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The effect of flaxseed added to calves' diets on production indices and meat composition

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The aim of the study was to determine the effect of adding flaxseed to the feed rations of Limousine (LM) calves, and in particular its impact on rearing indicators, the basic composition of veal, and the fatty acid profile of intramuscular fat. The experiment was conducted during the pasture period on 24 animals divided into groups: K – control (including Kk – control cows and Kc – control calves), and D – experimental group (including Dk – experimental cows and Dc – experimental calves). The following were determined during the experiment: the chemical composition and nutritional value of the feeds used, average daily weight gain (g/day), and consumption of concentrate mixture per kg of weight gain in the calves. After the experimental period 4 male calves from each group were slaughtered. The basic composition of the meat was determined in the muscles obtained (short loin, shoulder and round), as well as the fatty acid profile of the intramuscular fat. The results obtained were analysed statistically. A 6% supplement of flaxseed was found to have a positive, statistically significant effect on weight gain in the calves. The flaxseed supplement only slightly influenced the basic composition of the veal, but significantly modified the fatty acid profile of the intramuscular fat. The most beneficial fatty acid profile was noted in the intramuscular fat of the short loin, in which a slight decrease in the percentage of monounsaturated fatty acids (MUFA) was accompanied by a significant increase in the proportion of polyunsaturated fatty acids (PUFA).

KEY WORDS: beef cattle / nutrition / linseed / meat / fatty acids

The increasing demands of consumers who want high quality meat determine cattle production technology and fattening systems. Currently, the main concern, apart from improvement of animal health, is to obtain high quality veal and beef cattle in an economical manner. One method is to use a variety of feedstuffs in animal diets, including the seeds of oilseed plants and vegetable oils [5]. When modifying meat characteristics through diet, we should focus not only on the beneficial aspects of adding fat to the feed, but on their negative effects as well [5, 28]. The effect of fat added to feed for ruminants depends on its degree of protection, level, source and type [4, 14]. In ruminants, ruminal microbial activity causes the fat from oilseed plants to largely undergo lipolysis, while unsaturated fatty acids undergo biohydrogenation. Fat, especially if it contains polyunsaturated fatty acids, may adversely affect the activity of ruminal bacteria, particularly cellulolytic bacteria, thereby reducing the digestibility of crude fibre components from the feed [15]. For this reason the amount of such fat in the feed ration must be limited. The addition of unprotected fat to compound feeds for adult ruminants should not exceed 5% [4, 7, 28]. This percentage is considered to be optimal and not to interfere with fermentation processes in the forestomach. The simplest and least expensive way to protect fatty acids from biodegradation in the rumen and thereby improve the utilization of polyunsaturated fatty acids by ruminants is to use whole seeds of oilseed plants in the diet [29].

Contemporary methods of feeding animals for fattening can be used to modify not only the ratio of fat to meat, but also the proportions of essential fatty acids (EFAs) in the intramuscular fat [18, 28, 29]. Meat obtained from cattle, especially in pasture feeding, has a higher content of beneficial fatty acids and biologically active substances [19, 28, 35], which play a major role in rational human nutrition [10, 11, 21, 23, 30, 34].

The aim of the study was to determine the effect of using flaxseeds in the diet of Limousin calves (LM), particularly its effect on rearing indicators, the proximate composition of the veal, and the fatty acid profile of the intramuscular fat.

Material and methods

The experiment was conducted at a private farm specializing in the production of meat cattle (Limousin breed). During the summer (May to October), the herd stays in the pasture 24 hours a day. Feed rations are balanced according to the INRA system [17]. In summer the diet of the herd is based on ad libitum pasture forage. In addition, the animals receive meadow hay and concentrate feed (triticale, oats and barley) with a mineral and vitamin supplement, and have constant access to licks and water. Calves stay with their mothers after birth and have access to milk and the cows' feed.

