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Effect of bulky feed type on slaughter traits and meat quality of finishing Limousin bulls

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Summary

The study was carried out during the finishing period of 70 days. A total of 18 Limousin bulls at an initial weight of approx. 440 kg were divided into three analogous feeding groups (6 animals per group) according to body weight. Each feeding group was given a different bulky feed on an ad libitum basis: maize silage (group KK), wilted meadow grass silage (group KT) or both silages (group KKKT). These were supplemented with meadow hay (1 kg/day) and concentrate mixture (1-1.2 kg/100 kg body weight). Body weight, chemical composition and fatty acid profile of the feeds were determined. Chemical composition, levels of fatty acids and total cholesterol in the meat samples from the thoracis muscle (TM), and dressing percentage were also determined. Limousin bulls fed meadow grass silage had lower levels of saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA), higher levels of polyunsaturated fatty acids (PUFA, especially C 18:3 n-3) and a narrower n-6/n-3 PUFA ratio than animals fed maize silage or both silages. Similar results were obtained in groups for carcass meat content, dressing percentage and total cholesterol content.

Keywords: beef cattle; feeding; fatty acid profile

Beef continues to play a major role in the global food balance of the highly developed countries and its elimination from the modern human diet seems unlikely (13). In recent years food has been viewed not only as a source of nutrients but also in terms of its effects on human health (2). The increasing consumer demand for high-quality beef stimulated breeders to select appropriate breeds for fattening and technologies for rearing and feeding young slaughter cattle (17). Current animal fattening methods are aimed at modifying not only the fat to meat ratio (6, 21), but above all the percentage and mutual proportions of essential unsaturated fatty acids (EUFA) in bovine carcasses (3, 5, 6). Previous studies on improving the dietetic value for beef used dietary supplements of different vegetable fats (15, 19). There are no conclusive data in the available literature concerning the possibility of improving the dietetic value of beef by using rations containing different types of bulky feeds.

The aim of the present study was to determine the extent to which the type of silages fed to Limousin bulls during the finishing period affected the composition and health-promoting properties of the meat.

Material and methods

Experimental design, feeding and management. The study was carried out during the finishing period of 70 days. A total of 18 Limousin bulls at an initial weight of approx. 440 kg were assigned to three analogous feeding groups (6 animals per group) according to body weight. The experimental bulls were reared during the calf period with foster mothers for 6-8 months and later fed indoors with farm-produced feeds (silage, hay and concentrate) to obtain daily weight gains of approx. 1000 g/day. Animals were fed the following basic bulky feed on an *ad libitum* basis: maize silage (group KK), wilted meadow grass silage (group KT) or both silages (group KKKT) at a 50 : 50 weight ratio. These feeds were supplemented with meadow hay (1 kg/day) and concentrate mixture (1-1.2 kg/100 kg body weight), which contained ground barley (42%), ground wheat (20%), ground triticale (17%), rapeseed meal (15%), soybean meal (2%) and a mineral-vitamin mixture (4%).

Animals were fed individually and feed intake was monitored daily. The energy and protein value of the feeds and percentage composition of the concentrate were determined according to IZ-INRA feeding standards (18), assuming daily weight gains of 1300 g/day. Wet roughages and concentrates were fed twice daily, and meadow hay was given once a day after the evening feeding.

During the experiment, animals were kept in tie-up stalls equipped with automatic drinkers and partitions in troughs, with separate containers for concentrate.

Measurements, analyses and calculations. Initial and final body weights of the animals, chemical composition of the feeds and meat samples from the thoracis muscle (TM), and the fatty acid profile of the feed and meat samples were determined during the experiment. Basic chemical composition of the feeds was determined according to standard methods (1). NDF and ADF fractions in silages and hay were determined using the method of Goering and Van Soest (8). Volatile fatty acids (VFA) in silages and the profile of higher fatty acids in the feed samples were analysed by gas chromatography (Varian 3400 with a CP-WAX 58 column, 25 m × 0.53 mm × 1.0 micron, FID detection), using an 8200 CX autosampler. Lactic acid was determined using a Shimadzu chromatograph (Nucleosil 250/4 - C 18 column, UV-Vis SPP-6 AV detector and SIL-10 AX autosampler), and silage pH was determined using an Elwro N 5170 potentiometer. At the end of fattening, animals were transported to a slaughterhouse. 24-hour fasting was followed by the control slaughter of animals, postmortem carcass analysis and dissection of 5 valuable cuts into meat, fat and bones. The samples of meat from the thoracis muscle were analysed for the basic chemical composition (1), total cholesterol using the colourimetric method (colour reaction with $FeCl_2$ solution) and fatty acid profile using gas chromatography, using the same chromatograph as for determination of the fatty acid profile of the feed samples. All the chemical analyses and determinations were performed in line with current procedures at the Main Laboratory of the National Research Institute of Animal Production.

