Journal of Animal and Feed Sciences, 9, 2000, 585 – 603

Effects of canola and soya lecithins compared with canola oil and seed on performance, carcass quality and body fat composition of growing bulls

H.-R. Wettstein, M. Kreuzer[1], F. Sutter and M.R.L. Scheeder

Institute of Animal Sciences, Animal Nutrition
ETH Zurich, ETH Centre/LFW B56
CH-8092 Zurich, Switzerland

(Received 27 April 2000; accepted 4 October 2000)

ABSTRACT

Fattening bulls (six per treatment) were fed rations supplemented either with raw or modified (deoiled and deoiled/partially hydrolyzed) canola lecithins or deoiled soya lecithin at 30 g/kg DM on a fatty acid basis. These were also compared with rations supplemented with canola oil or crushed canola seed. No differences occurred in liveweight gain, feed conversion efficiency or carcass traits. The elevated proportions of odd-chain fatty acids found in the body fats indicate that lecithins might affect rumen fermentation less than oils. Trends in rumen fluid ammonia concentration suggest a reduced ruminal protein degradation with lecithins. Polyenoic fatty acids were highest with canola oil in kidney fat and intermuscular fat. The fatty acid profile of body fat depended more on the origin of lecithin (canola vs soyabean) than on the exchange of oil or technological lecithin modifications. Consequently, canola lecithins can replace canola oil without greater effects on growth and carcass yield and only minor variation in carcass fat composition.

KEY WORDS: lecithin, canola, fatty acids, performance, body fat composition, beef bulls

INTRODUCTION

Plant lecithins are obtained as by-products during the refining process of raw plant oils. The term 'lecithins', as used for these by-products, covers complex

[1] Corresponding author

mixtures mainly of different phospholipids but also of other polar substances and, if not further processed, residual triglycerides (Pardun, 1988). In contrast to oils, lecithins are dispersible in water (Pardun, 1988) and contain a fraction that slowly disappears in the rumen (Jenkins et al., 1989) presumably because different enzymes are necessary to hydrolyze phospholipids and triglycerides (Harfoot, 1981). Consequently, attachment of plant lecithins to feed particles or rumen microbes might be less pronounced than with oils and the release of the fatty acids (FA) could be slower from lecithins, both resulting in less adverse effects on rumen fermentation than with corresponding oils as was shown *in vitro* (Wettstein et al., 2000). As far as the direct adverse effects of lipids against rumen microbes are concerned, this also depends on specific FA. The FA composition of lecithins is quite variable and substantially differs when the lecithins originate from different plants. Until now, most investigations on lecithins in ruminant nutrition focussed on soya lecithins (e.g., Yoon et al., 1986; Jenkins et al., 1989; Jenkins and Fotouhi, 1990; Lough et al., 1991, 1992). Nowadays, considerable amounts of canola lecithins are also available as potential feedstuffs, but data on the actual feeding value of any type of canola lecithin for growing ruminants are still lacking. Canola lecithins might suppress rumen cellulolytes even less than soya lecithins because of their lower content of linoleic acid (Nagaraja et al., 1997). Additionally, the undesired residual oil can be removed and the specific properties of lecithins can be enhanced by new processing technologies. Such products were shown *in vitro* to be particularly promising in terms of reduced perturbation of rumen fermentation (Wettstein et al., 2000). Using canola lecithins instead of oil as the only lipid supplement was furthermore found to reduce the *in vitro* ruminal degradation of feed protein (Wettstein et al., 2000), possibly due to the amphiphatic (i.e., polar - apolar) properties of the lecithins (Jenkins et al., 1989). This might increase the amount of absorbable protein entering the duodenum.

The objective of the present study was to investigate the effects of differently processed canola lecithins and deoiled soya lecithin in the diet of growing bulls in comparison with canola oil and seed. Using raw and modified lecithins should make it possible to identify the effects of particular physical and chemical properties. In order to be able to determine any lecithin effects on duodenal protein supply, diets were designed to contain slightly (10%) less calculated duodenally absorbable protein (FAG, 1994) than recommended. Apart from fattening performance and carcass quality, focus was put on the effects on body fat composition since lecithins of different origin (canola and soyabean) and from different processing techniques clearly differ in FA composition. The data obtained should provide the basis for the possible application of lecithins in feeding practice as an energy source and/or as a mode to selectively modify body fat composition.

MATERIAL AND METHODS

Design of the experiment and of the diets

The present experiment consisted of six different dietary treatment groups all supplemented with 30 g/kg dry matter (DM) of lipids calculated as triglyceride equivalents. Three different canola lecithins and deoiled soya lecithin (SL_d) were examined. The canola lecithins formed a series with increasing dispersibility in water: raw canola lecithin (CL_r), deoiled canola lecithin (CL_d) and deoiled/partially hydrolyzed canola lecithin ($CL_{d/h}$). These lecithins were opposed to canola oil (CO) and crushed whole canola seed (CS). No unsupplemented control was used since due to the lower energy content of the respective concentrate a different ratio of forage to concentrate would have been necessary. Whole canola seed was offered in a crushed form, which is necessary for sufficient digestion of the seed, but still provides the lipids in a partially rumen protected form (Drochner and Heller, 1996). Crushed canola seed, supplied at the proportion used in the present study, was shown earlier to be suitable for fattening bulls (Kreuzer et al., 1985; Sutter et al., 2000). All six lipid supplements were provided by Lucas Meyer GmbH and Co (Hamburg, Germany) with all of the canola products originating from one batch of canola seed.

The lipids were included at proportions equivalent to 100 g triglycerides (calculated from fatty acid methyl esters) per kg in the concentrates, with the concentrates making up proportionately 0.3 of total feed dry matter. Table 1 gives the ingredient composition of the concentrates used for the starting and finishing periods of fattening. Because of the use of urea in the finisher concentrates, these were supplemented with S, Cu, Zn and Mn as recommended (FAG, 1994). Both types of concentrate contained the same proportions of the lipid supplements and mainly differed in the ratio of protein and energy in order to cope with the age-dependent changes in requirements.

All complete diets were composed to meet the Swiss feeding recommendations (FAG, 1994). They consisted of maize silage, hay, concentrate and additional potato protein. The average composition as illustrated in Table 2 varied with age. The individual rations were adapted weekly to the actual liveweight (extrapolated from two-weekly measurements) for the individual animals to fulfill the recommendations of energy and protein for expected average daily gains of 1.2 kg/d (FAG, 1994). For this purpose, also the extra amount of potato protein (Table 2) was gradually reduced during fattening to account for the continuously decreasing protein requirements relative to the energy demand. The supply of absorbable protein at the duodenum (APD, corresponding to the French PDI) was limited to 91% of the tabulated values in order to promote growth responses to additional APD as expected from lecithin action in the rumen. The

diets were similar in calculated contents of net energy (NEV) according to the Swiss feeding standards (FAG, 1994) and of metabolisable energy (ME) according to the German feeding standards (DLG, 1997).