The experiment was conducted during the pasture season, from May to October. We selected 24 cows with planned calving dates from 20 March to 10 April 2011. The cows were divided into two main groups with the same calving dates, body weight and sex: K – control and D – experimental (12 animals in each). These were divided into subgroups: Kk – control group of cows, Kc – control group of calves (4 bulls and 2 heifers), Dk – experimental group of cows, and Dc – experimental group of calves (4 bulls and 2 heifers). Control cows and calves were fed standard feeds that had been in use on the farm, while the cows and calves of the experimental groups received similar feeds, but with a 6% share of flaxseed of (Szafir variety) in the concentrate mixture (Table 1). The concentrate feeds (Table 2) were given in feeders placed in the experimental areas of the pasture for each group (Fig.).

Table 1
Experiment design

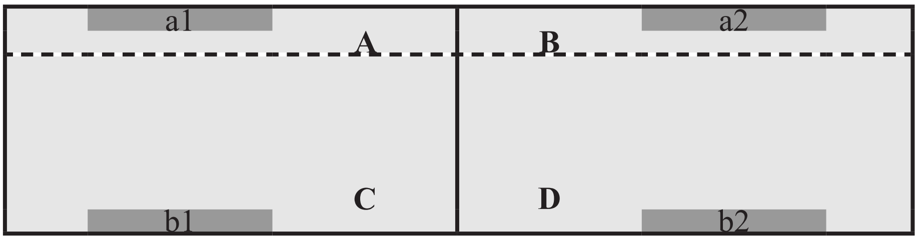
Experimental period	Cows	
	Kk	Dk
20 weeks (May – September)	pasture forage, meadow hay + MT	pasture forage, meadow hay + MTL
	Calves	
	Kc	Dc
1. 10 weeks (May – first half of July)	milk (suckled by mothers) + continual access to pasture forage and meadow hay + MT	milk (suckled by mothers) + continual access to pasture forage and meadow hay + MTL
2. 10 weeks (second half of July – September)	pasture forage, meadow hay + MT	pasture forage, meadow hay + MTL

Kk – control group of cows; Dk – experimental group of cows; Kc – control group of calves obtained from cows in the control group; Dc – experimental group of calves obtained from cows in the experimental group; MT – concentrate mixture; MTL – concentrate mixture with 6% flax seed

Table 2
Ingredient composition (%) of concentrate mixtures

Component	Concentrate mixture	
	MT	MTL
Triticale grain	47.0	45.0
Barley grain	25.5	23.5
Oat grain	25.5	23.5
Mineral-vitamin mixture	2.0	2.0
Flax seed	–	6.0

MT – concentrate mixture; MTL – concentrate mixture with 6% flax seed



Legend: **a1** – feeder (low) with concentrate mixture for control calves; **a2** – feeder (low) with concentrate mixture for experimental calves; **b1** – feeder (high) with concentrate mixture for control cows; **b2** – feeder (high) with concentrate mixture for experimental cows; **A+C** – pasture area where control calves grazed during the first period of the experiment; in the second period they remained in part A; **B+D** – pasture area where experimental calves grazed during the first period of the experiment; in the second period they remained in part B; **C** – pasture area where control cows grazed; **D** – pasture area where experimental cows grazed

- - - - - – Electric fence placed at such a height that calves could but cows could not pass under it during the first period of the experiment

——— – Electric fence placed at two levels so that the animals could not get past it

