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Performance and meat quality of fattening bulls fed complete feed with rapeseed oil cake or linseed

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ABSTRACT

The experiment was carried out on 44 Black-and-White Lowland bulls divided into 4 groups and fattened from 155 to 540 kg body weight to investigate the effect of feeding rapeseed oil cake or linseed on bull performance and meat quality. The animals were fed *ad libitum* a basic complete feed and barley straw (control group) or with similar amounts of supplement fat as linseed, rapeseed oil cake, or rape seed oil. At the end of the experiment 6 animals of each group were slaughtered. The physical and chemical properties of meat, composition of kidney and subcutaneus fat and fatty acid content were estimated. Fat composition and cholesterol levels were analysed in *M. longissimus dorsi*. Average daily body weight gains of animals were similar in all groups, reaching about 1.26 kg/day. The highest content of linolenic acid ($C_{18:3\,n-3}$) and conjugated linoleic acid (CLA) in the fat was found in bulls fed the ration with linseed. The level of cholesterol in the *M. longissimus dorsi* of animals fed the experimental complete feed with vegetable oils was significantly lower than in the control group. The physical and chemical properties of meat did not differ among the groups.

KEY WORDS: bulls, fattening, linseed, rapeseed oil cake, rape seed oil, fat composition, fatty acids

INTRODUCTION

The addition of fat into rations increases their energy value for fattening bulls and improves body weight gains (Spears, 1996). Addition of vegetable unsaturated oils leads to higher polyunsaturated fatty acid contents in meat fat (Chilliard, 1992; Clinquart et al., 1995; Strzetelski et al., 1998a). Despite the polyunsaturated fatty acids of feeds undergoing biohydrogenation in the rumen, their content in meat fat usually increases (Scollan et al., 1997a). The importance of polyunsaturated acids in the diet for humans has led to the production of animal food products containing higher levels of these acids, as described in a review by Givens et al. (2000). The influence of vegetable oil fed to ruminants on metabolic processes in the rumen, nutrient digestibility, performance of cattle and proportion of fatty acids in the lipids of the carcass may be modified by diet composition, type and physical form of fat that can be included into the rations as oils, whole seeds, meals, cakes or fatty acid calcium salts (Huhtanen and Poutiainen, 1985; Jigl et al., 1988; Murphy et al., 1990; Strzetelski et al., 1992; Kowalski, 1997).

Qualitative and quantitative balancing of energy and protein in the ration influences the size of microbial synthesis in the rumen. The proportion of fatty acids in ingested oils and the tissue enzymatic activity related to this might have an influence on fatty acid proportions in animal fat (Chang et al., 1992) and on the cholesterol levels of muscle, fat in milk and adipose tissue (Strzetelski et al., 1998b). The question of unsaturated fatty acid deposition in beef fat has become of interest during the recent decades, since it appears that the presence of polyunsaturated acids, particularly of the n-3 family, in the diet for humans can prevent numerous disorders, e.g. heart disease, inflammation, immune disorders (Simopoluos, 1991; Grimble, 1998; Sheard, 1998).

The aim of the present study was to assess the effect of feeding fattening bulls complete energy- and protein-balanced rations with increased levels of fat supplemented as linseed, rapeseed oil cake or rape seed oil on the bulls' performance, meat quality, unsaturated and saturated fatty acid proportions, and cholesterol levels in the deposited fat or meat tissue.

MATERIAL AND METHODS

Animals and feeding

The experiment was carried out on 44 Black-and-White Lowland bulls with an initial weight of 155 (±40) to 540 (±10) kg final body weight with an average 58% (33 to 87) HF blood share. The animals were divided into 4 groups of 11 according to an analogue method taking into account initial body weight and HF blood share.

Initial and final body weight was determined as the mean value of two morning weighings on two successive days before morning feeding. The animals were kept in individual stalls equipped with an automatic drinking bowl and a slatted floor lined with a rubber matting. The bulls were fed different complete feeds: control group C was fed a basal diet composed of 80% pellets of concentrate mixture (Table 1) and 20% of dehydrated whole maize plant pellets (ϕ = 8 mm), supplemented for the experimental group with: linseed, group L; cold-pressed rapeseed oil cake, group RC; rape seed oil, group RO. Complete feeds were composed to include maximal fat content with minimal differentiation between diets in energy content (UFV) and protein level (PDIE and PDIN).