The results were analysed statistically using the ANOVA procedure of one-way analysis of variance in the SAS package (1999/2001), while the significance of differences between the groups was determined using Duncan's test.

Results and discussion

The nutrient content of the silages and meadow hay and their nutritive value (tab. 1) corresponded to the values of medium-quality feeds produced in the climatic conditions of southern Poland. The daily intake of dry matter, energy (UFV) and protein (PDI) by the bulls (tab. 2) was similar to the requirement determined based on IZ-INRA feeding standards (18) for beef bulls of early-maturing breeds, with weight gains of 1200--1400 g/day.

There were no statistically significant differences in initial and final body weight, daily weight gains, carcass weight, dressing percentage and carcass meat content (tab. 3). The groups did not differ in the dry matter, crude ash and crude protein content of the thoracis muscle samples. Animals from the KT group had lower carcass weight ($p \leq 0.05$) compared to the other groups (KK and KKKT). The crude fat content of the thoracis muscle in the KT group was significantly ($p \leq 0.01$) lower than in the KK group, and non-significantly lower than in the KKKT group. Slightly lower total cholesterol content of the intramuscular fat of the thoracis muscle of bulls fed pre-wilted meadow grass silage was observed in comparison to similar muscle sample of bulls fed maize silage or both silage types (tab. 3), but the differences were not statistically significant.

Carcass traits and dressing percentage of the bulls were slightly lower than reported by Oprządek et al. (11) for bulls of different beef breeds receiving TMR rations. Differences in the crude fat content of the dorsal muscle, observed between the groups receiving

Tab. 1. Chemical composition (%) and nutrient content of feeds used in experiment

Components	Kind of feed			
	maize silage	grass silage	meadow hay	concentrate
Dry matter	29.20	37.50	85.24	87.70
Crude ash	1.31	4.16	7.87	6.95
Crude protein	2.51	4.67	7.76	14.80
Crude oil	1.16	1.47	1.52	2.41
Crude fibre	5.79	11.01	29.13	5.58
N-free extractives	18.33	18.19	38.96	56.06
ADF	8.73	14.34	29.34	–
NDF	12.15	19.92	47.50	–
Lactic acid	2.21	1.22	–	–
Acetic acid	0.41	0.55	–	–
Butyric acid	0.04	0.06	–	–
pH	3.67	4.70	–	–
Content in 1 kg of feed:				
UFV	0.24	0.27	0.56	0.92
PDIN, g	15.20	27.50	48.00	101.00
PDIE, g	19.10	22.80	57.00	98.10
P, g	0.49	1.78	2.62	4.60
Ca, g	0.79	3.66	5.39	0.70

Tab. 2. Average daily feed and nutrient intake

Feed	Dietary treatments*		
	KK	KT	KKKT
Maize silage, kg	17.30	–	10.20
Meadow hay silage, kg	–	13.80	8.30
Meadow hay, kg	1.00	1.00	1.00
Concentrate, kg	4.97	4.89	4.93
Nutrient intake:			
Dry matter, kg	10.26	10.31	11.26
UFV	9.28	8.78	9.77
Crude protein, g	1247.4	1445.8	1452.2
PDIN, g	813.0	921.4	928.3
PDIE, g	875.0	851.3	925.2

Explanations: *KK – maize silage; KT – meadow hay silage; KKKT – maize silage + meadow hay silage

Tab. 3. Body weight and daily weight gains, postmortem carcass analysis, chemical composition of thoracis muscle (TM) and total cholesterol content of TM (n = 6; $\bar{x}$ ± SE)