Fig. Diagram of the experimental pasture area

During the experiment, we determined the chemical composition and nutritional value of the feeds (5 times), average body weight gain (g/day), and consumption of concentrate feed per kg of calf weight gain. After the experimental period, 4 calves from each group (bulls) were slaughtered according to the technology used in the meat industry, under continual veterinary supervision. After slaughter and veterinary examination, the carcasses were chilled for 24 hours at about 2-4°C. Then, during the technological dissection, meat samples were taken from three major cuts (short loin, shoulder, and round) [24]. The proximate chemical composition of the meat and the fatty acid profile of the intramuscular fat were determined in the muscles. The proximate chemical composition of the feeds and meat was determined according to AOAC [1]. The nutritional value of the feeds was estimated using Winwar 2.1.3.13 [36]. The fatty acid profile in the fat of the compound feeds (MT and MTL) and intramuscular fat were determined according to standards PN-EN ISO 5509:2001 [32] and PN-EN ISO 5508:1996 [31]. The percentage of methyl esters of fatty acids was analysed by gas chromatography, according to the Varian CP-3800 chromatograph procedure, under the following conditions: CP WAX 52CB DF 0.25 mm capillary column, length 60 mm, helium as the carrier gas, flow rate 1.4 ml/min, column temperature 120°C, gradually increased by 2°C/min to 210°C, assay time 127 min, injector temperature 160°C, detector temperature 160°C, other gases – hydrogen and oxygen. The analyses were performed in the laboratory of the Institute of Animal Nutrition and Bromatology of the University of Life Sciences in Lublin. The results were analysed by one-way analysis of variance, using STATISTICA ver. 6.0 [33], and the significance of differences between means was determined by the Tukey test ($P \leq 0.05$ and $P \leq 0.01$).

Results and discussion

The chemical composition and nutritional value of the pasture forage, meadow hay and concentrate mixtures are shown in Table 3. The presence of flaxseeds in the experimental concentrate mixture (MTL), as compared to the control (MT), influenced the crude fat content (Table 3), but the differences were not statistically significant. The inclusion of flaxseeds in the concentrate feed significantly influenced the fatty acid profile in the fat (Table 4). The concentrate feed with flaxseeds (MTL) contained significantly more polyunsaturated acids (PUFA), especially C18:3 (Table 4), due to the presence of these acids in the flaxseeds [22]. At the same time, the reverse relationship was noted for the content of saturated fatty acids (SFA) in the feeds.

The calves' mean daily weight gains and the consumption of concentrate feed per kg of weight gain in the two 10-week experimental periods were varied (Table 5). In calves fed concentrate feed with flaxseed and born of mothers receiving a similar feed, average daily gains were significantly higher ($p \leq 0.05$) (Table 5). Differences in favour of the group receiving the flaxseed supplement were especially evident in the second experimental period. At the same time, the average consumption of the mixture per kilogram

Table 3
Chemical composition and nutritional value of the feeds

Specification	MT	MTL	Pasture forage	Grass hay
Dry matter (%)	88.7	88.7	17.9	85.0
		Per kg DM (g)		
Crude ash	80	78	101	83
Total protein	129	142	172	117
Ether extract	52	62	36	25
Crude fibre	57	56	232	329
NFE	682	662	459	446
		Nutritional value of 1 kg DM		
LFU	–	–	1.04	1.23
UFV	0.99	1.01	0.83	0.62
PDIN (g)	100	102	84	73
PDIE (g)	96	94	85	80

NFE – nitrogen-free extract, DM – dry matter; LFU – fill units for cows; UFV – feed units for meat production; PDI –– protein truly digestible in the small intestine: PDIN – protein truly digestible in the small intestine when N limits microbial protein synthesis, PDIE – protein truly digestible in the small intestine when energy limits microbial protein synthesis

of weight gain in these animals was slightly lower. Similar correlations were found in an experiment by Borowiec et al. [9], who used flaxseeds to feed lambs. Opinions on the exclusively beneficial effect of flaxseed on growth and feed conversion by animals are not consistent. To a large extent, apart from the inclusion of flaxseed in the diets, they also depend on the basic diet of the animals [2, 3, 7] and the forms of oil seeds used [4, 12, 14]. For example, slightly different dependencies and production effects from those found in the present study have been demonstrated when flaxseeds were given to calves in the form of extrudates [4, 14].