TABLE 1

Feed components of concentrate mixtures, %

Components	Concentrate mixtures for groups			
	C control	L linseed	RC rapeseed oil cake	RO rape seed oil
Triticale ground	57.5	62.5	56.0	54.7
Wheat bran	25.0	5.0	11.0	23.8
Soyabean oilmeal	15.0	11.0	1.5	14.3
Linseed	-	19.0	-	-
Rapeseed oil cake	-	-	29.0	-
Rape seed oil	-	-	-	4.8
Mineral mixture[1]	2.5	2.5	2.5	2.4

[1] in 1 kg, g: Ca – 214 ; P – 78; Na – 70; Mg – 35; mg: Cu – 93; Zn – 239; Fe – 817; Co – 6; Mn – 615; Mo – 56

Pellets were produced in a Type H – 710 granulator (Rofama-Rogoźno, Poland) after treatment at 185°C and 6 atm. for 1 sec with steam. Batches of pellets were stored no longer than 3 months. The amount of complete feed given *ad libitum* with 0.5 kg of barley straw per day and refusals were controlled daily. Energy, protein value and the composition of the diet were formulated according IZ-INRA standards (1997) using WINWAR, ver 1.0 (1996) and Winmix ver. 1.3 (1996) software.

Sampling and analysis

After the fattening period, 6 bulls of each group were chosen at random, slaughtered and samples of *M. longissimus dorsi*, kidney and subcutaneous fat were taken for analysis. Fatty acid composition from C 14 to C 20 in fat and from C 14 to C 22 in meat were determined by gas chromatography (Pay Unicam 104) using a 30 m long Supelcowax 10 column (ϕ = 0.53 mm), cholesterol was deter-

mined using GC Pye Unicam 106 equipment with a 10 m long HP-5 column (ϕ = 0.53 mm). The physical and chemical properties of meat were estimated as described by Strzetelski et al. (1998a). The nutrient content in feeds was determined according to AOAC (1990) methods.

The results were subjected to statistical analysis using one- or two-way analysis of variance according to SAS (1989) procedures and GLM software. Two-way analysis of variance was used to compare differences between the content of individual fatty acids (from C 14 to C 20).

RESULTS

The nutrient content in complete feeds and their nutritive values are shown in Table 2. The fat content in complete mixtures for the experimental groups was from 2.2 (group RC) to 2.7 (group L) times higher than for the control group, C. The proportion of vegetable oil added to the experimental diet to the total fat in the diets was, in %; 71.8 in the linseed (L) diet; 65.5 rapeseed oil cake (RC) diet, and 61.7 in the rape seed oil (RO) diet. Complete feeds contained, per kg: 150 ± 7.2 g crude protein, 100 ± 2.0 g PDIN, 94 ± 6.0 g PDIE and 0.942 ± 0.06 UFV. Daily intake of supplemented fat was, g/day: 0, group C; 427, group L; 301, group RC, and 338, group RO.

Daily intake of complete feed, dry matter and PDIN did not differ significantly between the groups (P>0.05) but differences in crude protein and PDIE and net energy (UFV) intake were significantly different (Table 3). Daily rations ingested by animals were better balanced with respect to the proportion (PDIE – PDIN)/UFV in groups C and RO (-1.6 g) than in groups RC (-16.1 g) or L (-8.3 g).

Daily body weight gain, feed and dry matter efficiency did not differ statistically between the groups (P>0.05) although there was a tendency in group RC

TABLE 2

Nutrient content in complete feed mixtures[1], in 1 kg

Groups	Dry matter	Crude protein	Ether extract	Crude fibre	Ash	UFV	PDIN	PDIE
	g	g	g	g	g		g	g
C – control	886.2	148.5	24.2	90.6	36.4	0.912	101.6	100.0
L – lineseed	894.2	154.1	66.6	104.0	36.7	1.000	101.6	93.6
RC – rapeseed oil cake	891.8	157.3	52.5	113.6	25.6	0.872	101.6	87.2
RO – rape seed oil	890.2	142.9	61.7	89.0	35.7	0.984	97.6	96.0

[1] composition, %: concentrate mixture – 80, dehydrated whole maize plant – 20; in 1 kg, g: dry matter – 919, crude protein – 95, ether extract – 31, crude fibre – 189, ash – 31

