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Comparison of growth performance and slaughter characteristics of Limousin and Charolais heifers

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Abstract

The objective of this study was to determine the effects of breed and a diet containing linseed on the growth and carcass composition characteristics of heifers. A total of 48 Limousin (LI) and Charolais (CH) heifers with an average weight of 270 kg were assigned to two diets containing either extruded linseed (LIN) or no supplemental oilseed (CON). The target slaughter weight was set at 500 kg. The diet had no effect on any of the observed production traits. The CH heifers had higher live weight gains ($P<0.001$) and a lower feed conversion ratio ($P<0.001$). The LI heifers had a higher dressing percentage ($P<0.001$), higher meat to bone ratio ($P<0.001$), greater *m. longissimus lumborum et thoracis* area ($P<0.05$), and produced more internal and carcass fat ($P<0.05$). It was concluded that purebred LI heifers grew less rapidly and less efficiently but produced heavier carcasses with a more favourable meat to bone ratio compared to purebred CH heifers.

Keywords: heifers, Charolais, Limousin, linseed, growth, carcass composition

Zusammenfassung

Vergleich von Wachstums- und Schlachtkörpermerkmalen bei Färsen der Rassen Limousin und Charolais

Verglichen wurden Wachstums- und Schlachtkörpermerkmale bei Färsen der Rassen Limousin (LI) und Charolais (CH), die mit oder ohne gepressten Leinsamen gefüttert wurden. Einbezogen waren 48 Färsen beider Rasse bei einem Versuchsbeginn mit durchschnittlich 270 kg bis zur Schlachtung von durchschnittlich 500 kg. Ein Fütterungseinfluss bei Leinsamenzugaben konnte nicht nachgewiesen werden. CH-Färsen erreichten gegenüber LI-Färsen signifikant höhere tägliche Zunahmen bei geringerem Nährstoffbedarf je kg Lebendgewichtszuwachs. LI-Färsen zeigten ein signifikant geringeres Wachstum, höhere Schlachtausbeuten, ein günstigeres Fleisch : Knochenverhältnis, größere Flächen beim *m. longissimus lumborum* und *m. thoracis*, einen höheren Innenfettanteil und Verfettungsgrad der Schlachtkörper.

Schlüsselwörter: Färse, Charolais, Limousin, Leinsamen, Wachstum, Schlachtkörperzusammensetzung

Introduction

In contrast to dairy and dual-purpose cattle, the stock of beef animals, including crossbreds, has been increasing in the Czech Republic over the last fifteen years. At present, there are a total of 12 beef breeds widely differing in their production characteristics. Of them, the French breeds Limousin and Charolais belong to the most numerous beef breeds, representing 9 and 25 %, respectively, of the total number of suckler cows. Female calves that are not used for herd replacement are either sold or fattened and provide a valuable source of high quality meat.

Growth ability and meat performance are of great economic importance in beef cattle. Many authors were concerned with genetic evaluation of growth ability in beef breeds (JAKUBEC *et al.* 2003, SZABÓ *et al.* 2007, VOSTRÝ *et al.* 2007). Large variations in growth performance and carcass composition traits exist among different beef breeds (HOLLÓ *et al.* 2004, BARTOŇ *et al.* 2006, CUVELIER *et al.* 2006, LINK *et al.* 2007, ALBERTÍ *et al.* 2008). Therefore, breed comparison experiments provide valuable information on the suitability of different beef breeds for different production and market conditions.

The differences in production traits between Charolais and Limousin breeds have been previously studied in bulls (JURIE *et al.* 2005), cows (JURIE *et al.* 2006), and steers (MANDELL *et al.* 1997, CHAMBAZ *et al.* 2001). Only limited information is, however, available about the fattening capacity and carcass value of young heifers of these breeds.