Diet is one of the most important ways to modify the proportions of meat and fat and the content of individual types of fatty acids in cattle meat [16, 18, 26, 29]. One natural

Table 4
Fatty acid composition of the concentrate mixtures (%)

Fatty acids	MT	MTL
C12:0	0.02	0.03
C14:0	0.54	0.19
C16:0	24.81[a]	12.39[b]
C18:0	3.97	7.26
C20:0	0.63	0.28
C18:1	19.79	19.04
C18:2	46.03[a]	20.95[b]
C18:3	3.50[b]	39.51[a]
Other:	0.71	0.35
other saturated	0.19	0.14
other monounsaturated	0.39	0.12
other polyunsaturated	0.13	0.09
SFA	30.16[a]	20.29[b]
MUFA	20.18	19.16
PUFA	49.66[b]	60.55[a]

SFA – saturated fatty acids
MUFA – monounsaturated fatty acids
PUFA – polyunsaturated fatty acids
a, b – values differ significantly between groups in rows at $p \leq 0.05$

and economically efficient way to improve the health properties of veal or beef may be to reduce the intensity of feeding at the end of the fattening period, by increasing the amount of bulk feed in the diet or by enriching the feed rations with beneficial nutrients [3, 18]. Diets with a larger proportion of bulky feed have a more favourable fatty acid profile than diets with a higher proportion of concentrate feeds, especially those based on the grain of basic cereals, which translates into a favourable change in the composition of fatty acids in animal tissues (an increased proportion of linolenic acid) [8]. A higher proportion of pasture forage in the diet reduces the content of SFAs in the intramuscular fat and increases that of mono- and polyunsaturated fatty acids (MUFA and PUFA) [8]. However, an excessive reduction in the intensity of cattle feeding during the fattening period, by limiting the amount of concentrate feed, may have an adverse effect on fattening efficiency and on the carcass and quality characteristics of the meat [6, 13]. By adding oilseeds (e.g. flaxseed or rapeseed) to feed, we can favourably modify the fatty acid profile in meat [28] and milk [20, 27] to a certain degree, reducing the ratio of *n-6* to *n-3* fatty acids, and thus improve dietary properties, especially of meat [2, 3, 18]. In the present study, the content of dry

Table 5
Average daily weight gain in calves and consumption of concentrate mixture per kg weight gain

Experimental period		Group		SD
		Kc	Dc	
Body weight of calves (kg)				
1	initial	59.0	58.3	0.98
	at weaning	139.2[b]	150.7[a]	6.09
2	final	228.2[b]	249.3[a]	11.2
Daily weight gain (g)				
1		1146[b]	1320[a]	91.6
2		1271[b]	1409[a]	73.7
Consumption of concentrate mixture per kg weight gain (g DM)				
1		530	560	16.3
2		1870	1820	30.9

a, b – values differ significantly between groups in rows at $p \leq 0.05$

matter, protein and fat in the muscles (Table 6) was similar to that reported in the literature [25]. The differences between groups for the individual basic constituents of the meat cuts were slight; only the fat content in the short loin of the calves from the experimental group (Dc) was twice as high as in the control (Kc). Protein content was lower in all evaluated cuts from calves in the experimental group, especially in the shoulder, although the difference was not statistically confirmed (Table 6). While there were no significant differences in the proximate composition of the cuts of meat, significant changes were observed in the fatty acid profile of the intramuscular fat (Table 7). The addition of flaxseeds to the

Table 6
Basic composition of the meat of the animals (%)

Muscle	Group	Dry matter	Ash	Protein	Fat
Round	Kc	24.26	1.12	22.42	0.71
	Dc	24.09	1.07	22.19	0.82
Shoulder	Kc	24.57[a]	1.11	22.50	0.93
	Dc	22.69[b]	1.03	20.92	0.73
Short loin	Kc	24.74	1.15[a]	22.63	0.92[b]
	Dc	24.81	1.05[b]	21.78	1.95[a]

a, b – values differ significantly between groups in columns at $p \leq 0.05$

Table 7

The proportion of fatty acids in selected muscles of intramuscular fat calves (%)

