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The effects of different amounts and types of fat on metabolites 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 (40±5 kg) fitted with permanent rumen cannulas to determine the effects of fat source on basic rumen parameters. The basic ration for the control group consisted of meadow hay and concentrate (60:40) and was supplemented for experimental groups with rape seed oil, hydrogenated rape seed oil, or linseed oil at a level of 0 (control), 4, 8 and 10% in dry matter of concentrate. Samples of rumen fluid were analyzed for ammonia, volatile fatty acid (VFA) concentrations, and pH. VFA profiles, except of the level of isovaleric acid, were not influenced by the type of fat when rape seed oil or hydrogenated rape seed oil was added to sheep rations ($P<0.05$; $P<0.01$). A significant ($P<0.05$; $P<0.01$) decrease in the ammonia level was found when 4, 8 and 10% of rape seed oil was supplied to the ration. The addition of rape seed oil caused an increase ($P<0.01$) in pH in the group with 10% fat supplementation. Hydrogenated rape seed oil and linseed oil have no influence on the rumen pH level. Diets for ruminants can be supplemented with up to 10% of vegetable origin fat as an additional energy source without altering ruminal fermentation when the proper forage: concentrate ratio is maintained.

KEY WORDS: sheep, fat, volatile fatty acids, ammonia, pH

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INTRODUCTION

Accurate estimates of energy and protein values of diets is important because of the large quantities of these nutrients required by high producing ruminants. Diets that do not provide adequate energy and protein reduce milk production, cause excessive weight loss, impair reproduction and may decrease resistance to disease (Weiss, 1998). Rumen microorganisms break down plant material to provide the energy and protein required for their growth and during this process, they produce volatile fatty acids (VFAs) and ammonia as waste products (Garnsworthy, 1997). Fat supplements in ruminant rations can have a deleterious effect on these basic rumen parameters, as well as on rumen pH. The response by ruminants to supplementary fat is complex and not always predictable.

The aim of the experiment was to determine the effect of different kinds of vegetable origin fat added as an additional energy source on the levels of basic metabolites such as VFA and ammonia, and on pH in the rumen fluid.

MATERIAL AND METHODS

Animals and diets

The experiments were carried out in a 4 x 4 Latin square design on 4 rams (40±5 kg) fitted with permanent rumen cannulas to determine the effects of fat source on basic rumen parameters. The basic ration for the control group consisted of meadow hay and concentrate (60:40), which was supplemented for the experimental groups with rape seed oil, hydrogenated rape seed oil, or linseed oil at a level of 0 (control), 4, 8 and 10% in dry matter of the diet.

The energy value of the rations was 5.06 MJ EN/kg, whereas the crude protein content was 118 g/kg. The daily ration was divided into two equal portions and fed at 08.00 and 18.00 h. Water was continuously available.

Sampling and analysis

The experiments consisted of four 16-day trials, 14 days for adaptation to the diet, the last two for sample collection. Samples of the rumen fluid were collected before the morning feeding and 3 and 6 h after feeding (Grummer et al., 1993). pH was measured potentiometrically, ammonia according to Conway (1962), and individual volatile fatty acids by gas chromatography as described by Ziołecki and Kwiatkowska (1973).

Statistical analysis

All data were analyzed using SAS procedures (User's Guide, 1990).

RESULTS

The ruminal VFA profiles observed in the experiments did not indicate modification except for the level of isovaleric acid when rape seed oil (Table 1) and hydrogenated rape seed oil (Table 2) were added to the sheep ration. A slight but significant ($P<0.05$) decrease in the level of isovaleric acid was observed when 8% of hydrogenated rape seed oil was added, and a significant ($P<0.05$) increase was seen when 10% hydrogenated rape seed oil was added. A significant decrease ($P<0.05$; $P<0.01$) in the level of isovaleric acid in all experimental groups was recorded when 4, 8 and 10% of rape seed oil was added. No changes were observed in other groups, regardless of the source and level of fat added. The concentrations of VFAs when linseed oil was added are presented in Table 3. The ammonia level decreased significantly ($P<0.05$; $P<0.01$) (Table 4) when 4, 8 and 10% of rape seed oil was added to rations. Similar trends were observed when hydroge-