TABLE 3

Daily intake of feed and nutrients

Item	Groups				RMSE[1]
	C control	L lineseed	RC rapeseed oil cake	RO rape seed oil	
Complete mixture, kg	8.85	8.94	8.67	8.79	0.50
Dry matter, kg	8.23	8.44	8.15	8.22	0.46
Crude protein, g	1329.9^{AaBb}	1394.6^{Aa}	1380.8^{Aa}	1271.8^{Bb}	77.1
PDIN, g	908.5	918.6	891.1	867.3	51.0
PDIE, g	895.3^{Aa}	848.3^{Ab}	767.7^{Bc}	854.1^{Ab}	47.1
UFV	8.19^{Bb}	9.08^{Aa}	7.69^{Bc}	8.77^{Aa}	0.48

[1] $\sqrt{s^2}$; ^{a,b,c} – $P \leq 0.05$; ^{A,B,C} – $P \leq 0,01$

towards a decrease in daily weight gain and worse feed and dry matter efficiency per kg of body weight gain (Table 4). The animals of group C and RO consumed less crude protein per kg body gain than in groups L and RC, but energy utilisation was better in groups C and RC than in L and RO. However, these differences in nutrient utilisation were not always statistically significant. The control animals (group C) used significantly more PDI per kg body weight gain ($P<0.05$ or $P<0.01$) than animals in the remaining groups, among which the differences were not significant.

TABLE 4

Body liveweight, daily gains and feed utilisation

Item	Groups				RMSE[1]
	C control	L lineseed	RC rapeseed oil cake	RO rape seed oil	
Initial liveweight, kg	155.4	157.9	155.5	155.7	27.12
Final liveweight, kg	536.8	541.1	537.8	539.4	6.71
Fattening period, days	305.5	306	315.9	301.4	44.64
Body liveweight gain, g · day^{-1}	1255	1283	1222	1284	129.9
Feed utilisation per 1 kg gain:					
complete mixture, kg	7.05	6.97	7.10	6.85	0.56
dry matter, kg	6.56	6.58	6.67	6.40	0.53
crude protein, g	1059.7^{AaBb}	1087.0^{AaB}	1130.0^{Aa}	990.5^{Bb}	86.9
PDI, g	891.8^{Aa}	837.6^{Ab}	764.2^{Bc}	850.9^{Ab}	47.1
UFV	6.53^{ABbc}	7.08^{Aa}	6.30^{Bc}	6.83^{AaBb}	0.54

[1] $\sqrt{s^2}$; ^{a,b,c} – $P \leq 0.05$; ^{A,B,C} – $P \leq 0.01$

The fatty acid contents and composition in subcutaneous, kidney or *M. longissimus dorsi* fat depended on the type of fat supplementing diets (Table 5). The proportion of unsaturated fatty acids (UFA) was significantly lower in kidney fat, and saturated fatty acids (SFA) was higher ($P<0.01$) than in subcutaneous fat or that of *M. longissimus dorsi,* in which these proportions were similar. Kidney fat contained twice as much stearic acid (C 18:0) as subcutaneous or *M. longissimus dorsi* fat. Fat of *M. longissimus dorsi* in comparison with kidney or subcutaneous fat contained two times more linolenic acid (C 18:3 n-3) and less eicosonic acid (C 20:1), ($P<0.01$). The highest contents of myristoleic acid (C 14:1), palmitoleic acid (C 16:1), oleic acid (C18:1) and conjugated linoleic acid (C 18:2, CLA) were found in subcutaneous fat, their lowest concentration was in kidney fat ($P<0.01$). In the fat of *M. longissimus dorsi,* the proportion of linoleic (C18:2 n-6) to linolenic acid (C 18:3 n-3) was the highest; in subcutaneous fat the proportion of hypocholesteroleic to hypercholesteroleic acids was the lowest ($P<0.01$).

