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The effects of different amounts and types of fat on the extent of C18 unsaturated fatty acid hydrogenation in the rumen of sheep*

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ABSTRACT

The experiments were carried out in a 4 x 4 Latin square design on 4 rams of 40±5 kg body weight, fitted with permanent rumen and duodenal cannulas, to determine the influence of fat source and amount in the ration on the extent of C18 unsaturated fatty acid hydrogenation in the rumen. The basic ration for the control group consisted of meadow hay and concentrate (60:40). For the experimental groups this ration was supplemented with vegetable fat in the form of rape seed oil, hydrogenated rape seed oil, or linseed oil at a level of 0 (control), 4, 8 or 10% in dry matter of the diet. There was no influence of the type and amount of vegetable fat on the level of biohydrogenation except in the diet containing 10% hydrogenated rape seed oil, which resulted in increased ($P<0.05$) C18 unsaturated fatty acid hydrogenation in the rumen of sheep.

KEY WORDS: ruminal biohydrogenation, fatty acids, fat, sheep

INTRODUCTION

Biohydrogenation of unsaturated fatty acids in the rumen is defined mostly as the disappearance of linoleic and linolenic acid between the mouth and duodenum

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(Chillard at al., 2000). It is recommended that saturated fatty acids contribute no more than 10% of dietary energy (Williams, 2000). Current consumer demand for unsaturated fatty acids in food has considerably increased interest in studying biohydrogenation. The extent of ruminal biohydrogenation depends mainly on the type and quantity of dietary fatty acids, but there is no clear relation between the amount and origin of dietary lipids and biohydrogenation. According to LaChanda et al. (1998) supplementing ruminant diets with unsaturated vegetable oils has only a limited capacity of increasing unsaturated fatty acids in body tissues. This is because in the rumen, long-chain fatty acids containing 18 carbon atoms are biohydrogenated in a stepwise process. At each step of biohydrogenation, a particular fatty acid can either pass out of the rumen or be biohydrogenated further (Moate et al., 2000). Nevertheless, manipulation of ruminant diet composition is the best way of improving unsaturated fatty acid concentrations in milk and meat for consumption.

The objective of this study was to determine the effect of fats differing in fatty acid composition on the extent of C18 unsaturated fatty acid hydrogenation in the rumen of sheep.

MATERIAL AND METHODS

The experiments were carried out in a 4 x 4 Latin square design on 4 rams of 40±5 kg body weight fitted with permanent rumen and duodenal cannulas to determine the influence of fat source and amount in the ration on the extent of C18 unsaturated fatty acid hydrogenation in the rumen. Experiments consisted of four 16-day trials, 14 days of adaptation to the diets and 2 days of sample collection. The basic ration for the control group consisted of meadow hay and concentrate (60:40), which for the experimental groups was supplemented with vegetable fat in the form of hydrogenated rape seed or linseed oil at a level of 0 (control), 4, 8 or 10% in dry matter of the diet. Drinking water was available *ad libitum* throughout the experiment. The energy value of the rations was 5.06 MJ EN per kg, whereas the crude protein content was 118 g per kg DM. The daily ration was divided into two equal portions and fed at 08.00 and 18.00 h.

During the two days of sample collection, samples of duodenum digesta representing 10% of total digesta passage were collected continuously from the sheep. Samples were frozen for further analysis. Total and individual fatty acid contents in feed and duodenum digesta samples were determined according to the procedures of Heinig et al. (1998), modified by Czauderna et al. (2001). Biohydrogenation in the rumen of unsaturated acids supplied with different sources of fat was calculated as described by Zinn et al. (2000) by subtracting the sum of the 18-carbon unsaturated fatty acids in the control and treated groups:

$$\text{Biohydrogenation} = 100 - 100 \times (A/B - C/D),$$

where:
A – amount of all C18 unsaturated fatty acids reaching the duodenum
B – amount of all C18 fatty acids reaching the duodenum
C – amount of all C18 unsaturated fatty acids in the diet
D – amount of all C18 fatty acids in the diet.

The obtained data obtained was analyzed using SAS® procedures (Users' Guide, 1990).

RESULTS

The content of C18 fatty acids in the diets is shown in Table 1. The level of fatty acids in the digesta of the duodenum and treatment effects on C18 fatty acid biohydrogenation are given in Table 2. Biohydrogenation of unsaturated fatty acids was not affected ($P>0.05$) by dietary treatments, regardless of the source and amount of added fats, with the exception of the diet supplemented with 10% hydrogenated rape seed oil, which increased ($P<0.05$) the extent of C18 fatty acid

TABLE 1

Dietary fatty acid content in the diets, g/day

Fats/acids	0%	4%	8%	10%
Rape seed oil				
linoleic acid	0.14	0.41	1.35	1.68
linolenic acid	1.32	2.94	7.22	8.90
oleic acid	0.99	5.46	14.42	18.18
stearic acid	0.11	0.35	0.81	1.05
Hydrogenated rape seed oil				
linoleic acid	0.14	0.20	0.35	0.17
linolenic acid	1.36	1.89	3.16	1.62
oleic acid	0.80	2.86	6.15	5.85
stearic acid	0.12	0.86	1.47	1.65
Linseed oil				
linoleic acid	0.21	0.31	0.30	0.53
linolenic acid	1.79	0.99	0.80	1.16
oleic acid	1.49	1.09	1.27	2.22
stearic acid	0.21	0.22	0.31	0.89