Slaughter traits and chemical composition of meat	Treatments			s.e.m.
	KK	KT	KKKT	
Initial body weight, kg	440.5 ± 5.95	437.7 ± 1.89	438.8 ± 3.11	9.88
Final body weight, kg	536.3 ± 11.58	527.0 ± 4.45	531.8 ± 4.60	18.71
Days on feed	70	70	70	–
Daily weight gain, g	1368.7 ± 83.19	1242.0 ± 37.21	1328.3 ± 59.87	154.21
Carcass weight, kg	341.50 ± 7.82	329.1 ± 2.40	335.4 ± 3.05	12.35
Dressing percentage	63.67 ± 0.53	62.38 ± 0.59	63.06 ± 0.39	1.25
Meat content of carcass, %	78.38 ± 0.61	76.76 ± 1.10	78.00 ± 0.97	2.25
Chemical composition of meat (%):				
Dry matter	24.27 ± 0.21	24.06 ± 0.29	24.34 ± 0.16	0.56
Crude ash	1.12 ± 0.08	1.10 ± 0.01	1.10 ± 0.05	0.02
Crude protein	22.48 ± 0.15	22.32 ± 0.19	22.43 ± 0.11	0.38
Crude fat	1.73^{Aa} ± 0.13	1.23^{Bb} ± 0.10	1.48^{ABab} ± 0.04	0.07
Total cholesterol, mg/100 g	44.34 ± 0.91	42.18 ± 0.83	43.26 ± 0.35	0.45

Explanations: a, b ≤ 0.05; A, B ≤ 0.01

maize silage (KK) or maize and meadow grass silage (KKKT) and the group fed meadow grass silage (KT) are evidence that the type of ration had an effect on fat deposition in the muscle tissue of fattened animals. Thus, a higher crude fat content was shown in the carcasses of animals receiving higher-energy diets (groups KK and KKKT) compared to the carcass of animals fed a meadow grass silage diet (KT) characterized by a lower energy concentration per kg of dry matter. Similar to the present study, other experiments (20) did not found statistically significant differences in the total cholesterol content of the thoracis muscle in hereford and brahman cattle according to the type of feed given in the finishing period.

Comparison of the results obtained for the fatty acid profile of the feed samples (tab. 4) showed that maize silage and concentrate (with similar total PUFA values for both types of feed) were characterized by a markedly higher content of MUFA and *n-6* PUFA acids than meadow grass silage and hay. Meadow grass silage and hay were many times richer in *n-3* PUFA and had a much lower *n-6*/*n-3* PUFA ratio compared to maize silage and concentrate. Compared to silages and meadow hay, concentrate was characterized by a much higher content of total conjugated linoleic acid (CLA) isomers.

The levels of fatty acids in TM samples are given in table 5. The data obtained for feeding groups show that the type of silage fed had no significant effect on differences in the profile of most fatty acids and sum of CLA isomers except α-linolenic acid (C 18:3 *n-3*), which was significantly ($p \leq 0.01$ or $p \leq 0.05$) more abundant in meat of animals fed meadow grass silage (group KT) compared to the other groups,

Tab. 4. Fatty acid content of feed samples (% of total acids)

Fatty acids	Feed			
	maize silage	grass silage	meadow hay	concentrate
SFA (total)	12.46	19.74	27.70	11.39
C 14:0	0.17	0.31	0.69	0.21
C 16:0	8.38	16.20	19.87	9.89
C 18:0	1.56	1.42	2.68	1.12
UFA (total)	87.54	80.26	72.29	88.61
C 18:2 n-6	66.83	30.38	31.49	65.44
C 18:3 n-6	0.035	0.084	0.121	0.014
C 18:3 n-3	3.89	45.88	34.68	4.68
MUFA (total)	16.41	3.70	5.80	17.60
PUFA (total)	71.14	76.56	66.49	71.00
PUFA n-6	66.86	30.47	31.61	75.46
PUFA n-3	3.89	45.88	34.68	4.68
PUFA n-6/n-3	17.21	0.66	0.91	13.99
CLA (total isomers)	0.388	0.216	0.208	0.870

Tab. 5. Fatty acid content in intramuscular fat of the thoracis muscle of fattened bulls (% of total acids) (n = 6; $\bar{x}$ ± SE)