A decrease of SFA and increase of UFA and, as a consequence, an increased ratio UFA to SFA in the groups fed diets with vegetable oil compared to the control ration, were found. This effect was the most pronounced on the ration containing linseed ($P<0.05$ or $P<0.01$), (Table 5). In the fat of linseed-fed animals, the levels of stearic (C 18:0) ($P<0.05$) and heptadecenoic acids (C 17:1) ($P<0.05$ or 0.01) were the lowest, but the concentration of linolenic (C 18:3 n-3) and conjugated linoleic (C 18:2, CLA) acids was higher ($P<0.01$) than in the fat of control animals. The ratio of n-6 to n-3 acids in the fat of animals fed linseed, and ratio of hypocholesteroleic to hypercholesteroleic acids was lower ($P<0.01$) than in the remaining groups. The proportion of UFA to SFA in the fat of the RC group was about 10% higher than in the RO group, but this difference did not reach statistical significance ($P>0.05$). The results of feeding the diet with RC in many cases only slightly varied from the results obtained for group L.

Significant interaction between myristic (C 14:0) and palmitic (C 16:0) acid ($P<0.05$) or eicosenoic (C 20:1) and conjugated linoleic (C 18:2, CLA) acids ($P<0.05$) was found. Concentration of myristic (C 14:0) and palmitic (C 16:0) acids in animal fat was higher in groups C and RO; of eicosenoic (C 20:1) in groups RC and RO; conjugated linoleic acid (C 18:2, CLA) in group L or slightly less in RC.

In fat of *M. longissimus dorsi* the ratio of UFA:SFA and concentration of oleic acid (C 18:1) was higher but the concentrations of palmitic acid (C 16:0) and stearic acids (C 18:0) were lower in L and RC than in the remaining groups (Table 6). The lowest UFA:SFA ratio in fat of *M. longissimus dorsi* fat was found in group RO. The concentration of linoleic (C18:2 n-6) acid was lower ($P>0.05$), but CLA and C 18:3 n-3 was higher ($P<0.01$; $P<0.05$) in group L than in the remaining groups. The concentrations of dihomo-γ-linolenic (C 20:3 n-6), ($P<0.05$) and arachidonic (C 20:4 n-6) acids, ($P<0.05$) and the ratio of n-6:n-3 acids ($P<0.01$) in the

TABLE 5

Fatty acids (FA) – saturated (SFA) and unsaturated (UFA) contents in fat of *M. longissimus dorsi* (MLD), kidney (KF) and subcutaneous (SC) fat

Fatty acids	Body fat			Dietary fat, group					
	MLD *M. longissimus dorsi*	KF kidney fat	SF subcutaneous fat	C control	L lineseed	RC rapeseed oil cake	RO rape seed oil	RMSE	Interaction
SFA:									
C 14 : 0	2.12^{C}	2.61^{B}	2.24^{A}	2.73^{AaB}	2.59^{AaBb}	2.42^{Bb}	2.87^{Aa}	0.43	
15 : 0	0.40^{B}	0.44^{B}	0.63^{A}	0.54^{Aa}	0.45^{Bb}	0.51^{ABb}	0.46^{Bb}	0.07	n.s.
16 : 0	0.15^{B}	0.22^{A}	0.22^{A}	0.21^{A}	0.19^{B}	0.20^{AB}	0.18^{B}	0.03	n.s.
16 : 0	20.01^{B}	19.59^{B}	21.25^{A}	22.26^{A}	19.06^{C}	19.17^{C}	20.63^{B}	1.61	
17 : 0	1.24^{C}	1.66^{A}	1.40^{B}	1.74^{A}	1.31^{B}	1.41^{B}	1.30^{B}	0.20	n.s.
18 : 0	15.15^{B}	28.58^{A}	12.86^{B}	19.24^{a}	17.00^{b}	19.40^{a}	19.80^{a}	3.29	n.s.
20 : 0	0.13^{B}	0.28^{A}	0.14^{B}	0.16^{Bb}	0.15^{Bb}	0.22^{Aa}	0.22^{Aa}	0.06	n.s.
Total SFA	39.45^{B}	53.38^{A}	39.73^{B}	46.89^{Aa}	40.73^{Cc}	43.33^{Bbc}	45.46^{aBb}	3.46	n.s.
UFA:									
C 14:1	0.46^{B}	0.26^{C}	1.01^{A}	0.60	0.59	0.49	0.62	0.20	n.s.
16:1	3.30^{B}	1.60^{C}	4.44^{A}	3.20	3.23	2.92	3.09	0.75	n.s.
17:1	1.06^{B}	0.50^{C}	1.18^{A}	1.10^{Aa}	0.80^{Bc}	0.91^{Bb}	0.84^{Bb}	0.15	n.s.
18:1	39.45^{B}	39.91^{B}	44.66^{A}	38.08^{C}	41.43^{A}	42.35^{A}	39.50^{B}	2.96	n.s.
18:2 n-6	6.83^{A}	2.13^{B}	2.30^{B}	3.85	3.60	3.58	3.98	1.44	n.s.
18: 2 conjugated (CLA)	0.24^{B}	0.15^{C}	0.36^{A}	0.18^{C}	0.37^{A}	0.28^{B}	0.18^{C}	0.09	
18:3 n-3 (ALA)	0.97^{A}	0.49^{B}	0.51^{B}	0.42^{B}	1.30^{A}	0.42^{B}	0.49^{B}	0.24	n.s.
20:1	0.39^{B}	0.59^{A}	0.57^{A}	0.37^{B}	0.39^{B}	0.68^{A}	0.64^{A}	0.11	
Total UFA	52.72^{A}	42.62^{B}	55.04^{A}	47.83^{Bc}	52.44^{Aab}	53.09^{Aa}	50.69^{ABbc}	2.99	n.s.
UFA: SFA	1.34^{A}	0.80^{B}	1.38^{A}	1.02^{a}	1.29^{b}	1.22^{ab}	1.11^{ab}	0.42	
Total n-6 ; n-3	7.28^{A}	4.65^{B}	5.21^{B}	9.59^{A}	3.05^{B}	9.19^{A}	8.49^{A}	2.45	
DFA[2] : OFA[3]	3.04^{A}	3.17^{A}	2.86^{B}	2.66^{A}	3.18^{B}	3.32^{B}	2.98^{B}	0.48	n.s.