TABLE 1

Ingredients used in the concentrates, g/kg DM

Treatment/lipid	Canola oil	Canola seed crushed	Raw canola lecithin	Deoiled canola lecithin	Deoiled/ hydrolysed canola lecithin	Deoiled soya lecithin
	CO	CS	CL_r	CL_d	$CL_{d/h}$	SL_d
Period 1 (< 300 kg LW)						
canola oil	100	-	-	-	-	-
canola seed	-	227	-	-	-	-
canola lecithin (CL) raw	-	-	161	-	-	-
CL deoiled	-	-	-	200	-	-
CL deoiled/hydrolysed	-	-	-	-	200	-
soya lecithin deoiled	-	-	-	-	-	200
barley	200	202	122	131	140	121
straw meal	176	186	168	178	177	178
soyabean meal	471	244	502	386	374	403
potato protein	-	94	-	58	62	51
urea	6	-	-	-	-	-
NaCl	1	1	1	1	1	1
mineral premix[1]	46	46	46	46	46	46
Period 2 (> 300 kg LW)						
canola oil	100	-	-	-	-	-
canola seed	-	227	-	-	-	-
CL raw	-	-	161	-	-	-
CL deoiled	-	-	-	200	-	-
CL deoiled/hydrolysed	-	-	-	-	200	-
soya lecithin deoiled	-	-	-	-	-	200
barley	590	453	512	433	434	434
straw meal	80	96	71	88	88	87
soyabean meal	122	129	154	181	181	181
urea	51	38	45	41	40	41
Na_2SO_4 (138 g S/kg)	15	15	15	15	15	15
mineral premix[1]	40	40	40	40	40	40
trace element premix[2]	2	2	2	2	2	2

[1] per kg: Ca, 170 g; P, 50 g; Mg, 30 g; Na, 40 g; vit. A, 1,000,000 IU; vit. D_3, 220,000 IU; vit. E, 1,500 mg

[2] per kg: Cu, 6.8 g; Zn, 34.1 g; Mn, 50 g

TABLE 2

Average composition of the complete diets within the whole fattening period as well as fatty acid (FA) composition of the lipids supplemented

	CO	CS	CL_r	CL_d	$CL_{d/h}$	SL_d
Ingredient composition of the complete diets, g/kg DM						
maize silage	597	591	591	589	590	594
meadow hay	98	99	99	100	100	99
concentrate	296	300	301	302	300	298
type for period 1	79	89	88	82	94	77
type for period 2	217	211	213	220	206	221
extra potato protein	9	10	9	9	10	9
Nutrient composition of the diets, g/kg DM						
ME[1], MJ/kg DM	11.1	11.0	11.2	11.2	11.2	11.2
NEV[2], MJ/kg DM	7.03	7.03	7.05	7.04	7.04	7.03
crude protein	147	144	150	149	152	147
APD[2]	88	89	89	89	89	88
organic matter	947	945	945	942	943	943
ether extract	46.8	53.7	54.1	55.5	52.5	53.6
total FA	47.4	46.0	45.9	50.8	49.0	49.3
FA, g/kg total FA						
C16:0	93	93	113	123	131	178
C18:0	20	20	19	16	18	36
C20:0	6	6	4	3	3	3
C22:0	5	6	5	4	4	7
C18:1	457	449	409	393	381	128
C20:1n-9	12	13	2	3	3	2
C22:1n-9	5	9	2	1	1	1
C18:2n-6	302	298	358	379	381	550
C18:3n-3	92	98	79	69	70	86
Composition of the lipid supplements						
total FA[3], g/kg	1000	423	581	556	529	540
FA, g/kg total FA						
C16:0	46	47	78	98	109	183
C18:0	17	17	15	12	14	42
C20:0	7	7	4	2	2	2
C22:0	4	4	3	2	2	6
C18:1	594	577	520	477	463	73
C20:1n-9	16	18	2	3	3	1
C22:0n-9	6	14	2	1	1	1
C18:2n-6	208	207	296	340	340	601
C18:3n-3	97	107	76	62	62	88

[1] metabolisable energy calculated according to tabulated values (DLG, 1997)

[2] calculated as net energy meat (NEV) and absorbable protein at the duodenum (APD) from tabulated values (FAG, 1994)

[3] calculated as triglyceride equivalents

Animals and experimental techniques

At the start of the experiment 36 Brown Swiss bulls weighing on average 170 kg were allocated to groups of six animals per pen. Each animal within a pen received a different ration out of the six treatments. The fattening period was subdivided into a starter period (period 1) until the animals reached 300 kg liveweight and the subsequent finisher period (period 2) until slaughter, separated by the change of concentrate type. Pens had two areas, one with deep litter in the rear part, and one with a concrete floor in the front part at the feeding places. Tap water was continuously available. Each bull had access to only one feeding place by passing a special door (American Calan Inc., Northwood, NH, USA) equipped with a transponder for electronic identification control (Westfalia Separator, Oelde, Germany). The total rations were replenished two times per day. Refusals were recorded separately for each compound on four days per week. Forage was sampled twice per week and analyzed for dry matter content. Part of the samples were dried in an oven at 60°C and pooled over two weeks. Concentrates were sampled once per week and pooled over four weeks for compositional analyses. The bulls were weighed every second week. The fattening period lasted until 500 kg liveweight was reached on average for all animals of one pen. With this procedure, the average duration of the fattening period was exactly the same for all treatments. Slaughter was performed at a commercial slaughter plant. Weights were measured before transport and 45 min p.m. (hot carcass weights). At slaughter 200 ml of rumen fluid were collected directly from the rumen. Kidney fat was weighed and samples of kidney fat were taken. Carcass grading was carried out according to the Swiss beef classification grid (GSF, 1994), which is similar to the EUROP grading system of the European Union. Samples of the *M. longissimus dorsi* (LD) for analysis of intramuscular fat and of the intermuscular fat between LD and *M. spinalis et semispinalis dorsi et cervicis* were obtained from the 8th and the 9th rib 18 h subsequent to slaughter. The LD sample was homogenized with a Moulinette® S food mixer (GROUP Moulinex, Paris, France) and vacuum sealed before freezing.

Chemical and statistical analyses

The nutrient composition of the feed ingredients was determined by standard procedures (Naumann and Bassler, 1997). In rumen fluid, pH and ammonia were measured with a pH meter (model 713, Metrom, Herisau, Switzerland) equipped with the respective electrodes. Bürker counting chambers (Blau Brand, Wertheim, Germany) were used for enumeration of ciliates (depth 0.1 mm) and bacteria (depth 0.02 mm). Volatile fatty acid concentrations in rumen fluid were analyzed by gas chromatography (GC Star 3400 CX, Varian, Palo Alto, CA, USA) according to Tangerman and Nagengast (1996).