Fatty acids	Treatments			s.e.m.
	KK	KT	KKKT	
SFA (total)	40.50 ± 1.150	37.06 ± 1.28	38.76 ± 0.900	2.76
C 14:0	1.060 ± 0.100	0.940 ± 0.150	0.990 ± 0.090	0.29
C 16:0	20.01 ± 0.900	18.68 ± 1.060	19.35 ± 0.630	2.16
C 18:0	19.05 ± 0.680	18.70 ± 0.970	18.87 ± 0.940	1.98
UFA (total)	58.41 ± 1.23	61.22 ± 1.960	59.81 ± 1.410	3.84
C 18:2 n-6	17.41 ± 2.240	21.45 ± 3.250	19.43 ± 2.160	6.37
C 18:3 n-6	0.160 ± 0.011	0.140 ± 0.007	0.150 ± 0.006	0.22
C 18:3 n-3	1.24^{Bc} ± 0.11	2.22^{Aa} ± 0.17	1.73^{ABb} ± 0.08	0.32
MUFA (total)	35.09 ± 1.810	31.25 ± 2.280	33.17 ± 1.430	4.59
PUFA (total)	23.84 ± 2.330	29.47 ± 4.100	26.64 ± 2.610	7.63
C 20:5 n-3 (EPA)	0.390 ± 0.036	0.550 ± 0.083	0.470 ± 0.050	0.15
C 22:6 n-3 (DPA)	0.130 ± 0.015	0.170 ± 0.025	0.150 ± 0.010	0.05
PUFA n-6	20.44 ± 1.950	26.07 ± 3.640	23.31 ± 2.220	6.63
PUFA n-3	2.880 ± 0.410	3.900 ± 0.470	3.490 ± 0.380	1.03
PUFA n-6/n-3	7.100 ± 0.380	6.580 ± 0.290	6.830 ± 0.220	0.75
CLA (total isomers)	0.562 ± 0.031	0.563 ± 0.051	0.570 ± 0.020	0.09

Explanation: as in tab. 2 and 3

and significantly ($p \leq 0.05$) more abundant in group KKKT than in group KK. In meat of group KT, the level of the other PUFA with health-promoting properties (*n-3* PUFA, including C 20:5 *n-3* and C 22, and *n-6* PUFA) and the *n-6/ n-3* PUFA ratio were more favourable than in the other groups (tab. 5).

The results obtained in different feeding groups for the fatty acid profile of TM meat samples indicate that the health-promoting properties of beef can be nutritionally modified, e.g. by giving diets differing in the type of silages. This is also shown by the higher values of *n-3* PUFA (desirable in the human diet) and the lower values for undesirable fatty acids (C14:0 and C16:0) and total cholesterol, obtained for the group receiving meadow grass silage compared to the group fed maize silage or both silage types. The results of the EUFA profile in the muscle tissues of the animals fattened concur with the findings of O'Sullivan et al. (12), who also showed that compared to maize silage, feeding bulls with grass silage had a more favourable effect not only on increasing the proportion of PUFA acids (C 18:3 *n-3* and C 18:2 *n-6*) in intramuscular fat, but also on α-tocopherol antioxidants. The same authors reported that grass silage had an effect on meat colour stability and on reducing lipid oxidation, although when fed alone, it slightly increased the SFA content compared to the use of both silage types together. Some experiments (14) showed that the EUFA profile in the muscle tissue of fattened animals can be influenced by increasing the ratio of bulky feeds to concentrates in a finishing diet. Yang et al. (21) showed that the carcasses of animals receiving mixed rations (bulky feeds and concentrates) had a lower level of SFA (including C 14:0) in intramuscular fat compared to animals fed concentrates only. French et al. (6), who compared the fatty acid profile of the meat of fattened cattle reported that as the proportion of pasture grass or grass and meadow hay silage increased in the diet at the expense of concentrates, there was an increase in the content of MUFA (C18:1) and PUFA (acids C 18:2 and C 18:3) and a decrease in SFA (C 14:0 and C 16:0).

The higher *n-3* PUFA content, observed in the present study in fat of bulls fed grass silage compared to animals receiving maize silage or both silage types, resulted probably from the higher content of C 18:3 *n-3*, which is the main fatty acid of meadow grass silage and the precursor of EPA (C 20:5 *n-3*) and DPA (C 22:6 *n-3*), deposited in animal tissues (10). Likewise, Itoh et al. (9) and Scollan and Wood (16) found a higher content of desirable acids (including EPA and DPA) in the fat of carcasses of animals fattened with pasture forage with clover, compared to concentrate-fed animals. This was confirmed by the study of Dymnicka et al. (4) with bulls of different beef breeds (Charolais, Limousin and Hereford) fed grass silage with hay and concentrate, compared to animals receiving maize silage, hay and concentrate.

Although the bulls receiving meadow grass silage were characterized by a lower cholesterol content of TM meat sample compared to animals fed maize silage or both silage types, similar to other studies there were no significant relationships between these traits (20).

Conclusion

In conclusion, feeding Limousin bulls during the finishing period with diets containing wilted meadow grass silage, hay and concentrate has a beneficial effect, compared to feeding maize silage or both silage types with the same supplement of hay and concentrate, on the profile of fatty acids with health-promoting properties, the *n-6*/*n-3* PUFA ratio and the total cholesterol and crude fat content of thoracis muscle.

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