[1] $\sqrt{s^2}$; [2] – UFA + C 18 : 0 (dietary fatty acids having desirable neutral or hypocholesteroleic effect in human); [3] – C 14 + C 16 (dietary fatty acids having undesirable neutral or hypocholesteroleic effect in human); ^{a,b} – $P \leq 0.05$; ^{A,B,C} – $P \leq 0.01$

TABLE 6

Contents of fatty acids (FA) – saturated (SFA) and unsaturated (UFA) and cholesterol level in *M. longisimus dorsi* fat

FA	Groups				RMSE[1]
	C control	L lineseed	RC rapeseed oil cake	RO rape seed oil	
SFA:					
C 14:0	1.96^{b}	2.47^{a}	1.81^{b}	2.23^{ab}	0.40
15:0	0.43	0.40	0.40	0.38	0.07
16:0	0.17^{a}	0.14^{ab}	0.14^{ab}	0.16^{b}	0.03
16:0	20.35	19.26	19.91	20.50	1.68
17:0	1.42	1.21	1.17	1.17	0.27
18:0	15.23^{ab}	13.84^{b}	14.92^{ab}	16.60^{a}	1.76
20:0	0.12^{ab}	0.11^{b}	0.14^{ab}	0.15^{a}	0.02
Total SFA	39.70^{a}	37.32^{b}	37.81^{b}	41.19^{a}	3.62
UFA:					
C 14:1	0.39	0.58	0.41	0.47	0.17
16:1	3.00	3.58	3.42	3.18	0.78
17:1	1.19^{a}	0.91^{b}	1.11^{ab}	1.02^{ab}	0.19
18:1	39.02	40.71	40.39	37.69	3.51
18:2 n-6	7.05	5.44	7.25	7.60	2.37
18:2 coniugated CLA	0.17^{Bb}	0.37^{Aa}	0.23^{Ab}	0.18^{Bb}	0.08
18:3 n-3 (ALA)	0.65^{B}	1.79^{A}	0.70^{B}	0.74^{B}	0.26
18:3 n-6	0.11	0.12	0.11	0.09	0.02
20:1	0.42	0.31	0.44	0.40	0.12
20:2 n-6	0.15	0.13	0.14	0.11	0.05
20:3 n-6 (DGLA)	0.50^{a}	0.15^{b}	0.51^{a}	0.39^{ab}	0.22
20:4 n-6 (AA)	2.53^{a}	0.80^{b}	2.42^{a}	2.22^{a}	1.10
20:5 n-3 (EPA)	0.24	0.34	0.31	0.25	0.13
22:4 n-6 (adrenic)	0.22	0.16	0.17	0.17	0.11
22:5 n-3	0.74	0.56	0.79	0.77	0.30
22:6 n-3	0.00	0.04	0.02	0.04	0.03
Total UFA	56.38	56.86	58.42	55.32	3.01
UFA : SFA	1.42^{ab}	1.51^{b}	1.54^{b}	1.34^{a}	0.23
n-6 : n-3	6.58^{A}	2.63^{B}	5.95^{A}	5.98^{A}	2.22
DFA[2] : OFA[3]	3.18	3.23	3.35	3.14	0.05
Cholesterol level (mg/100 g MLD)	52.52^{Aa}	45.08^{ABb}	46.65^{ABab}	41.13^{ABb}	1.41