Lipids were extracted with hexane/isopropanol 3:2 (v/v). In samples of feed ingredients, extraction was done in an Accelerated Solvent Extractor (ASE 200, Dionex Corporation, Sunnyvale, CA, USA). Body fat tissues were homogenized in the solvent mixture and stored for 1 h before being filtered. FA methyl esters (FAME) were prepared according to IUPAC (1987). Two different analyses on gas chromatographs (HP 5890 and HP 6890, Hewlett Packard, Wilmington, DE, USA) were performed using Supelcowax™ 10 and 2560 capillary columns (Supelco, Bellefonte, PA, USA), respectively, in order to separate (i) FA according to chain length and number of double bonds and (ii) C18:1 isomers (only in body fat samples). Total FA contents of the feed ingredients and LD samples were determined using triundecanin as the internal standard, which was given into the extraction cell prior to extraction. Canola oil was used as the reference fat to determine the response factor. C18:1 *cis* and *trans* isomer percentage (ii) was related to total C18:1 (i). Without previous thin layer chromatography it is not possible to separate all C18:1 isomers and C18:1 *trans* isomers with a double bond in position $\leq \omega6$ from certain *cis* isomers (Precht and Molkentin, 1995). Thus, only the *trans* isomers with double bonds in positions $\omega13$ - $\omega7$ were taken into account for the calculation of total *trans* C18:1. With this simplification the effective content of C18:1 *trans* isomers was presumably slightly underestimated and vice versa for the *cis* isomers. The melting behaviour of the intermuscular fat was analyzed by differential scanning calorimetry (DSC 2010, TA Instruments, Alzenau, Germany) as described by Casutt et al. (1999).

Statistical evaluation was carried out by analysis of variance regarding diet and pen as fixed effects applying the GLM-procedure of SAS (1996). The pen effect includes the effect of slaughter day. Multiple comparison of the least square (LS) means was done with the Tukey-Kramer method applying $P<0.05$.

RESULTS

One bull from the canola oil treatment had to be removed due to problems with severe pneumonia. Feed intake increased from 3.8±0.5 to 8.3±0.4 kg DM per day on average of all groups during the experiment. Daily DM intake was slightly lower with the canola seed diet than with the other diets ($P<0.1$) and no significant group differences were found in daily liveweight gain and feed conversion efficiency (Table 3). The same is true for energy and protein expenditure per kg weight gain. Also final liveweight, hot carcass weight and dressing percentage were similar in all six treatments. Conformation, fatness scores and proportion of kidney fat did not significantly differ among groups, but fatness scores were numerically lower in the raw canola lecithin and in the soya lecithin treatment.

Rumen fluid pH ranged in all diets at a similarly high level (Table 3). There was a non-significant trend in rumen fluid ammonia concentration with lower values being found in all of the lecithin-supplemented diets. Neither total volatile fatty acid (VFA) concentrations nor individual VFA proportions differed signifi-

TABLE 3

Fattening performance, carcass characteristics and rumen fluid properties[1]

	CO	CS	CL_r	CL_d	$CL_{d/h}$	SL_d	SEM	P
Dry matter intake, kg/d	6.49	6.28	6.46	6.50	6.53	6.61	0.069	0.062
Gains, kg/d	1.17	1.14	1.18	1.21	1.21	1.21	0.046	0.908
Feed conversion efficiency, per kg gain								
dry matter, kg	5.56	5.59	5.54	5.39	5.43	5.51	0.201	0.985
ME, MJ	61.9	61.3	62.0	60.3	60.8	61.6	2.25	0.994
NEV, MJ	39.1	39.3	39.1	37.9	38.2	38.8	1.42	0.987
crude protein, g	821	808	828	802	818	810	30.9	0.992
APD, g	492	498	492	475	479	484	20.0	0.974
Carcass characteristics								
final liveweight, kg	504	494	509	513	515	515	12.9	0.882
hot carcass weight, kg	270	266	274	276	278	278	7.2	0.858
kidney fat, % of carcass	2.75	2.45	2.03	2.24	2.41	2.26	0.257	0.560
dressing percentage	53.6	53.8	54.0	53.7	53.9	54.0	0.41	0.979
conformation score[2]	2.92	2.94	2.84	2.89	2.76	2.95	0.139	0.950
fatness score[3]	2.26	2.09	1.78	2.41	2.41	1.57	0.236	0.106
Rumen fluid properties at slaughter								
pH	6.95	6.79	6.90	6.74	6.94	6.73	0.099	0.449
NH_3, mmol/l	7.09	5.65	4.60	4.88	5.02	3.98	0.946	0.375
volatile fatty acids								
total, mmol/l	69.9	77.9	73.2	73.9	72.9	76.9	4.38	0.840
proportion of individual volatile fatty acids, mmol/mol								
acetate	778	762	772	761	766	760	21.2	0.991
propionate	130	138	134	128	140	139	14.7	0.991
iso-butyrate	82	83	98	94	81	81	1.0	0.733
butyrate	55	61	52	68	56	60	7.5	0.717
iso-valerate	12	14	14	16	12	14	1.4	0.304
valerate	17	17	19	17	18	19	1.6	0.929
acetate:propionate	6.95	6.99	6.19	6.71	6.48	6.83	0.841	0.984
bacteria, 10^{10}/ml	2.33	2.24	2.36	2.19	2.14	2.41	0.186	0.890
ciliates, 10^5/ml	3.25	4.80	1.91	2.38	3.38	3.93	0.939	0.326

[1] SEM = standard error of the means. LS means by treatment, n = 6

[2] conformation score: 1 (very weak) to 5 (very pronounced) according to GSF (1994)

[3] fatness score: 1 (low) to 5 (high) according to GSF (1994)

cantly between the diets. The VFA profile was of a kind that is typical of forage-based diets. The number of bacteria in rumen fluid was similar for all the diets and no significant group differences were found for ciliate counts despite the numerically high difference between diets.