It is well known that diets supplemented with linseed improve the fatty acid profile of beef, lamb and pork from the human health perspective (HOLLÓ *et al.* 2005, GRUSZECKI *et al.* 2006, SCOLLAN *et al.* 2006, VÁCLAVKOVÁ and BEČKOVÁ, 2007). However, the effects of different dietary treatments involving linseed on production traits of fattened cattle are not entirely clear and need to be elucidated. Therefore, the objective of the present study was to determine the effects of breed and a diet containing linseed on the growth and carcass composition characteristics of heifers.

Material and methods

The experiment involved 24 Limousin (LI) and 24 Charolais (CH) purebred heifers. The animals were purchased from two commercial farms after weaning at the age of approx. 8 months. The heifers were loose-housed in pens with straw bedding, and during a 2-month adaptation period they were given a mixed diet consisting of maize silage, grass hay, and concentrates (wheat and extruded soybean meal). At the beginning of the experimental period, the animals of each breed were assigned according to live weight and age to one of two diets containing either extruded linseed (LIN) or no supplemental oilseed (CON). Both diets offered *ad libitum* were isocaloric and isonitrogenous but differed in the content and source of dietary fat. Diet ingredient samples were regularly collected and analysed. The feeds were dried at 105 °C to a constant weight. Crude protein, fat, and fibre contents were determined using the Kjeltec AUTO 1 030 Analyser, Soxtec 1 043 and Fibertec 2 010 (FOSS Tecator AB, Höganäs, Sweden) instruments, respectively. The average ingredient and chemical composition of the diets has been reported previously (BARTOŇ *et al.* 2007a).

The heifers were fed from electronically controlled feeding troughs (Insentec, Marknesse, The Netherlands), and thus the individual daily feed intake of each heifer could be recorded.

The animals were weighed at the beginning of the experiment and then every two weeks. The target live weight was 500 kg. Two animals from the CON group (1 LI and 1 CH) had to be withdrawn from the experiment due to health problems. The growth and feed intake data were separately analysed for the period from the start to day 168 of the experiment (when the first heifers reached the target live weight and were slaughtered) and for the entire experiment from start to slaughter. The two or three heaviest animals from each dietary regime were selected for slaughter on each slaughter day. These animals were weighed 3 days before slaughter (final weight used for the calculation of daily live weight gain and feed intake) and on the slaughter day after approximately 18 h of fasting (slaughter weight used for the calculation of slaughter characteristics).

The slaughtering was performed in the experimental abattoir of the Institute of Animal Science. The heifers were stunned with a captive bolt gun and killed by exsanguination. The carcasses were dressed according to EU specifications and assessed by a trained classifier for conformation (a 6-point scale) and external fatness (a 5-point scale) according to the SEUROP classification system (EU 2008). The weights of the hot carcass and internal fat depots (kidney, rumen, and udder fat) were recorded. The dressing percentage was calculated as 100×hot carcass weight/slaughter weight. Carcass gain was obtained as the ratio of hot carcass weight to days of age at slaughter.

After chilling for approximately 24 h, cold carcass weights were recorded and the right sides were divided into standardized joints. The joints were separated into lean meat, bones and tendons, and separable fat (subcutaneous and intermuscular), and their weights were recorded. 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 trimmed rump, shoulder, loin and fillet, and low-priced meat as the lean meat from the remaining joints plus the lean trimmings. The *m. longissimus lumborum et thoracis* (MLLT) area was measured planimetrically at the section between the 8th and 9th thoracic vertebrae.

The GLM procedure of SAS (SAS 2001) was used to analyse all experimental data. Fixed effects of breed and diet and their interaction were included in the initial model. However, the interactions were omitted from the final model, as they were not significant for any of the examined traits. In addition, the age at the beginning of the experiment (overall mean 293 days) was used as a covariate for growth performance traits and carcass gain, while the slaughter weight (overall mean 489 kg) was used as a covariate for slaughter and carcass composition traits. Thus, the following statistical model was used:

$$y_{ijkl} = \mu + A_i + B_j + \beta x_{ijkl} + e_{ijkl} \quad (1)$$

Where y_{ijkl} is the analysed trait, μ is the mean value, A_i is the effect of breed, B_j is the effect of diet, β is the regression coefficient, x_{ijkl} is the alternatively initial age or slaughter weight and e_{ijkl} is the residual error.