[1] $\sqrt{s^2}$; [2] – UFA + C 18 : 0 (dietary fatty acids having desirable neutral or hypocholesteroleic effect in human); [3] – C 14 + C 16 (dietary fatty acids having undesirable neutral or hypocholesteroleic effect in human); ^{a,b} – $P \leq 0.05$; ^{A,B} – $P \leq 0.01$

fat of *M. longissimus dorsi* fat were lower in group L than in the others. The ratio of hypocholesteroleic to hypercholesteroleic acid was only slightly higher in groups L and RC (P>0.05) than in groups C and RO.

The values obtained for the physical and chemical properties of meat (Table 7) did not differ significantly between the groups.

TABLE 7

Physico-chemical properties of *M. longissimus dorsi* meat

Analysis	Groups				RMSE[1]
	C control	L linesced	RC rapeseed oil cake	RO rape seed oil	
pH 45 min in *M. longissimus dorsi* at 11, 12 and 13 rib, mean	6.45	6.67	6.65	6.74	0.25
pH 24 h in *M. longissimus dorsi*	5.62	5.63	5.69	5.58	0.12
Water holding capacity, %	28.32	28.87	27.36	27.50	2.86
Natural drip, %	1.03	1.06	0.80	1.21	0.60
Thermal drip loss, %	30.54	29.12	30.38	29.13	3.78
Total colouring substances content, mg/kg	133.57	124.69	127.38	128.41	29.87
Colour lightness, %	12.40	13.49	12.80	14.60	1.82
Colour stability, %	3.96	7.27	4.93	5.83	4.53

[1] $\sqrt{s^2}$

DISCUSSION

The similar daily intake of complete feed and dry matter in all groups suggests that the sources and levels of vegetable oils used in the present experiment were properly formulated. Strzetelski et al. (1992) found that feeding fattening bulls *ad libitum* with complete mixtures containing 15 or 30% rape seed did not decrease dry matter intake compared with the control group. Similar results were obtained by other authors feeding fattening bulls different rations containing different sources and levels of vegetable or fish oils (Rule et al., 1994; Kreuzer et al., 1995; Scollan et al., 1997b; Strzetelski et al., 1998a; Choi et al., 1999). In other experiments, feeding diets containing linseed, sunflower or soyabean seed decreased dry matter intake (e.g. O'Kelly and Spiers, 1993; Clinquart et al., 1995). It seems that the dry matter intake of diets containing high levels of vegetable oils, and consequently animal performance, are highly influenced by factors that affect digestion in the rumen, i.e. diet composition, method of fat inclusion into the ration, and its energy-protein balance.

Jenkins (1993), summarising the results of other authors on lipid metabolism in the rumen, concludes that fermentation inhibition caused by increased levels of fat in the diet can be considerably reduced if the content of meadow hay or lucerne meal in the diet is high; e.g. a 10% supplement of rape seed oil to the diet did not depress organic matter digestion in the rumen when the basic ration contained 50% meadow fescue hay.

The lack of differences between the groups in daily body weight gain indicate that the complete feeds used in the experiments covered energy (UFV) and protein (PDI) requirements for rumen micro-organisms and the requirements of animals, and that the increased vegetable oil intake did not cause digestive disorders in the gastro-intestinal tract of fattened bulls.