The intramuscular fat contents as measured in LD muscle (here determined as total FA content) were generally low (Table 4). They showed a weak trend towards lower values with raw canola oil and deoiled soya lecithin that resembled the trend in fatness scores. Also no significant differences were found in the proportions of total saturated, monoenoic and polyenoic FA in intramuscular fat. This is also the case for the major saturated FA, C16:0 and C18:0, whereas the proportions of saturated odd-numbered FA (C15:0, C17:0 and C19:0) was significantly higher with deoiled and deoiled/hydrolyzed canola lecithin than with canola oil and canola seed. The same trend was observed with C17:1 as odd-numbered monoenoic FA. The proportion of C20:0 was significantly higher with the canola oil than with the soya lecithin diet, with intermediate values for all other groups. The proportion of total C18:1 *cis* and C18:1 *trans* was similar for all diets. However, C18:1n-6-*cis* proportion was significantly highest with the soya lecithin diet which was counterbalanced by respectively lower C18:1n-12-*trans* proportions. With canola oil, canola seed as well as deoiled canola lecithin there was a trend for a higher C20:1n-9 proportion in LD. In none of the individual polyenoic FA significant differences in proportion among the diets were found. However, the soya lecithin treatment showed the numerically highest content of polyenoic FA.

Diet effects on the composition of intermuscular fat as well as on kidney fat were similar (Tables 5 and 6). No significant differences between diets in the proportions of total saturated or monoenoic FA were found in either intermuscular or kidney fat. In both fats, the proportion of total polyenoic FA was significantly higher with the use of canola oil (and canola seed) than with the deoiled canola lecithin, which is in some contrast to the findings in intramuscular fat. Furthermore, in kidney fat a significant ($P<0.05$) treatment effect on the proportion of C16:0 occurred, but no significant differences were identified between individual diets by multiple comparison among means. The proportion of C16:0 in intermuscular fat and kidney fat showed a trend to be highest with the deoiled soya lecithin diet. In both fats the proportion of C20:0 was significantly lower with deoiled/hydrolyzed canola lecithin and deoiled soya lecithin than with canola oil or canola seed. Highly significant differences were once again found in both body fats in the proportion of the saturated odd-numbered FA, with the highest values measured for the deoiled and the deoiled hydrolyzed canola lecithin. Values for raw canola lecithin and deoiled soya lecithin were intermediate and lowest for canola oil and canola seed. Trends in C17:1 were similar. Proportions of C18:1n-7-*cis* were lowest with the deoiled canola lecithin diet, and significantly differed from the canola oil diet in both fats and from the canola seed diet in intermuscular fat. With

deoiled soya lecithin, the proportions of C18:1n-6-*cis* and C18:1n-2-*trans*/n-4-*cis* were significantly highest. Proportions of C20:1 were significantly higher with canola oil followed by canola seed, and was lowest with all deoiled lecithins in both body fats. Proportions of C18:2n-6 were lowest in both fats when deoiled

TABLE 4

Intramuscular fatty acid (FA) content and composition of *M. longissimus dorsi*[1]

	CO	CS	CL_r	CL_d	CL_{dH}	SL_d	SEM	P
FA content, g/kg	19.3	19.7	16.2	17.3	18.1	14.3	2.55	0.694
FA profile, g/kg total FA								
saturated FA	468.8	469.2	473.2	464.4	471.1	463.7	10.45	0.985
C14:0	18.9	19.4	18.3	17.0	18.6	17.1	1.29	0.711
C16:0	209.7	213.8	209.1	198.1	204.7	207.4	5.69	0.515
C18:0	219.8	216.0	224.2	226.2	224.6	218.2	7.77	0.924
C20:0	2.1^{a}	1.9^{ab}	1.7^{abc}	1.8^{abc}	1.6^{bc}	1.4^{c}	0.09	0.001
odd numbered[2]	14.7^{c}	15.2^{bc}	16.5^{abc}	17.8^{ab}	18.2^{a}	15.9^{abc}	0.62	0.004
monoenoic FA	428.7	433.2	413.5	423.5	419.8	411.5	10.40	0.667
C16:1	22.8	24.3	23.1	23.9	23.7	25.2	1.09	0.705
C17:1	6.4^{b}	7.3^{ab}	7.6^{ab}	8.8^{a}	7.9^{ab}	7.4^{ab}	0.44	0.034
total C18:1	394.0	396.0	378.2	385.6	383.6	374.6	9.92	0.632
C18:1 *cis*	368.8	372.2	352.0	362.8	358.9	347.0	10.54	0.548
C18:1n-9c[3]	346.9	350.1	330.7	342.1	336.7	322.9	10.88	0.518
C18:1n-7c	13.5	13.5	13.1	12.8	13.4	14.5	0.69	0.659
C18:1n-6c	2.2^{b}	2.1^{b}	2.0^{b}	1.9^{b}	2.3^{b}	3.2^{a}	0.18	0.000
C18:1n-2t/n-4c	3.1	3.2	3.1	3.1	3.4	3.4	0.11	0.179
C18:1 *trans*	25.2	23.7	26.2	22.8	24.7	27.7	1.58	0.339
C18:1n-12t	4.0^{a}	3.9^{a}	3.9^{a}	3.6^{ab}	4.0^{a}	3.0^{b}	0.20	0.012
C18:1n-9t - n-7t	20.9	19.6	22.0	19.0	20.5	24.5	1.45	0.139
C20:1n-9	2.4	2.5	1.9	2.4	1.7	1.6	0.27	0.085
polyenoic FA	102.5	97.6	113.3	112.2	109.0	124.8	13.29	0.779
C18:2n-6	60.1	55.8	64.3	63.7	63.4	72.7	8.03	0.793
C18:2 conjugated	3.8	3.9	3.9	3.2	3.4	4.1	0.28	0.213
C20:2	1.7	1.7	2.1	2.8	2.3	2.4	0.31	0.123
C18:3n-3	6.6	6.9	6.7	6.4	6.3	6.6	0.75	0.993
C20:4n-6	15.2	14.7	18.3	18.3	16.9	20.2	2.44	0.624
C20:5n-3	3.2	3.2	3.6	3.6	3.3	3.8	0.41	0.877
C22:6n-3	1.2	1.4	1.6	1.8	1.5	1.7	0.24	0.768

[1] SEM = standard error of the means. Means by treatment, n = 6. LS mean values within the same line sharing no common superscript are significantly different ($P<0.05$)

[2] C15:0, C17:0 and C19:0

[3] other C18:1 isomers possibly included are n-12c and n-6t to n-3t (Precht and Molkentin, 1995)

TABLE 5

Fatty acid (FA) composition and melting properties of intermuscular fat[1]

