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A note on the effect of different amounts and types of fat on the fatty acid composition of duodenal digesta in sheep

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ABSTRACT

Three experiments were carried out on four rams of 40±5 kg body weight fitted with rumen and duodenum cannulas in a 4 x 4 Latin square design. The animals were fed a 1200 g daily basal ration consisting of meadow hay and concentrate (60:40) in two equal portions at 08.00 and 18.00 h. The basal diet was supplemented with rape seed oil, hydrogenated rape seed oil or linseed oil in respective experiments in amounts equal to 0, 4, 8 or 10% dry matter of the diet. Duodenal digesta was analyzed for fatty acid content. Fat addition, independent of the amount of vegetable fat, decreased the polyunsaturated fatty acid level but increased that of monounsaturated fatty acids, consequently causing an increase in the sum of poly- and monounsaturated fatty acids in the duodenal digesta.

KEY WORDS: sheep, dietary fat, duodenum, fatty acids

INTRODUCTION

The role of nutrition in the prevention of many diseases in humans has been widely studied during the last decade. Consumers are increasingly looking for products with specified compositions, mainly in terms of fatty acids and some other chemopreventive agents associated with fat. The fatty acid composition of

ruminant products can be altered by nutrition. According to Wagner et al. (1998) long chain fatty acids reaching the duodenum enter, after absorption from the small intestine, directly into milk fat. Saturated fatty acids reaching the duodenum such as C 18:0 are partly desaturated by intestinal and mammary desaturase activity (Kennelly and Glimm, 1998). Products containing n-3 polyunsaturated fatty acids are the most desirable as polyunsaturated fatty acids play an essential role in brain and retinal physiology (Carrie et al., 2000). Feeding ruminants different fat sources can be a way of increasing the energy density of the diet and also of achieving products with a preferred, from the health promotion point of view, fatty acid composition (Bauman et al., 2001; Newbold et at., 2001).

The aim of the present experiment was to establish the effect of different vegetable oils given in sheep diets: rape seed oil as a source of C 18:1 and C 18:2, linseed oil as a source of C 18:1 and C18:3, and hydrogenated rape seed oil containing saturated and unsaturated fatty acids, on the fatty acid composition of duodenal digesta.

MATERIAL AND METHODS

Three experiments were carried out on 4 rams of 40±5 kg body weight fitted with rumen and duodenum cannulas in a 4 x 4 Latin square design. The basal ration for all animals in each experiment consisted of meadow hay and concentrate (60:40). The energy value of the basal rations was 5.06 MJ EN per kg, whereas the crude protein content was 118 g per kg. The daily 1200 g basic ration was divided into two equal portions and fed at 08.00 and 18.00 h. The basic ration was supplemented in the respective experiments with: 0 – control group, 4, 8 or 10% (in dry matter of the diet) rape seed oil (RSO), hydrogenated rape seed oil (HRSO) or linseed oil (LSO). Throughout all of the experiments water was available *ad libitum*.

Each experiment consisted of four 16-day trials, 14 days of adaptation to the diet and two days for duodenal digesta collection. Ten percent aliquots of total duodenal digesta entering the duodenum were taken and frozen until fatty acid analysis. The fatty acid content in duodenal digesta was determined according to the procedures of Heinig et al. (1998), modified by Czauderna et al. (2001).

All data were subjected to statistical analysis using SAS procedures (User's Guide, 1990).

RESULTS

The effect of different origin and amount of fat included into the diet for sheep on fatty acid composition in duodenal digesta is shown in Tables 1, 2 and 3.

TABLE 1

Fatty acid concentration in duodenal digesta of sheep fed diets supplemented with rape seed oil,%

Fatty acids	Fat added to basal diets, %			
	0	4	8	10
C 10:0	0.23	0.33[a]	0.25	0.11[a]
C 12:0	0.32	0.50	0.37	0.51
C 14:0	0.64	0.72[a]	0.52	0.35[a]
C 16:0	13.51[a]	10.47[b]	7.86	5.99[ab]
C 18:0	29.16	36.65	3.45	32.02
SFA[1]	44.16	48.67	40.46	39.00
MUFA[2]	45.51	44.08[a]	55.27	58.01[a]
PUFA n-3	1.30	1.44	0.94	0.69
PUFA n-6	9.03	5.81	3.32	2.29
PUFA[3]	10.33	7.25	4.27	2.98
MUFA+PUFA	55.84	51.33	59.54	60.99

means in rows with the same letter differ significantly [abc]- P≤ 0.05

[1] saturated fatty acids

[2] monounsaturated fatty acids

[3] polyunsaturated fatty acids

TABLE 2

Fatty acid concentration in duodenal digesta of sheep fed diets supplemented with hydrogenated rape seed oil, %

Fatty acids	Fat added to basal diets, %			
	0	4	8	10
C 10:0	0.30[ab]	0.18	0.12[a]	0.10[b]
C 12:0	0.35[a]	0.26	0.25	0.21[a]
C 14:0	0.71[ab]	0.55	0.50[b]	0.51[a]
C 16:0	15.54[ab]	1.16	11.17[a]	10.10[b]
C 18:0	29.08	31.91[a]	28.00	27.41[b]
SFA[1]	46.86[ab]	46.65[c]	40.46[a]	38.67[bc]
MUFA[2]	45.01[bc]	48.45[a]	55.20[c]	57.82[ab]
PUFA n-3	1.26[abc]	0.85[a]	0.71[b]	0.63[c]
PUFA n-6	6.87[abc]	4.06[a]	3.63[b]	2.88[c]
PUFA[3]	8.13[bc]	4.90[a]	4.43[c]	3.50[ab]
MUFA+PUFA	53.14[abc]	53.36[a]	59.53[b]	61.33[c]

means in rows with the same letter differ significantly [abc]- P≤ 0.05

[1, 2, 3] - as in Table 1

TABLE 3

Fatty acid concentration in duodenal digesta of sheep fed diets supplemented with linseed oil,%