Main effects (breed and diet) least-squares means, their standard errors, and levels of significance are presented in the tables.

Results and Discussion

Effects of diet

Linseed was included in the diet to primarily examine its potential for improving the fatty acid profile of beef, and the results have been published elsewhere (BARTOŇ *et al.* 2007a). The aim of the present study was to determine the effect of linseed feeding on production traits of fattened cattle. However, no significant effects of linseed feeding (approx. 7 % of extruded linseed on a DM basis) on growth, slaughter, and carcass traits were detected (Tables 1, 2 and 3). The inclusion of differentially processed linseed increased the average daily gain and gain to feed ratio in beef heifers probably due to the higher energy density of the linseed diets (MADDOCK *et al.* 2006). However, when the consumed diets were similar in their energy and protein content, linseed feeding did not significantly influence most of the growth and carcass traits (RAZMINOWICZ *et al.* 2008), which is in accordance with the present results. In a study by HOLLÓ *et al.* (2008) the diet with linseed supplementation caused significantly lower daily gain, but it had no effect on slaughtering and dressing traits in fattening bulls. It is apparent that the inclusion of extruded linseed in the diet at a reasonable level has no deteriorating effect on the production characteristics of beef heifers.

Effect of breed

The data of growth performance adjusted for a common age at the beginning of the experiment are given in Table 1. The animals of both groups were similar in their initial live weight. At day 168, however, the CH animals were heavier by 31 kg ($P<0.05$) as a result of a significantly higher daily live weight gain ($P<0.001$) during this period. Similarly, the CH heifers grew more rapidly throughout the entire experimental period by 250 g on the average ($P<0.001$) and consequently reached the final weight 45 d earlier ($P<0.001$) compared to the LI animals. Among the beef breeds, CH is well-known for its excellent growth performance (BARTOŇ *et al.* 2007b). Higher live weight gains of CH compared to LI animals were reported in a number of previous studies (e.g. MANDELL *et al.* 1997). Furthermore, similar results were also observed in the comparison of CH- and LI-sired crosses (FRELICH *et al.* 1998). In contrast, no significant differences in average daily gains between CH and LI bulls were found in a study investigating the variation in production traits of 15 European cattle breeds (ALBERTÍ *et al.* 2008).

No significant breed differences were observed in feed (dry matter, protein digested in the small intestine, net energy of fattening, and crude fibre) intake in both analysed experimental periods, which is in agreement with the results of MANDEL *et al.* (1997), who compared LI and CH steers at two slaughter endpoints. Contrary to the present results, however, lower feed intake capacity of LI compared to CH steers was reported (CHAMBAZ *et al.* 2001), possibly due to a lower digestive tract weight of the LI. AKBAS *et al.* (2006) explained the lower feed intake capacity of Limousin and Piemontese crossbred bulls as a result of their double-muscle characterization. Due to markedly higher live weight gains, the CH heifers exhibited a lower feed conversion ratio (daily nutrient intake/daily live weight gain) than the LI animals ($P<0.001$) in the first experimental period and during the entire experiment. An improved feed conversion ratio was also found in Charolais compared to Holstein bulls due to a higher growth capacity in CH animals in a study by PFUHL *et al.* (2007).