	CO	CS	CL_r	CL_d	$CL_{d/h}$	SL_d	SEM	P
FA profile, g/kg total FA								
saturated FA	577.7	583.4	604.6	602.9	589.3	600.0	11.07	0.474
C14:0	22.8	22.3	21.3	21.1	22.5	19.9	1.01	0.379
C16:0	200.0	206.2	201.1	196.8	202.8	210.3	4.37	0.348
C18:0	331.3	331.2	356.0	356.2	335.4	344.3	10.50	0.347
C20:0	3.9^{a}	3.8^{a}	3.5^{ab}	3.1^{ab}	2.9^{b}	2.8^{b}	0.19	0.001
odd numbered[2]	19.2^{c}	19.5^{c}	22.2^{b}	25.1^{a}	25.0^{a}	22.3^{b}	0.53	0.000
monoenoic FA	396.3	391.4	371.7	375.9	386.5	375.7	11.08	0.599
C16:1	16.2	16.5	15.7	15.7	17.7	17.8	0.82	0.275
C17:1	4.0^{b}	4.1^{b}	4.2^{b}	4.7^{ab}	5.1^{a}	4.3^{ab}	0.22	0.011
total C18:1	371.7	366.8	348.6	352.4	360.2	350.7	10.11	0.563
C18:1 *cis*	332.8	329.6	308.4	314.8	321.6	306.5	10.64	0.444
C18:1n-9c[3]	313.3	310.5	290.2	297.5	303.0	286.3	10.64	0.452
C18:1n-7c	9.4^{a}	9.1^{a}	8.7^{ab}	7.9^{b}	8.5^{ab}	8.9^{ab}	0.26	0.009
C18:1n-6c	2.5^{ab}	2.4^{b}	2.2^{b}	2.1^{b}	2.5^{ab}	3.2^{a}	0.16	0.001
C18:1n-2t/n-4c	5.0^{b}	5.1^{b}	5.0^{b}	4.9^{b}	5.1^{b}	5.8^{a}	0.12	0.001
C18:1 *trans*	38.9	37.1	40.2	37.6	38.6	44.2	2.79	0.526
C18:1n-12t	5.4	5.6	5.8	5.7	5.9	4.6	0.34	0.106
C18:1n-9t - n-7t	33.1	31.1	34.0	31.5	32.3	39.4	2.47	0.227
C20:1n-9	2.3^{a}	2.0^{ab}	1.6^{bc}	1.3^{c}	1.3^{c}	1.1^{c}	0.10	0.000
polyenoic FA	26.0^{a}	25.1^{a}	23.7^{ab}	21.2^{b}	24.2^{ab}	24.3^{ab}	0.77	0.006
C18:2n-6	19.4^{a}	18.5^{a}	17.8^{ab}	16.0^{b}	18.4^{ab}	18.4^{ab}	0.57	0.013
C18:2 conjugated	3.9	3.8	3.6	3.2	3.5	4.1	0.21	0.104
C18:3n-3	2.7^{ab}	2.8^{a}	2.3^{bc}	2.0^{c}	2.3^{abc}	1.8^{c}	0.12	0.000
DSC melting properties								
onset, °C	-25.5	-25.5	-24.6	-23.5	-25.1	-25.2	0.53	0.104
offset, °C	55.1	55.0	55.7	56.0	56.1	56.1	0.54	0.510
maximum, °C								
peak 1	13.4	12.5	13.2	14.1	13.0	12.9	0.34	0.059
peak 2	46.4	46.8	47.7	47.6	47.1	47.6	0.48	0.412
total enthalpy, J/g	103	103	103	104	103	103	1.4	0.991
relative enthalpy, %								
of peak 1	53.8	51.7	48.4	49.6	49.9	46.0	2.02	0.196
of peak 2	46.2	48.3	51.6	50.4	50.1	54.0	2.02	0.196
percentage of total enthalpy								
at 2°C	17.1	17.6	15.1	15.4	16.8	15.8	0.93	0.339
at 20°C	48.4	48.1	43.6	45.1	46.3	43.1	1.69	0.193

[1] SEM = standard error of the means. LS means by treatment, n = 6. Mean values within the same line sharing no common superscript are significantly different ($P<0.05$)

[2] C15:0, C17:0 and C19:0

[3] other C18:1 isomers possibly included are n-12c and n-6t to n-3t

TABLE 6

Fatty acid (FA) profile of the kidney fat, g/kg total FA[1]

	CO	CS	CL_r	CL_d	CL_{dh}	SL_d	SEM	P
Saturated FA	633.7	639.6	652.5	654.0	647.0	661.1	9.69	0.445
C14:0	25.9	26.5	24.9	26.2	28.0	25.3	1.04	0.413
C16:0	212.9	221.8	213.3	213.9	222.1	232.4	4.48	0.038
C18:0	370.3	366.4	387.2	384.3	367.1	376.5	9.96	0.570
C20:0	4.5^{ab}	4.5^{a}	4.1^{abc}	3.6^{bc}	3.4^{c}	3.3^{c}	0.21	0.001
odd numbered[2]	19.2^{c}	19.5^{c}	22.1^{b}	25.0^{a}	25.3^{a}	22.6^{b}	0.45	0.000
Monoenoic FA	341.7	337.1	325.2	326.0	330.5	316.0	9.62	0.534
C16:1	13.6	13.9	13.4	13.8	14.9	14.5	0.81	0.772
C17:1	3.1	3.1	3.3	3.8	3.9	3.2	0.18	0.014
total C18:1	319.6	315.0	304.3	304.3	307.3	294.5	8.70	0.465
C18:1*cis*	280.5	277.6	263.8	267.2	269.3	250.5	8.52	0.226
C18:1n-9c[3]	262.2	259.8	246.8	251.0	251.8	232.1	8.54	0.223
C18:1n-7c	9.0^{a}	8.5^{ab}	8.2^{ab}	7.4^{b}	8.0^{ab}	8.1^{ab}	0.28	0.023
C18:1n-6c	2.2^{ab}	2.1^{ab}	1.8^{b}	1.8^{b}	2.2^{ab}	2.8^{a}	0.16	0.002
C18:1n-2t/n-4c	4.7^{b}	4.8^{b}	4.6^{b}	4.8^{b}	5.0^{ab}	5.4^{a}	0.11	0.001
C18:1*trans*	39.1	37.3	40.5	37.0	38.0	44.0	2.53	0.394
C18:1n-12t	5.7	5.9	6.1	5.8	5.9	5.0	0.31	0.180
C18:1n-9t - n-7t	32.9	31.0	33.9	30.9	31.7	38.8	2.24	0.151
C20:1n-9	2.1^{a}	1.8^{ab}	1.4^{bc}	1.1^{cd}	1.1^{cd}	0.9^{d}	0.09	0.000
Polyenoic FA	24.7^{a}	23.3^{ab}	22.3^{ab}	20.0^{b}	22.5^{ab}	22.9^{ab}	0.79	0.017
C18:2n-6	18.8^{a}	17.6^{ab}	17.1^{ab}	15.4^{b}	17.6^{ab}	17.8^{ab}	0.56	0.011
C18:2 conjugated	3.1	3.1	3.1	2.7	2.8	3.3	0.20	0.394
C18:3n-3	2.7^{a}	2.6^{a}	2.1^{ab}	1.9^{b}	2.1^{ab}	1.8^{b}	0.14	0.001

[1] SEM = standard error of the means. LS means by treatment, n = 6. Mean values within the same line sharing no common superscript are significantly different (P<0.05)

[2] C15:0, C17:0 and C19:0

[3] other C18:1 isomers possibly included are n-12c and n-6t to n-3t

canola lecithin was used, and elevated when canola oil and canola seed were fed (significant only in intermuscular fat). In contrast, proportions of C18:3n-3 were lowest with deoiled canola lecithin and deoiled soya lecithin with significant differences from the canola seed diet in both fats and from the canola oil diet in kidney fat. No significant differences were found in proportions of conjugated linoleic acid (CLA), but in intermuscular fat there was a trend towards higher values for soya lecithin and lower values for the deoiled canola lecithins.