Fatty acids	Fat added to basal diets, %			
	0	4	8	10
C 10:0	0.14	0.23	0.15	0.08
C 12:0	0.27	0.33	0.23	0.21
C 14:0	0.40	0.58	0.45	0.25
C 16:0	7.63	10.33[a]	7.31	5.22[a]
C 18:0	27.36	33.04	29.14	26.84
SFA[1]	35.80	44.80	37.54	32.88
MUFA[2]	59.99	51.09	59.43	65.02
PUFA n-3	1.06	1.05	1.02	0.78
PUFA n-6	3.16[a]	3.05[b]	2.15	1.50[ab]
PUFA[3]	4.22	4.10	3.18	2.29
MUFA+PUFA	64.21[a]	55.19[b]	62.62	67.30[ab]

means in rows with the same letter differ significantly [abc]- $P \leq 0.05$

[1,2,3] - as in Table 1

Addition of rape seed oil caused changes in C 10:0, C 14:0, C 16:0 and MUFA (monounsaturated fatty acids) levels in relation to the control diet. Feeding the diet with 4% RSO increased the level of C 10:0 and C 14:0 and decreased the level of C 16: 0, whereas 10% RSO decreased the level of these saturated fatty acids in duodenal digesta. RSO as the source of MUFA (mostly C 18:1) increased the level of these fatty acids in the duodenum, reaching statistical significance when 10% RSO was given in the diet but when 8% RSO was fed RSO did not influence the PUFA level.

Hydrogenated rape seed oil fed at a 10% level in the diet decreased the proportion of all saturated fatty acids and of C 10:0, C 14:0 and C 16:0 when 8% HRSO was added to the ration. As a consequence, a decreased level of SFA was noticed when 8 or 10% HRSO was fed. The addition of 4% HRSO to sheep rations did not influence particular fatty acid levels in the duodenum. MUFA and PUFA n-3, and n-6 and consequently total PUFA levels increased significantly when 4, 8 and 10% HRSO was added. The concentration of MUFA and PUFA increased ($P<0.05$) when 8 and 10% HRSO was added to the ration.

Feeding the diet with 4% linseed oil increased the level of C 16:0 and decreased that of duodenal PUFA n-6 and the sum of MUFA and PUFA in digesta. Supplementing 10% LSO decreased the level of C 16:0 and PUFA n-6 but increased the sum of MUFA and PUFA in digesta, as a consequence of increased MUFA.

DISCUSSION

According to Elliot et al. (1999) flows of total C 16, total C 18, and the total fatty acids reaching the duodenum were increased by supplemental fat (partially hydrogenated tallow, hydrogenated tallow and hydrogenated free fatty acids). Also other authors indicated increased flow of fatty acids to the duodenum when rape seed (Hussein, 1996), calcium soaps of rape seed fatty acids (Kowalski, 1997), and rape seed oil (Potkański et al., 2001) were fed to ruminants. The effect of fat supplementation on fatty acid composition depends on the nature and the technological treatment of these supplements.

Our experiments also demonstrated that all kinds fat of vegetable origin added to the diet caused a decrease in saturated but increase of total unsaturated, particularly monounsaturated, fatty acid proportions in duodenal digesta, which is the consequence of higher intake of unsaturated fatty acids. At the same time the decreased proportion of C 18 polyunsaturated n-3 and n-6 family acids could be explained by the hydrogenation of these acids in the rumen, which is in agreement with the results of Cieślak et al. (2001) on hydrogenation of different sources and amounts of unsaturated C 18 acids in the rumen of sheep.

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STRESZCZENIE

Wpływ różnych źródeł tłuszczu na przepływ kwasów tłuszczowych w dwunastnicy owiec

Przeprowadzono trzy doświadczenia, w układzie kwadratu łacińskiego, na czterech trykach o średniej masie ciała 40±5 kg z kaniulami do żwacza i dwunastnicy. Zwierzęta żywiono dawką podstawową, 1200 g/dzień, złożoną z siana łąkowego i mieszanki treściwej (60:40%) w grupach kontrolnych, uzupełnioną w kolejnych doświadczeniach olejem rzepakowym, olejem lnianym bądź uwodornionym olejem rzepakowym w ilości 4, 8 i 10% suchej masy dawki. Paszę podawano w dwóch równych porcjach, o godzinie 08.00 i 18.00. W próbach treści dwunastnicy, reprezentujących dobowy przepływ treści, oznaczano wyższe kwasy tłuszczowe. Zastosowane dodatki tłuszczu roślinnego spowodowały, niezależnie od dodanej ilości, spadek zawartości wielonienasyconych kwasów tłuszczowych przy jednoczesnym wzroście kwasów jednonienasyconych, co w konsekwencji prowadziło do wzrostu poziomu sumy nienasyconych kwasów tłuszczowych.