SI- and HE-sired steers in the study of Kempster et al. (1988).

The bulls of different breeds significantly differed in the percentage of separable fat and subcutaneous fat thickness (P < 0.001). CH bulls produced less separable fat than AA while SI animals were intermediate. The highest percentage of separable fat was recorded in HE. CH and SI bulls had lower thickness of subcutaneous fat over MLLT than animals from AA and HE groups. In general, the animals of earlier maturing breeds AA and HE produced relatively more fat than the later maturing CH and SI in spite of the fact that they were slaughtered at significantly lower live weights. Wheeler et al. (2005) reported that AA- and HE-sired steers were fatter than CH- and SI-sired animals when slaughtered at constant age and carcass weight. Likewise, AA-sired steers had higher fat depths at the 12th rib than SI-sired crosses at time- and live weight-constant endpoints (Urick et al., 1991).

Breed differences were also found in percentages of meat from rump (P < 0.001) and fillet (P < 0.001). CH bulls had higher rump meat percentages than the animals from the other groups, and SI bulls were higher in this trait than AA and HE. The lowest percentage of meat from fillet was recorded in HE. In agreement with our results, Keane et al. (1990) reported lower proportions of muscle in the pelvic limb of CH crosses in comparison with HE crosses.

Means for observed breed by year interactions are shown in Table 6. The interactions for initial weight,

Table 6. Adjusted and LS means and their standard errors for breed by year interactions

Trait		Breed				Pr > F
		AA	CH	SI	HE	
Initial weight (kg)**	Year 1	335.3 (*8.27*)	350.7 (*9.91*)	341.7 (*8.71*)	237.8 (*8.75*)	
	Year 2	447.4 (*9.49*)	244.2 (*8.31*)	299.7 (*9.21*)	332.2 (*9.72*)	< 0.000
Age at slaughter (days)**	Year 1	485.7 (*7.66*)	486.7 (*9.19*)	503.6 (*8.08*)	500.4 (*8.11*)	1
	Year 2	381.8 (*8.80*)	565.8 (*7.70*)	527.5 (*8.54*)	464.6 (*9.01*)	
Carcass gain (kg/day)*	Year 1	0.71 (*0.01*)	0.73 (*0.02*)	0.68 (*0.02*)	0.69 (*0.03*)	1
	Year 2	0.78 (*0.02*)	0.59 (*0.02*)	0.61 (*0.02*)	0.68 (*0.02*)	< 0.000
Rumen fat (% slaughter weight)*	Year 1	0.92 (*0.08*)	0.67 (*0.07*)	0.77 (*0.09*)	0.96 (*0.12*)	1
	Year 2	0.98 (*0.09*)	0.36 (*0.07*)	0.56 (*0.12*)	0.91 (*0.08*)	0.0088
Total internal fat (% slaughter weight)*	Year 1	2.52 (*0.15*)	1.86 (*0.13*)	2.20 (*0.17*)	2.50 (*0.22*)	
	Year 2	2.56 (*0.17*)	1.27 (*0.13*)	1.83 (*0.23*)	2.39 (*0.15*)	
MLLT area/100 kg slaughter weight (cm^2)*	Year 1	14.47 (*0.63*)	15.32 (*1.03*)	13.94 (*1.10*)	12.87 (*1.15*)	
	Year 2	17.80 (*1.00*)	17.15 (*0.75*)	17.02 (*0.95*)	12.25 (*1.23*)	

*adjusted means; **LS means

age at slaughter and carcass gain were due to higher live weight gain until the start of the experiment in AA in year 2 while this gain was lower in CH and SI in year 2 than would be expected. Compared to the other breeds, AA produced more rumen and total internal fat in year 2 than in year 1. The recorded MLLT area/100 kg of slaughter weight was larger in all breeds in year 2 except for HE. There is no obvious explanation for these differences.

Significant breed differences in growth, slaughter and carcass traits were observed in the present study. The later maturing bulls of CH and SI breeds tended to achieve higher live weight gains during the experiment, produced less fat and had higher percentage of meat from high priced joints in comparison with earlier maturing AA and HE.

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