TABLE 1

Effect of rape seed oil on concentration of individual VFA in the rumen of sheep, mmol/L

Rape seed oil,%	0		4		8		10	
	mean	CV	mean	CV	mean	CV	mean	CV
Acetic acid	85.18	27.83	72.02	28.11	74.10	30.86	67.11	26.62
Propionic acid	20.91	28.04	22.19	34.07	21.52	36.10	22.06	32.70
Butyric acid	11.54	40.87	12.04	24.58	12.75	30.90	10.06	31.98
Isobutyric acid	1.67	19.18	1.55	26.33	1.66	24.61	1.41	18.45
Valeric acid	2.12	54.57	1.86	58.75	1.83	57.80	1.77	56.86
Isovaleric acid	2.90^{ABa}	19.90	1.54^{BC}	35.90	1.78^{Cab}	33.26	1.35^{Ab}	24.00

means in rows with the same letter differ statistically significant ^{A,B,C} – $P<0.01$; ^{a,b,c} – $P<0.05$

TABLE 2

Effect of hydrogenated rape seed oil on concentration of individual VFA in the rumen of sheep, mmol/L

Hydrogenated rape seed oil,%	0		4		8		10	
	mean	CV	mean	CV	mean	CV	mean	CV
Acetic acid	72.86	19.41	68.38	23.91	68.25	21.02	65.37	20.59
Propionic acid	19.99	27.20	21.80	30.62	20.29	28.03	23.69	44.13
Butyric acid	13.13	19.67	10.02	27.59	11.35	39.48	10.19	27.66
Isobutyric acid	1.57	13.84	1.56	22.07	1.43	22.25	1.57	13.75
Valeric acid	1.85	49.40	1.83	47.03	1.58	42.87	1.79	55.55
Isovaleric acid	1.45	16.78	1.48	36.80	1.17^{a}	32.46	1.61^{a}	39.52

means in rows with the same letter differ statistically significant ^{A,B,C} – $P< 0.01$; ^{a,b,c} – $P<0.05$

TABLE 3

Effect of linseed oil on concentration of individual VFA in the rumen of sheep, mmol/L

Linseed oil,%	0		4		8		10	
	mean	CV	mean	CV	mean	CV	mean	CV
Acetic acid	66.30	28.39	65.93	16.38	59.09	28.14	59.01	21.94
Propionic acid	18.11	31.60	20.95	26.20	16.64	29.42	21.36	39.88
Butyric acid	13.51	47.92	13.16	19.51	10.03	31.82	9.64	17.53
Isobutyric acid	1.49	29.48	1.57	21.27	1.29	18.80	1.35	16.94
Valeric acid	1.86	58.13	1.65	33.81	1.50	55.13	1.59	44.61
Isovaleric acid	1.48	23.39	1.51	17.56	1.19	19.10	1.43	23.00

means in rows with the same letter differ statistically significant ^{A,B,C} – $P<0.01$; ^{a,b,c} – $P<0.05$

TABLE 4

Concentration of rumen ammonia in sheep fed diets with different source of fat supplementation, mmol/L

Supplemented oil,%	0		4		8		10	
	mean	CV	mean	CV	mean	CV	mean	CV
Rape seed oil	7.67^{AB}	37.78	6.18^{a}	36.85	5.42^{B}	43.32	6.11^{Aa}	9.05
Hydrogenated rape seed oil	4.05	52.41	3.97	57.91	3.61	55.33	2.32	60.35
Linseed oil	3.23	66.45	3.10	52.79	2.58	63.72	3.25	67.96

means in rows with the same letter differ statistically significant ^{A,B,C} – $P<0.01$; ^{a,b,c} – $P<0.05$

nated rape seed oil and linseed oil were added, but the differences were not significant. The addition of rape seed oil caused an increase ($P<0.01$) in the pH (Table 5) in the group receiving 10% fat supplementation. Hydrogenated rape seed oil and linseed oil had no influence on rumen pH.