DSC melting properties of intermuscular fat did not show any significant treatment differences (Table 5). With deoiled canola lecithin onset temperature was slightly higher, but offset temperatures and total enthalpy were similar to the other

groups. All melting profiles had two clearly separated peaks. A trend ($P<0.1$) for the maximum of peak 1 ranging at a lower temperature was found for the canola seed diet and for the soya lecithin diet, whereas the maximum of peak 2 was at a similar temperature for all diets. Neither total nor partial enthalpies clearly differed between groups. However, the relative enthalpy of the first peak was numerically highest for the canola oil and seed diet and lowest for the soya lecithin. Vice versa, the relative enthalpy of the second peak tended to be highest for the soya lecithin and lowest for the canola oil and seed diets.

DISCUSSION

In the present study, virtually no differences were found between the canola oil and the canola seed group, both of which were used as control groups. Previously, equivalence of the effects of unsupplemented and canola seed-supplemented rations in performance and carcass quality of bulls was described using similar types of rations (Sutter et al., 2000). Providing canola oil in an amount of 30 g/kg as done in the present study, obviously did not impair rumen digestion to an extent that is typical of oils rich in polyenoic FA (Nagaraja et al., 1997).

The results of the present study indicate that canola lecithins provided in amounts corresponding to 30 g/kg diet on a FA basis do not affect growth performance and feed conversion efficiency when replacing canola oil. Zinn (1989) found that the replacement of yellow grease and blended animal-vegetable-fat by raw soya lecithin had no effect on growth performance of steers either and Mathison (1978) found no significant effect on feed efficiency and carcass characteristics when adding to a steer diet up to 30 g/kg of rape seed gum, the non-dehydrated lecithin from the oil refining process. Due to the reason given above, differences between lecithin diets and the oil as well as oilseed diet might have been more pronounced when soyabean oil and whole soyabeans had been used instead of canola oil and seed. Nonetheless, despite its much higher content of polyenoic FA, the use of deoiled soya lecithin also did not impair growth performance and feed conversion efficiency. So this type of lecithin seems to have a reduced efficiency against (fibre) digestion in the rumen which supports the hypothesis of a certain rumen inertness of (deoiled) lecithins. When comparing a diet supplemented with soya lecithin and a diet containing crushed canola seed in lambs, Lough et al. (1991) found higher daily gains with soya lecithin but, like in the present experiment, an equal feed conversion efficiency due to the simultaneously higher feed and energy intake. The soya lecithin fed lambs expressed a higher dressing percentage than those fed canola seed and the carcasses were fatter (Lough et al., 1991). This is contrary to the present experiment with bulls, where no differences in dressing percentage occurred, and bulls from two lecithin groups, raw canola and deoiled

soya lecithin, showed a trend towards lower carcass fatness (fatness score, kidney fat proportion, intramuscular fat content).

Increased odd-numbered FA contents in body fats are related to higher microbial activity in the rumen since lipids of rumen microbes have relatively high proportions of odd-numbered FA, which result from FA synthesis starting with propionate (Jilg et al., 1988). The higher proportion of odd-numbered FA found with all canola lecithins suggests that these lecithins did not affect microbial *de novo* FA synthesis as much as canola oil or seed did. This is partly confirmed by correspondingly somewhat higher concentrations of propionate in rumen fluid at slaughter with the canola lecithins (9.8 mmol/l) relative to canola oil (9.1 mmol/l) but not relative to canola seed (10.8 mmol/l). The intermediate proportion of odd-numbered FA in body tissues found with the use of deoiled soya lecithin suggests that the soya lecithin effects on rumen microbes are slightly higher than those of canola lecithins and slightly lower than those of canola oil. This corroborates with the higher content of polyenoic FA in soya lecithin (Nagaraja et al., 1997). Rumen fluid propionate concentration with deoiled soya lecithin (10.7 mmol/l) was, however, even slightly higher than with the canola lecithins. Though not significant, the rumen fluid ammonia concentration showed the same trend towards reduced values with lecithins as had been found *in vitro* (Wettstein et al., 2000), an effect which might be due to the amphiphatic properties of lecithins (Jenkins et al., 1989). These allow the formation of complexes of lecithin and protein, thus possibly reducing protein degradation in the rumen. However, in the present study this did not increase crude protein or absorbable protein utilisation although the contents of calculated absorbable protein were slightly below the recommended allowance. Consequently, it may be concluded that protein was either still not a limiting factor in the metabolism of the bulls or that the protein complex building effect of lecithins was too weak to substantially increase protein flow to the small intestine.

The three fat tissues investigated responded quite similarly to the variation in dietary FA despite the clear general differences in fatty acid composition occurring among them. The reaction was, however, generally more pronounced and alike in intermuscular fat and kidney fat than in intramuscular fat. Generally, in intramuscular fat the amount of intramuscular phospholipids remains quite constant and the proportion of unsaturated FA in the phospholipids is high (Demeyer and Doreau, 1999). Therefore, a low intramuscular FA content coincides with an elevated proportion of unsaturated FA in total intramuscular lipids. This may have masked in part the trend observed in the other body fats.

The ratio of desired CLA to less desired C18:1-*trans* FA was much lower in body fat of the bulls compared with the ratio found in milk fat when similar types of lecithin were fed to dairy cows earlier (Wettstein et al., 1999). In intramuscular fat the proportion of C18:1-*trans* was less than 2/3 of the C18:1-*trans* percentage found in the two depot fats. Since the biochemical properties of *trans*-monoenoic

FA are more similar to those of saturated FA than to those of *cis*-monoenoic FA (Precht and Molkentin, 1995) this difference between body fats might be explained by the specific composition of the intramuscular lipids with their high content of phospholipids (Demeyer and Doreau, 1999).

As far as the lipid sources used in this study are concerned, effects on body fat composition were extraordinarily low when whole canola seed replaced canola oil. Obviously, ruminal biohydrogenation of unsaturated FA present in the canola lipids was either generally low or similar in both lipid sources. The latter would question a clear rumen-protective property of the oil when provided together with the seed hulls.