Table 1
Growth performance
Wachstumsmerkmale

	Breed				Diet				Significance	
	LI (n=23)		CH (n=23)		LIN (n=24)		CON (n=22)			
	LSM	SEM	LSM	SEM	LSM	SEM	LSM	SEM	Breed	Diet
Initial weight, kg	278.1	7.4	261.7	7.4	269.0	6.5	270.9	6.8	0.154	0.845
Weight at d 168, kg	431.2	9.2	462.3	9.2	443.9	8.2	449.6	8.5	0.033	0.631
Final weight, kg	505.5	6.4	507.3	6.4	503.4	5.6	509.3	5.9	0.852	0.474
Final age, d	562.2	4.9	517.0	4.9	540.4	4.3	538.7	4.5	<0.001	0.786
Duration	269.2	4.9	224.0	4.9	247.5	4.3	245.7	4.5	<0.001	0.780
Period from start to d 168 of the experiment										
Live weight gain, kg/d	0.911	0.025	1.194	0.025	1.041	0.022	1.064	0.023	<0.001	0.477
Feed intake										
Dry matter, kg/d	6.39	0.17	6.71	0.17	6.45	0.15	6.65	0.16	0.244	0.388
PDIN, kg/d[a]	0.46	0.01	0.49	0.01	0.46	0.01	0.49	0.01	0.242	0.133
NEF, MJ/d[b]	40.8	1.1	42.8	1.1	41.2	1.0	42.4	1.0	0.244	0.429
Crude fibre, kg/d	1.22	0.03	1.28	0.03	1.22	0.03	1.27	0.03	0.246	0.223
Feed conversion ratio										
Dry matter, kg/kg gain	7.01	0.14	5.60	0.14	6.29	0.12	6.32	0.13	<0.001	0.857
PDIN, kg/kg gain[a]	0.51	0.01	0.41	0.01	0.45	0.01	0.46	0.01	<0.001	0.327
NEF, MJ/kg gain[b]	44.7	0.9	35.8	0.9	40.2	0.8	4.03	0.8	<0.001	0.928
Crude fibre, kg/kg gain	1.33	0.03	1.07	0.03	1.19	0.02	1.21	0.02	<0.001	0.534
Period from start to end of the experiment										
Live weight gain, kg/d	0.850	0.025	1.104	0.025	0.964	0.023	0.991	0.024	<0.001	0.418
Feed intake										
Dry matter, kg/d	6.52	0.16	6.85	0.16	6.59	0.14	6.77	0.15	0.185	0.373
PDIN, kg/d[a]	0.47	0.01	0.50	0.01	0.47	0.01	0.50	0.01	0.185	0.105
NEF, MJ/d[b]	41.6	1.0	43.7	1.0	42.1	0.9	43.2	0.9	0.184	0.417
Crude fibre, kg/d	1.24	0.03	1.30	0.03	1.25	0.03	1.30	0.03	0.185	0.195
Feed conversion ratio										
Dry matter, kg/kg gain	7.69	0.35	6.21	7.69	6.93	0.15	6.97	0.15	<0.001	0.856
PDIN, kg/kg gain[a]	0.56	0.16	0.45	0.56	0.50	0.01	0.51	0.01	<0.001	0.355
NEF, MJ/kg gain[b]	49.1	1.1	39.66	49.1	44.3	0.9	44.4	1.0	<0.001	0.919
Crude fibre, kg/kg gain	1.46	0.03	1.18	1.46	1.31	0.03	1.34	0.03	<0.001	0.551

[a]Protein digested in the small intestine supplied by rumen-undegraded protein and microbial protein from rumen-degraded protein (SOMMER *et al.* 1994) [b]Net energy of fattening (SOMMER *et al.* 1994)

Thus, at approximately the same body weight range, the CH heifers gained more efficiently than LI. Among other factors, the differences in feed efficiency can be explained by a different composition of body weight gain, as the deposition of lipids requires a higher feed energy intake compared to protein (HERD *et al.* 2004). In the present study, the lower feed conversion ratio of the LI heifers may be due to their higher production of internal and carcass fat as further discussed below.

The development of body weight and dry matter intake from start to day 168 of the experiment, when the first animals were slaughtered, is shown in Figure 1. While the growth of heifers was generally linear in this period, the dry matter intake increased only until approximately day 70 of the experiment (about 360 days of age), and then remained stable.

In the final period of the experiment (from day 168 on), daily gains were reduced, and the feed conversion ratio increased in both breed groups. This pattern of growth and feed intake development was widely in agreement with the results of a fattening experiment with steers of different beef breeds (CHAMBAZ *et al.* 2001).