The tendency towards a slightly lower body weight gain of animals fed the diet with rapeseed oil cake than in the other groups can probably be explained by the worse balancing of the complete mixture than in the remaining groups. This resulted from introducing a relatively high amount of rapeseed oil cake (29%) into this mixture, which was necessary to obtain a level of fat similar as in the diets with linseed or rape seed oil. The degradability coefficient of rapeseed oil cake was high (0.75 to 0.78) and the content of PDIN was about two times higher than that of PDIE (Strzetelski and Niwińska, 1997). An attempt to obtain a complete feed mixture with a balanced energy and protein content with a similar level of vegetable oil from different sources resulted in differences in energy and protein contents of feed mixtures and differentiation of intake and utilisation of nutrients by bulls in respective groups. These differences were even statistically significant in some cases.

Fatty acid deposition was markedly differentiated between types of animal fat, similarly as in the experiment of Rule et al. (1994) on fattening bulls and rations with soyabean or rape seed oil. The content of SFA or UFA in samples of *M. longissimus dorsi* fat did not differ markedly from their content in subcutaneous fat, but there was significantly ($P<0.01$) more saturated and less unsaturated acids in kidney fat; a similar tendency was also found in other studies on vegetable oil use for fattened bulls (Chang et al., 1992; Rule et al., 1994; Yang et al., 1999). The increased linolenic acid (C 18:3 n-3) and conjugated linoleic acid (C 18:2, CLA) contents in *M. longissimus dorsi* fat found in our experiment are compatible with the results reported by Chang et al. (1992) and Choi et al. (1999). Nettleton (1991) gives the metabolic pathway of n-3 and n-6 fatty acid conversion to their long-chain derivatives, docosahexaenoic (C 22:6 n-3) and arachidonic (C 20:4 n-6) acids, as a possible transformation of these acids.

A pronounced decrease of SFA and increase of UFA in the tissues of fattened bulls fed different kinds of vegetable oils were also reported by Chilliard (1993), Rule et al. (1994) and Choi et al. (1999). Wu et al. (1991) stated that supplementary fat in the diet, independently of its origin, linearly increases fatty acid passage into the duodenum, creating conditions for absorption from the small intestine.

The higher ratio of UFA:SFA found in the tissue of animals receiving linseed or rapeseed cake in their diets resulted mainly from the high oleic acid (C 18:1) content. The majority of UFA is biohydrogenated in the rumen to stearic acid (C 18:0), which is easily absorbed from the small intestine. However, the high proportion of oleic acid (C 18:1) in the examined tissues suggests that stearic acid (C 18:0) had been modified to oleic acid (C 18:1) as a consequence of acetyl CoA desaturase activity before incorporation into the ruminant tissues (Chang et al., 1992). However, it cannot be excluded that the higher oleic acid (C 18:1) content in the tissues of ruminants fed linseed or rapeseed oil cake was partly a consequence of limited biohydrogenation of this acid in the rumen. Such limitation could be due to increased intake of this acid, particularly with rape seed oil, which contains a high proportion of this acid (about 51.2%), as well as the physical form of these feeds (Murphy et al., 1990; Chang et al., 1992; Rule et al., 1994). Limited biohydrogenation of oleic acid (C 18:1) in the rumen of animals fed linseed also suggests a lower concentration of stearic acid (C 18:0) in the studied vegetable oils than in the diets for the remaining groups. The increased amount of oleic acid (C 18:1) in the animal tissue could entail an increased concentration of the trans-isomer of C 18:1, which is not a desirable substance for human health as it can elevate total cholesterol and low density lipid (LDL) fractions and decrease the high density lipid (HDL) fraction (Mensink and Katan, 1990; Kennelly, 1996). However, it does not seem that the trans form of oleic acid (C 18:1) has been accumulated in the tissue after feeding bulls diets containing linseed or rape seed oil, as a higher concentration of conjugated linoleic acid (C 18:2, CLA) was found in their tissues than in those of animals fed the diet with rape seed oil. It can be presumed that despite the higher intake of linoleic acid (C 18:2) with rape seed oil (79 g/d) than with linseed or rapeseed cake (72 and 70 g/d, respectively), the rate of its biohydrogenation was much higher in the rumen. An increase of oleic acid (C 18:1) in the tissue of bulls fed mixtures with linseed and rapeseed cake could be a consequence of elongation of palmitic acid (C 16:0), what is suggested by the lower content of this acid in this than in the remaining groups (Chang et al., 1992).