The use of various types of canola lecithins instead of oil also mostly had only weak effects on body fat composition. Despite clear differences in the percentage of several important FA such as C16:0, C18:1, C18:2 and C18:3 between the canola oil and the canola lecithin diets, corresponding alterations in the body fats remained weak or did not exist. In contrast, the lower proportions of C20:0 and C20:1 in canola lecithins compared with the oil were reflected to a certain extent in C20 FA proportion of kidney fat and, to a lower extent, in inter- and intramuscular fat. The values found with canola oil and lecithins in the proportions of the unsaturated FA do not support the hypothesis of a lower ruminal biohydrogenation of the lecithins. The weak trend towards a higher DSC melting onset temperature of intermuscular fat with raw and deoiled canola lecithin relative to the other groups might be explained by the slightly higher content of saturated FA, particularly C18:0. C18:0 was identified to be decisive for the melting properties of bovine fat (Casutt et al., 1999). Accordingly, the slightly lower relative enthalpy of peak 1 in intermuscular fat with the canola lecithins relative to oil might have resulted from the slightly decreased C18:1-*cis* proportion.

Generally, the clearest effects on body fat composition were found when using deoiled soya lecithin instead of (deoiled) canola lecithin although even these differences were small and far lower than in the feed. As expected from the dietary lipid composition, the proportions of C16:0 and polyenoic FA were slightly higher and some C18:1 isomers as well as C20 FA showed a trend towards lower proportions (in part significant) with the use of soya lecithin. Similar effects were reported by Lough et al. (1992) for subcutaneous adipose tissue of lambs with C16:0, C20 and C18:2 when canola seed in feed was exchanged by deoiled soya lecithin. In contrast, Lough et al. (1992) found higher proportions of C18:1 with soya lecithin which might be explained by the associated increase in carcass fatness observed with soya lecithin (Demeyer and Doreau, 1999) whereas in the present experiment fatness was not affected by soya lecithin. Using sunflower seed as another source of C18:2 more clearly increased the C18:2 proportion in subcutaneous fat and kidney fat when compared with canola seed (Casutt et al., 2000).

The higher C18:1n-6-*cis* proportion presently found with soya lecithin presumably can be explained by the higher content of C18:2n-6 of soya lecithin compared with the canola lecithins since C18:1n-6-*cis* is described as a product of biohydrogenation of C18:2n-6 by certain rumen microbes (Harfoot and Hazlewood, 1997). This also coincides with the slightly higher proportion of C18:1-*trans* FA in intramuscular fat with soya lecithin. *Trans* FA are formed during biohydrogenation of C18:2 (Harfoot and Hazlewood, 1997). However, the reasons for higher proportions of C18:1n-12-*trans* with canola lipids instead of soya lecithin (significant in intramuscular fat) remain unclear. Interestingly, the proportion of C18:2 in kidney fat and intermuscular fat was highest with canola oil followed by canola seed and not with soya lecithin as expected from the FA composition of the diet. Therefore the question arises whether canola oil and seed inhibit rumen microbes to a greater extent so resulting in less effective biohydrogenation than with lecithins. This would correspond to the findings of higher proportions of odd-numbered FA with the canola lecithins. However, the differences in fat composition as occurring between the soya lecithin and canola lecithin fed bulls were not high enough to cause significant effects on melting properties of intermuscular fat.

CONCLUSIONS

The present study demonstrated that, when offered in complete rations to fattening bulls in an amount equivalent on a fatty acid basis, the various tested lecithins allowed a growth performance and carcass composition similar to canola oil and seed. Therefore, it can be assumed that they supply similar amounts of net energy as the corresponding oils when adjusted to the same fatty acid content. Further processing of canola lecithins such as deoiling had only minor effects and seems to be of limited use when lecithins are supplemented at relatively low proportions. On the other hand, deoiling might be a key procedure to avoid adverse effects on rumen fermentation when higher amounts, particularly of soya lecithin, are used. It further remains a matter of conjecture under which conditions lecithins might reduce ruminal protein degradation and so would be advantageous in protein-limited rations. Furthermore, the results illustrate that the use of any of the canola lecithins remains without major consequences on body fat tissue composition when replacing canola oil. Consequently, when lecithins are supplemented to a low-fat ration, similar effects on depot fat composition as well as on its technological and sensory properties can be expected as with the use of oil or whole crushed canola seed.

ACKNOWLEDGEMENTS

We are grateful to Prof. M. Wanner, Institute of Animal Nutrition, Faculty of Veterinary Medicine, University of Zurich, and his laboratory for analyzing the volatile fatty acids, and to Dr. H. Leuenberger and the staff of the ETH research station Chamau for their assistance in performing the experiment. We also acknowledge the help of B. Pineroli in the laboratory and the valuable cooperation of the Zurich slaughter plant, namely Dr. Lauper, and of Mr. Lanz of Züri Fleisch.

REFERENCES

Casutt M.M., Scheeder M.R.L., Escher F., Dufey P.-A., Kreuzer M., 1999. Relating texture properties and composition of bovine fat tissue. Fett-Lipid 101, 283-290

Casutt M.M., Scheeder M.R.L., Ossowski D.A., Sutter F., Sliwinski B.J., Danilo A.A., Kreuzer M., 2000. Comparative evaluation of rumen-protected fat, coconut oil and various oilseeds supplemented to fattening bulls. 2. Effects on composition and oxidative stability of adipose tissues. Arch. Anim. Nutr. 53, 25-44

Demeyer D., Doreau M., 1999. Targets and procedures for altering ruminant meat and milk lipids. Proc. Nutr. Soc. 58, 593-607

DLG (Deutsche Landwirtschaftsgesellschaft), 1997. DLG-Futterwerttabellen Wiederkäuer. 7th Edition. DLG-Verlags GmbH, Frankfurt am Main (Germany)

Drochner W., Heller R., 1996. Neue Ergebnisse zum Einsatz geschützter Fette bei Wiederkäuern. Übers. Tierernähr. 24, 52-61

FAG (Forschungsanstalt für viehwirtschaftliche Produktion), 1994. Fütterungsempfehlungen und Nährwerttabellen für Wiederkäuer. 3rd Edition. Landwirtschaftliche Lehrmittelzentrale, Zollikofen (Switzerland)

GSF (Genossenschaft für Schlachtvieh und Fleischversorgung), 1994. Einschätzungssystem für grosses Schlachtvieh und Schlachtkälber. Finkenhubelweg 11, CH-3001 Bern (Switzerland)

Harfoot C.G., 1981. Lipid metabolism in the rumen. In: W.W. Christie (Editor). Lipid Metabolism in Ruminant Animals. Pergamon Press, Oxford (UK), pp. 21-55