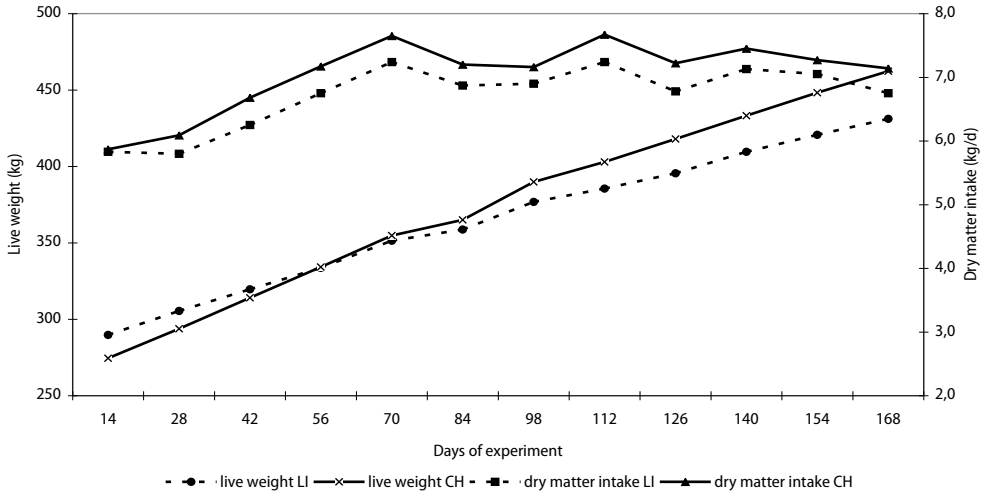

Figure 1
Live weight and dry matter intake from start to day 168
Lebendgewicht und Trockenmasseaufnahme vom 14. bis 168. Tag

Slaughter characteristics are summarized in Table 2. When adjusted for common slaughter weight, the LI heifers produced heavier carcasses ($P<0.001$) and had a higher dressing percentage ($P<0.001$). They also received higher fatness scores ($P<0.001$), whereas conformation scores were similar in both groups. In addition, the LI deposited more kidney ($P<0.05$), rumen ($P<0.05$), and udder ($P<0.01$) fat. The superiority of LI compared to most beef breeds in dressing percentage has been previously well documented in experiments with crossbred as well as purebred animals (WHEELER *et al.* 2005, ALBERTÍ *et al.* 2008).

On the other hand, the higher degree of fatness of the LI heifers compared to CH is rather surprising, as in other studies no differences between these breeds in fatness scores and fat production were reported, or the fatness exhibited by LI was even lower (MANDELL *et al.* 1997, ALBERTÍ *et al.* 2008). The explanation of the observed results may be related to the different physiological age of the animals used in our experiment and/or the prolonged fattening period of the LI group. The compared breeds differed in a number of carcass composition traits (Table 3). At a common slaughter weight, the LI heifers produced heavier right carcass sides ($P<0.001$), more total ($P<0.001$), high-priced ($P<0.01$), and low-priced ($P<0.001$) meat, more fat separated during dissections ($P<0.01$), and less bone and tendon ($P<0.001$). When expressed as percentages of the right side weight, the LI tended towards a higher proportion of total meat ($P=0.092$), they had a lower percentage of bones and tendons ($P<0.001$), and a higher percentage of separable fat ($P<0.05$).