[a, b, c] – means with the same letter are significantly different ($P<0.05$)

TABLE 2

Content of fatty acids in duodenum, g/d, and biohydrogenation value, %

Level of added fat	0%		4%		8%		10%	
Fats/acids	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Rape seed oil								
linoleic acid	0.26	26.2	0.26	23.2	0.14	7.1	0.23	30.4
linolenic acid	2.01	17.5	1.11	51.4	0.55	23.4	0.77	2.0
oleic acid	1.63	30.3	1.10	17.9	0.87	13.9	1.65	12.1
stearic acid	6.77	46.7	9.65	45.5	5.67	39.3	10.19	22.4
biohydrogenation	61.76	12.2	73.87	16.0	76.42	7.6	78.01	4.8
Hydrogenated rape seed oil								
linoleic acid	0.16	40.6	0.28	50.5	0.12	146.9	0.21	25.5
linolenic acid	0.97	33.5	1.48	54.6	0.88	160.0	0.99	13.2
oleic acid	1.22	46.9	2.24	83.8	1.36	162.1	1.48	19.3
stearic acid	5.00	51.5	12.71	57.3	5.64	144.2	10.97	35.2
biohydrogenation	64.44[a]	11.6	72.85	4.7	65.90	8.4	74.79[a]	9.4
Linseed oil								
linoleic acid	0.20	41.6	0.34	14.3	0.38	41.8	0.44	25.6
linolenic acid	0.68	35.9	0.94	11.2	0.88	24.3	0.86	19.7
oleic acid	0.67	53.7	1.35	16.2	0.96	47.0	1.11	23.2
stearic acid	7.35	23.5	11.72	30.9	13.27	39.7	16.12	34.2
biohydrogenation	81.52	12.5	79.00	9.0	82.97	5.1	83.19	3.1

[a, b, c] – means with the same letter are significantly different ($P<0.05$)

biohydrogenation from 64.4% in the group without added fat to 74.8%. Although a tendency to increase the extent of biohydrogenation in other experimental groups fed diets with added fat was observed, these differences were not significant in comparison with the control group. Differences in the extent of fatty acid biohydrogenation between different types of added fat can be seen in Table 2. The level of biohydrogenation in groups of sheep fed diets with linseed oil was higher when compared with groups with rape seed or hydrogenated rape seed oil.

DISCUSSION

Ruminal biohydrogenation is extensive in most cases, on average 80 and 92% for linoleic and linolenic acids, respectively. The extent of ruminal biohydrogenation depends mainly on the type of diet; when concentrates comprise more than 70% of the diet, biohydrogenation averages only 50 and 65% for linoleic and linolenic acids, respectively (Chilliard et al., 2000). This is a result of a drop in pH

caused by a high starch level. On our experiment, the composition of the diet and level of different types of added fats had no influence on the extent of biohydrogenation, except in the group where 10% hydrogenated rape seed oil was added. According to Doreau et al. (1997), hydrogenation apparently does not depend on fatty acid intake, although it has been shown that it was low when the fatty acid concentration in the diet was lower than 10g kg^{-1} DM intake. Based on the findings of Beam et al. (2000), high linoleic acid concentrations in the diet would possibly reduce biohydrogenation and increase the postruminal flow of this unsaturated fatty acid. In the case of our experiments high concentrations of oleic, linolenic and linolenic acids in the diet did not modify the quality or quantity of fatty acids reaching the duodenum except in the diet containing 10% hydrogenated rape seed oil, which resulted in increased ($P<0.05$) C18 unsaturated fatty acid hydrogenation in the rumen of sheep. We also observed differences in the extent of biohydrogenation between sources of fat added to the diets. The level of biohydrogenation in groups fed diets with linseed oil was higher when compared with the groups receiving rape seed or hydrogenated rape seed oil.

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STRESZCZENIE

Wpływ dodatku tłuszczu na stopień biouwodornienia nienasyconych kwasów tłuszczowych (NKT) z rodziny C18 w żwaczu owiec

Celem przeprowadzonych doświadczeń było określenie poziomu biouwodorowania kwasów tłuszczowych z rodziny C18 w żwaczu owiec żywionych dawką z dodatkiem tłuszczu roślinnego - oleju rzepakowego, uwodorowanego oleju rzepakowego lub oleju lnianego. Doświadczenie przeprowadzono na 4 skopach, o masie ciała 40±5 kg, z założonymi przetokami żwacza i dwunastnicy, w układzie kwadratu łacińskiego 4 x 4. Zwierzęta grupy kontrolnej karmiono dawką podstawową składającą się z 60% siana i 40% paszy treściwej uzupełnioną w grupach kontrolnych 4, 8 i 10% dodatkiem tłuszczu oleju rzepakowego, uwodorowanego oleju rzepakowego bądź oleju lnianego. Badane dodatki tłuszczu nie miały statystycznie istotnego wpływu na poziom biouwodorowania w żwaczu nienasyconych C18 kwasów tłuszczowych, z wyjątkiem grupy owiec karmionych dawka z dodatkiem 10% uwodorowanego oleju rzepakowego; stwierdzono u nich zwiększenie ($P<0,05$) poziomu uwodorowania kwasów tłuszczowych z rodziny C18.