Harfoot C.G., Hazlewood G.P., 1997. Lipid metabolism in the rumen. In: P.N. Hobson, C.S. Stewart (Editors). The Rumen Microbial Ecosystem. 2nd Edition. Blackie Academic and Professional, London (UK), pp. 382-426

IUPAC (International Union of Pure and Applied Chemistry), 1987. Standard Methods for the Analysis of Oils, Fats and Derivates. 7th Edition. Blackwell Scientific Publications, Oxford (UK)

Jenkins T.C., Fotouhi N., 1990. Effects of lecithin and corn oil on site of digestion, ruminal fermentation and microbial protein synthesis in sheep. J. Anim. Sci. 68, 460-466

Jenkins T.C., Gimenez T., Cross D.L., 1989. Influence of phospholipids on ruminal fermentation in vitro and on nutrient digestion and serum lipids in sheep. J. Anim. Sci. 67, 529-537

Jilg T., Aiple K.P., Steingass H., 1988. Fettstoffwechsel und Wirkungen von Futterfetten beim Wiederkäuer. Übers. Tierernähr. 16, 109-152

Kreuzer M., Gerhardy H., Ossowski D., Voss, G.E.M., 1995. Improved storage and dietetic properties of carcass fat tissues in growing Holstein as well as Charolais × Holstein bulls fed full-fat rapeseed. Arch. Anim. Breed. 38, 163-175

Lough D.S., Solomon M.B., Rumsey T.S., Elsasser T.H., Slyter L.L., Kahl S., Lynch G.P., 1991. Effects of dietary canola seed and soy lecithin in high-forage diets on performance, serum lipids, and carcass characteristics of growing ram lambs. J. Anim. Sci. 69, 3292-3298

Lough D.S., Solomon M.B., Rumsey T.S., Elsasser T.H., Slyter L.L., Kahl S., Lynch G.P., 1992. Effects of dietary canola seed and soy lecithin in high-forage diets on cholesterol content and fatty acid composition of carcass tissues of growing ram lambs. J. Anim. Sci. 70, 1153-1158

Mathison G.W., 1978. Rapeseed gum in finishing diets for steers. Can. J. Anim. Sci. 58, 139-142

Nagaraja T.G., Newbold C.J., van Nevel C.J., Demeyer D.I., 1997. Manipulation of ruminal fermentation. In: P.N. Hobson, C.S. Stewart (Editors). The Rumen Microbial Ecosystem. 2nd Edition. Blackie Academic and Professional, London (UK), pp. 523-632

Naumann K., Bassler R., 1997. Die chemische Untersuchung von Futtermitteln. Methodenbuch. Vol. III. 3rd Edition. VDLUFA-Verlag, Darmstadt (Germany)

Pardun H., 1988. Die Pflanzenlecithine: Gewinnung, Eigenschaften, Verarbeitung und Anwendung pflanzlicher Phosphatidpräparate. Verlag für chemische Industrie H. Ziolkowsky K.G., Augsburg (Germany)

Precht D., Molkentin J., 1995. *Trans* fatty acids: implications for health, analytical methods, incidence in edible fats and intake. Nahrung 39, 343-374

SAS 1996. SAS/STAT User's Guide: Statistics, Version 6.12, SAS Institute Inc., Cary, VC (USA)

Sutter F., Casutt M.M., Ossowski D.A., Scheeder M.R.L., Kreuzer M., 2000. Comparative evaluation of various oilseeds, coconut oil and rumen-protected fat in the nutrition of fattening bulls. 1. Effects on growth, carcass and meat quality. Arch. Anim. Nutr. 53, 1-23

Tangerman A., Nagengast F.M., 1996. A gas chromatographic analysis of fecal short-chain fatty acids, using the direct injection method. Anal. Biochem. 236, 1-8

Wettstein H.-R., Machmüller A., Kreuzer M., 2000. Effects of raw and modified canola lecithins compared to canola oil, canola seed and soy lecithin on ruminal fermentation measured with Rumen Simulation Technique. Anim. Feed Sci. Tech. 85, 153-169

Wettstein, H.-R., Sutter, F., Machmüller, A., Scheeder, M.R.L., Kreuzer, M., 1999. Effect of partial replacement of rumen-protected fat by various plant lecithins on nutrient digestion and milk composition in dairy cows. In: G. Stone, T.D.A. Forbes, J.W. Stuth, F.M. Byers (Editors). Nutritional Ecology of Herbivores. San Antonio, TX (USA)

Yoon C.S., Jung K.K., Bae D.H., 1986. Effect of crude soybean lecithin supplementation on the digestibility, rumen and blood fatty acid composition in sheep. Korean J. Anim. Sci. 28, 488-499

Zinn R.A., 1989. Influence of level and source of dietary fat on its comparative feeding value in finishing diets for steers: feedlot cattle growth and performance. J. Anim. Sci. 67, 1029-1037

STRESZCZENIE

Wpływ lecytyn canoli i soi w porównaniu z olejem i nasionami canoli na wyniki produkcyjne, jakość tuszy i skład tłuszczu ciała rosnących buhajów

Opasane buhaje, brunatne szwyce, o początkowej masie ciała 170 kg, żywiono dawkami pasz z dodatkiem surowych lub preparowanych (odolejonych lub odolejonych/częściowo hydrolizowanych) lecytyn canoli lub odolejonych lecytyn sojowych w ilości 30 g/kg s.m. kwasów tłuszczowych. Porównano je także z dawkami uzupełnionymi olejem z canoli lub gniecionymi nasionami canoli.

Nie stwierdzono różnic w przyrostach, wykorzystaniu paszy oraz cechach tusz buhajów z różnych grup żywieniowych. Zwiększony udział kwasów tłuszczowych o nieparzystej liczbie atomów węgla w tłuszczu ciała wskazuje, że lecytyny w mniejszym stopniu mogą wpływać na przebieg fermentacji w żwaczu niż oleje. Tendencja w zmianach stężenia amoniaku w żwaczu sugeruje, że przy podawaniu lecytyn zmniejsza się degradacja białka w żwaczu. Zawartość wielonienasyconych kwasów tłuszczowych w tłuszczu nerkowym i miedzymięśniowym była największa przy podawaniu oleju canoli. Profil kwasów tłuszczowych tłuszczu ciała w większym stopniu zależał od pochodzenia lecytyn (canola lub soja) niż pochodzenia oleju lub technologicznej modyfikacji lecytyn.

W podsumowaniu stwierdzono, że lecytynami canoli można zastąpić olej z canoli bez większego wpływu na wzrost buhajów oraz wydajność rzeźną, i tylko na pewne zmiany w składzie tłuszczu tuszy.