TABLE 5

Mean rumen pH in sheep fed diets with different source of fat supplementation

pH	0		4		8		10	
	mean	CV	mean	CV	mean	CV	mean	CV
Rape seed oil	6.88^{C}	5.09	6.75^{A}	7.56	6.72^{B}	11.74	8.06^{ABC}	2.43
Hydrogenated rape seed oil	6.28	5.20	7.18	13.07	6.36	10.58	6.96	6.51
Linseed oil	6.80	15.05	6.66	5.14	6.62	9.39	6.70	11.67

means in rows with the same letter differ statistically significant ^{A,B,C} – $P<0.01$; ^{a,b,c} – $P<0.05$

DISCUSSION

Volatile fatty acids are produced in the rumen by microbial fermentation of carbohydrates and protein. The concentration of acetic, propionic and butyric acids and their proportions are related to the level of feed intake (Sutton, 1985) and the composition of the diet (Murphy et al., 1982). High forage diets deliver substrates for microorganisms and do not alter fermentation in the rumen. There is considerable interest in modification of rumen fermentation towards increasing the efficiency of production of ruminant animal products (Hobson and Stewart, 1997). Possible ways of altering rumen fermentation include modification of the diet and use of feed additives. Fat added to ruminant rations as an additional source of energy can alter rumen fermentation by inhibiting species of microorganisms that are prominent in cellulose degradation, and thus production of the main VFAs and ammonia. In the presented experiment, diets supplemented with fat had no effect on the level of these fatty acids. Neither composition of the diet, nor addition of fat influences VFA levels. According to Jenkins (1993) fat that normally inhibits fermentation and digestion often causes less inhibition when the hay content of the basal diet is high. Similar observations have been made by Tackett et al. (1996) who fed cows high forage diets with 10% added rape seed oil.

Most efforts are aimed at increasing the ability of rumen microorganisms to assimilate ammonia, thus reducing nitrogen loss to the animal (Hobson and Stewart, 1997). The level of ammonia, the major source of nitrogen for bacteria in the rumen, was affected only by adding rape seed oil, but in all groups the ammonia level was sufficient for maximal microbial growth yield. Addition of fat supplements had no influence on rumen pH. It is important to maintain the proper pH because some rumen microorganisms, such as cellulolytic bacteria, fail to grow at low pH (<6.0), which leads to a decrease in dry matter intake, fibre digestibility and microbial yield, and increased feed costs. Boila et al. (1993) and Madison Anderson et al. (1997) also did not observe rumen disturbances in experiments on adding fat to ruminant diets. When the proper forage:concentrate ratio is maintained, diets for ruminants can be supplemented with up to 10% vegetable origin fat as an additional energy source without altering fermentation in the rumen.

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STRESZCZENIE

Wpływ rodzaju i ilości dodanego do diety tłuszczu na niektóre metabolity w żwaczu owiec

Doświadczenie, którego celem było zbadanie wpływu rodzaju i ilości dodanego tłuszczu do diety składającej się z siana i mieszanki treściwej (60:40%) na zmiany stężenia niektórych metabolitów w żwaczu, przeprowadzono na 4 trykach z trwałymi kaniulami żwaczowymi, w układzie kwadratu łacińskiego 4 x 4. Do dawki podstawowej dodawano tłuszcze pochodzenia roślinnego - olej rzepakowy, uwodorniony olej rzepakowy lub olej lniany w ilości 0 (grupa kontrolna), 4, 8 i 10% suchej masy paszy treściwej. Określono poziom lotnych kwasów tłuszczowych, amoniaku oraz pH płynu żwaczowego. Stwierdzono statystycznie istotne różnice ($P<0,05$; $P<0,01$) w poziomie kwasu izowalerianowego u owiec otrzymujących dodatek oleju rzepakowego oraz uwodornionego oleju rzepakowego. Stwierdzono również statystycznie istotny ($P<0,05$; $P<0,01$) spadek poziomu amoniaku we wszystkich grupach otrzymujących dodatek oleju rzepakowego do dawki. Dodatek 10% oleju rzepakowego do paszy spowodował statystycznie istotny ($P<0,01$) wzrost poziomu pH w żwaczu.

Dodatek tłuszczu roślinnego, w ilości 10%, do dawek dla owiec nie spowodował istotnych zmian w procesach fermentacji żwacza.