Muscle	Group	SFA: C12:0	C14:0	C15:0	C16:0	C17:0	C18:0	C20:0
Round	Kc	0.31^{b}	2.90^{b}	0.53	22.55	0.92	15.30^{a}	0.14
	Dc	0.60^{a}	3.78^{a}	0.60	22.13	0.90	12.88^{b}	0.07
Shoulder	Kc	0.30^{b}	2.60^{b}	0.28^{b}	21.98	0.84	16.01^{a}	0.13
	Dc	0.55^{a}	4.84^{a}	0.70^{a}	22.76	0.69	12.44^{b}	0.09
Roastbeef	Kc	0.41	4.08^{b}	0.57^{b}	24.75	1.23	18.23^{a}	0.15
	Dc	0.59	7.20^{a}	1.09^{a}	25.36	0.96	13.77^{b}	0.18

Muscle	Group	MUFA: C16:1 *c-7*	C16:1 *c-9*	C17:1	C18:1 *c-9*	C18:1 *c-7*	C20:1 *n-9*	C20:1 *n-7*	C22:1
Round	Kc	0.33	1.87^{b}	0.64	33.13	1.84^{b}	0.19^{b}	0.02	0.01
	Dc	0.33	2.37^{a}	0.84	34.04	3.11^{a}	0.50^{a}	0.06	0.01
Shoulder	Kc	0.36	1.82^{b}	0.36	32.31^{a}	1.62^{b}	0.07	0.11	0.01
	Dc	0.31	2.97^{a}	0.38	27.86^{b}	2.79^{a}	0.14	0.00	0.00
Roastbeef	Kc	0.37	2.44^{b}	0.55	36.00^{a}	0.89^{b}	0.10	0.01	0.01
	Dc	0.32	3.97^{a}	0.53	30.58^{b}	3.32^{a}	0.18	0.08	0.00

Muscle	Group	PUFA: C18:2	C18:3 *n-3*	C20:2	C20:3 *n-9*	C20:4	C20:5	C22:5	C22:6
Round	Kc	12.25^{a}	0.37^{b}	0.00	1.12^{a}	4.86^{a}	0.19^{b}	0.52^{b}	0.01^{b}
	Dc	10.18^{b}	1.97^{a}	0.07	0.56^{b}	2.14^{b}	1.38^{a}	1.28^{a}	0.20^{a}
Shoulder	Kc	14.15^{a}	0.38^{b}	0.01	1.18^{a}	5.07	0.16^{b}	0.11^{b}	0.14
	Dc	11.19^{b}	2.62^{a}	0.09	0.82^{b}	4.95	1.85^{a}	1.63^{a}	0.33
Roastbeef	Kc	7.82^{a}	0.31^{b}	0.12	0.37	1.42	0.05^{b}	0.11^{b}	0.01^{b}
	Dc	5.04^{b}	1.85^{a}	0.05	0.43	1.56	1.00^{a}	1.79^{a}	0.15^{a}

Muscle	Group	Groups of fatty acids: SFA	MUFA	PUFA
Round	Kc	42.65^{a}	38.03^{b}	19.32
	Dc	40.96^{b}	41.26^{a}	17.78
Shoulder	Kc	42.14	36.66^{a}	21.20^{b}
	Dc	42.07	34.45^{b}	23.48^{a}
Roastbeef	Kc	49.42	40.37	10.21^{b}
	Dc	49.15	38.98	11.87^{a}

a, b – values differ significantly between the groups in columns at $p \leq 0.05$

concentrate feed used in the pasture period slightly reduced the content of saturated fatty acids (SFA) in the intramuscular fat, especially in the round. At the same time, there was a significant increase in the proportion of monounsaturated fatty acids in the intramuscular fat of the round and polyunsaturated fatty acids in that of the shoulder and short loin.

The research showed that flaxseed added to the concentrate feed in the amount of 6% had a positive, statistically significant effect on the growth of the calves. The addition of flaxseeds slightly influenced the proximate composition of the veal meat, but significantly modified the fatty acid profile of the intramuscular fat, though not always in the same way. The most beneficial fatty acid profile was observed in the intramuscular fat of the short loin, with a slight decrease in the proportion of monounsaturated fatty acids (MUFA) and a significant increase in the proportion of polyunsaturated fatty acids (PUFA). To optimize the intramuscular fat composition of veal, the use of flaxseed as an addition to the feed ration can be recommended.

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