Table 2
Slaughter characteristics
Schlachtmerkmale

	Breed				Diet				Significance	
	LI (n=23)		CH (n=23)		LIN (n=24)		CON (n=22)			
	LSM	SEM	LSM	SEM	LSM	SEM	LSM	SEM	Breed	Diet
Carcass weight, kg	296.3	2.2	281.8	2.2	288.8	2.1	289.2	2.2	<0.001	0.893
Dressing percentage, %	60.6	0.4	57.7	0.4	59.1	0.4	59.1	0.4	<0.001	0.955
Carcass gain, kg/d	0.518	0.011	0.543	0.011	0.529	0.006	0.531	0.007	0.141	0.801
Conformation[a]	3.42	0.11	3.54	0.11	3.44	0.11	3.52	0.11	0.430	0.621
Fatness[b]	3.30	0.11	2.87	0.11	3.18	0.11	2.99	0.11	0.010	0.223
Kidney fat, %[c]	2.31	0.10	1.55	0.10	1.93	0.09	1.93	0.10	<0.001	0.968
Rumen fat, % [c]	1.07	0.09	0.77	0.09	0.93	0.09	0.90	0.09	0.030	0.854
Udder fat, % [c]	1.10	0.05	0.87	0.05	0.98	0.04	0.99	0.05	0.001	0.908

[a]scale 1 S (best) to 6 P (poorest), [b]scale 1 (leanest) to 5 (fattest), [c]% of slaughter weight

They also exhibited a higher meat: bones and tendons ratio ($P<0.001$) and a greater MLLT area/100 kg of slaughter weight ($P<0.05$). The capacity of the LI breed to produce carcasses with high lean meat yields has been reported in a number of previous studies (MANDELL *et al.* 1997, WHEELER *et al.* 2005, ALBERTÍ *et al.* 2008). A favourably high meat to bones and tendons ratio in the LI was also confirmed in a study by CHAMBAZ *et al.* (2001).

Table 3
Carcass composition
Zusammensetzung des Schlachtkörpers

	Breed				Diet				Significance	
	LI (n=23)		CH (n=23)		LIN (n=24)		CON (n=22)			
	LSM	SEM	LSM	SEM	LSM	SEM	LSM	SEM	Breed	Diet
Right side, kg	145.3	1.1	138.3	1.1	141.6	1.1	142.1	1.1	<0.001	0.735
Total meat, kg	113.9	1.2	107.1	1.2	110.2	1.1	110.7	1.2	<0.001	0.740
Total meat, %[a]	78.3	0.4	77.4	0.4	77.8	0.3	77.9	0.4	0.092	0.856
Bones, kg	24.1	0.3	25.5	0.3	25.0	0.2	24.7	0.2	<0.001	0.338
Bones, %[a]	16.6	0.2	18.5	0.2	17.7	0.2	17.4	0.2	<0.001	0.354
High-priced meat, kg	59.9	0.8	56.1	0.8	58.1	0.8	57.9	0.8	0.002	0.879
High-priced meat, %[a]	41.2	0.4	40.6	0.4	41.0	0.3	40.7	0.4	0.250	0.551
Low-priced meat, kg	53.9	0.5	51.0	0.5	52.1	0.5	52.8	0.5	<0.001	0.337
Low-priced meat, %[a]	37.1	0.2	36.8	0.2	36.8	0.2	37.2	0.2	0.335	0.180
High/low priced meat	1.11	0.01	1.10	0.01	1.11	0.01	1.10	0.01	0.652	0.270
Total meat/bones	4.72	0.06	4.20	0.06	4.43	0.06	4.49	0.06	<0.001	0.463
MLLT area/100 kg slaughter weight, cm^2	16.5	0.5	14.8	0.5	15.5	0.5	15.8	0.5	0.017	0.665
Separable fat, kg	7.35	0.41	5.70	0.41	6.37	0.39	6.67	0.41	0.008	0.602
Separable fat, %[a]	5.08	0.29	4.12	0.29	4.51	0.28	4.69	0.29	0.029	0.661

[a]% of right side weight

It is concluded that the CH heifers outperformed the LI animals in terms of daily live weight gain and feed conversion ratio in both analysed experimental periods. They also had

lower proportions of carcass and internal fat. In contrast, the LI heifers produced heavier carcasses with a higher meat to bone ratio. The inclusion of extruded linseed at the level of approximately 7 % on a DM basis had no effect on any of the observed production traits.

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