The significantly higher concentration of linolenic acid (C 18:3 n-3) in the tissues of bulls receiving linseed, compared with the other groups, could be explained by the higher intake of this acid (214.3 g/d) than in the case of rapeseed cake or oil (34 g/d). However, it cannot be excluded that C 18:3 n-3 acid originating from linseed also enriched the pool of conjugated linoleic acid (C 18:2, CLA). Indeed, biohydrogenation of linolenic acid (C 18:3 n-3) does not refer to the conjugated form of this acid (Harfood and Hazlewood, 1988), however, trans-11-oleic acid is produced during hydrogenation of linolenic acid, and, in turn, may be transformed endogenously in the presence of δ-9 desaturase into conjugated linoleic acid (C 18:2, CLA) (Griinari et al., 1997). Conjugated linoleic acid (C 18:2, CLA) has recently been thought to be a factor inhibiting some types of cancer (Parodi,

1997). The higher content of eicisenoic acid (C 20:1) in the tissue of bulls fed rapeseed cake and oil was probably caused by the nearly seven times higher concentration of this acid (2.2%) compared with linseed (0.29%), however, elongation of oleic acid (C 18:1) in the tissues can not be excluded, either (Rule et al., 1994; Kennelly, 1996).

The ratio of n-6:n-3 in the examined tissues ranged from 4:1 to 7:1. Horrobin (1990) reported that in the majority of body tissues, this ratio oscillates from 3:1 to 9:1. The markedly lower, compared with that of the remaining groups, ratio of n-6:n-3 acids in the meat of bulls fed linseed suggests that it was of better dietetic value because of the advantageous anti-sclerotic action of n-3 family acids (Brisson, 1986; Givens et al., 2000). Drevon (1992) claims that acids of n-3 family advantageously increase HDL and total cholesterol concentrations. In our experiment, in all groups fed diets with vegetable oils, a beneficial effect on the cholesterol level in lipids of *M. longissimus dorsi* was observed, compared with the control group.

CONCLUSIONS

Summarising the results of the experiment, it can be concluded that in fattening bulls from 155 to 540 kg body weight with daily gains of about 1.3 kg, feeding granulated complete feed with energy and protein balanced according to IZ-INRA standards (1997) and containing about 60 g of crude fat in 1 kg of feed, of which about 66% is from vegetable oils (linseed, rapeseed cake or rape seed oil), does not negatively affect daily body weight gain or dry matter intake. Kidney fat contains the lowest, and subcutaneous fat the highest ratio of UFA:SFA. Supplementing diets with linseed or, to a lesser degree, rapeseed oil cake enriches meat fat with indispensable long-chain fatty acids and conjugated linoleic acid, and augments the ratio of neutral and hypocholesteroleic to hypercholesteroleic acids.

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STRESZCZENIE

Wpływ skarmiania makuchu rzepakowego lub nasion lnu w mieszankach pełnodawkowych na wyniki produkcyjne i jakość mięsa opasanych buhajów

Doświadczenie przeprowadzono na 44 buhajkach rasy cb, opasanych od 155 do 540 kg masy ciała, podzielonych na 4 grupy i żywionych do woli granulowanymi mieszankami pełnodawkowymi – grupa kontrolna oraz uzupełnionymi jednakowymi ilościami tłuszczu roślinnego, pochodzącego z nasion lnu, makuchu rzepakowego lub oleju rzepakowego. Po zakończeniu opasania 6 zwierząt z każdej grupy ubito i oznaczono fizyko-chemiczne właściwości mięsa oraz zawartość kwasów tłuszczowych w tłuszczu podskórnym, okołonerkowym i mięśnia najdłuższego grzbietu oraz poziom cholesterolu w tym mięśniu.

Średnie dzienne przyrosty masy ciała były podobne we wszystkich grupach zwierząt i wynosiły około 1,26 kg. Fizyko-chemiczne właściwości mięsa były również podobne we wszystkich grupach. Zawartość kwasu linolenowego (C 18:3 n-3) i sprzężonego kwasu linolowego (C 18:2) w tłuszczu mięśnia najdłuższego grzbietu była największa, a cholesterolu najmniejsza u buhajków żywionych dawkami z nasionami lnu, co wskazuje na korzystny jego wpływ na jakość mięsa.