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A note on the effect of diet and type of fat on cellulose degradability in the rumen of sheep

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ABSTRACT

The effect of diet type and fat addition on cellulose degradability was estimated on four rams fitted with rumen cannulas in a 4x4 Latin square design experiment. The animals were fed diets composed of 100% meadow hay (1st trial) or 40% meadow hay and 60% concentrate (2nd trial). Diets were supplemented with 0, 4, 8 or 10% rape seed oil, linseed oil or tallow. There were three experiments in each trial. Effective degradability of cellulose may vary among different fat sources and type of diet. Adding rape seed oil decreased effective degradability and when the animals were given meadow hay (1st trial), differences were significant ($P \leq 0.05$). A decrease was observed in effective degradability when linseed oil was added to meadow hay (1st trial), but the differences were not significant, whereas linseed oil added to concentrate-hay rations (2nd trial) significantly ($P \leq 0.05$) increased effective degradability. Adding tallow had no effect on effective cellulose degradability in the rumen of sheep.

KEY WORDS: rumen, fat, cellulose degradability, *in sacco*, sheep

INTRODUCTION

High producing ruminants require additional energy in the diet from supplementary sources. Traditional sources of energy like high starch diets result in rapid fermentation in the rumen, decreased pH, which may inhibit forage-digesting bacteria (Garnsworthy, 1997). Inclusion of fat in ruminant diets increases energy density without depressing dry matter intake, however, high levels of fat can reduce fibre digestibility (Honing van der and Tamminga, 1986; Tackett et al., 1996). Kowalczyk et al. (1977) maintain that lipids inhibit growth of cellulolytic bacteria, reducing fibre digestibility. According to Holter et al. (1993) unsaturated fats, rape

seed or linseed oil, can have a detrimental effect on ruminal microbiota particularly cellulolytic ones, while saturated fats like tallow have a minimal effect on rumen bacteria.

The present study was undertaken to determine the influence of different types of fat given to sheep fed hay or hay-concentrate diet, on cellulose degradability in the rumen.

MATERIAL AND METHODS

Animal, feed and feeding

Four rumen-cannulated rams (mean body weight 50±3 kg) were fed four diets in a 4x4 Latin square design in 16-d periods. The first 14 days were used for adaptation to the diet, the last two days for sample collection. Six experiments were carried out in two trials, three experiments in each trial. In the first trial diets were formulated on the basis of 100% meadow hay chopped into 5 cm length pieces, in the second, diets were formulated on the basis of 40% meadow hay and 60% concentrate. In both trials feeds were supplemented with 0, 4, 8 and 10% of rape seed oil (RSO), linseed oil (LSO) and tallow (TAL) in dry matter. The daily ration was divided into two equal portions and fed at 08.00 and 16.00. The energy value of the rations was 5.31 MJ NE / kg, whereas the crude protein content was 144 g per kg. Water was available *ad libitum* throughout the experiments.

Estimation of rate of degradation of cellulose in sacco

Nylon bag incubations in the rumen started on day 15. The pore size of bags was 46 μm. Bags contained approximately 1 g cellulose. Samples were incubated for 0, 2, 4, 6, 8, 10, 12, 16, 24 and 48 h. After withdrawal from the rumen, bags were washed with running tap water and stored at –18°C. Degradation data were fitted in two mathematical models (Stensig et al., 1994).

Model of Ørskov and McDonald (1979) (1):

$$Y(t) = a + b(1 - e^{-ct}) \quad (1)$$

and the revised model of McDonald (1981) (2):

$$Y(t) = a \qquad \text{for } t \le t_o$$
$$Y(t) = a + b(1 - e^{-c(t-to)}) \qquad \text{for } t > t_o \quad (2)$$

where
Y(t) – the degraded part at time t
a – the intercept with the Y-axis

b – the insoluble but potentially degradable fraction
c – the degradation rate constant (h^{-1})
t – the incubation time (h)
t_o – the lag time (h)

Effective degradability (ED) was calculated according the equation given by Ørskov and McDonald (1979):

$$ED = a + \frac{bc}{c + k}$$

where a, b, c values come from model (2) and k is the fractional rate of passage.

Statistical analysis

The results were subjected to statistical analysis of variance using the SAS software program (User's Guide, 1990).

RESULTS AND DISCUSSION

The ability to predict animal performance on diets containing different quality of roughages by using simple, reliable and cheap techniques is becoming important in animal nutrition (Khazaal et al., 1993). In our experiments to determine effective degradability of cellulose in sheep we used the *in sacco* method, which is more suitable than *in vitro* methods because rumen micro-organisms need time to adapt to new conditions, and *in vitro* methods therefore tend to underestimate microbial degradation at short incubation times (Stensig et al., 1994; Noziere and Michalet-Doreau, 1996). The results obtained from our experiments indicate that effective degradability (ED) may vary among different fat sources and type of diet (Tables 1 and 2). More important than the quantity of fatty acids in the diet is their type, since long-chain unsaturated fatty acids have a detergent effect on bacterial cell walls (Garnsworthy, 1997). Khorasani et al. (1991) reported that a high concentration of fat containing polyunsaturated fatty acids inhibits growth of micro-organisms and fibre digestibility. Also Tackett et al. (1996) found that unprotected fat may cause disturbances in ruminal fermentation that lead to reduced fibre digestibility. Palmquist (1984) suggests that the negative influence of fat on digestibility is less conspicuous if the dietary fibre intake is high. In our experiments, adding RSO decreased the ED degradability in all diets. In the first experiment, where the animals were given meadow hay, the differences were statistically significant ($P \leq 0.05$). A decrease was observed in ED when linseed oil (LSO) was

TABLE 1

Cellulose effective degradability (ED) in the rumen of sheep fed diet composed of 100% meadow hay

	Diet			
	I	II	III	IV
RSO	47.3^{c} ± 7.1	42.7^{b} ± 6.9	33.5^{a} ± 5.4	33.5^{a} ± 4.9
LSO	54.2^{c} ± 10.2	44.1^{a} ± 7.0	45.2^{a} ± 6.8	49.8^{b} ± 9.3
TAL	44.2 ± 7.0	48.8 ± 9.0	48.7 ± 9.2	40.2 ± 5.7

^{a,b,c} – $P \leq 0.05$

TABLE 2

Cellulose effective degradability (ED) in the rumen of sheep fed diet composed of 40% meadow hay and 60% concentrate

	Diet			
	I	II	III	IV
RSO	37.7 ± 10.2	38.9 ± 10.1	34.4 ± 5.0	36.4 ± 9.4
LSO	46.1^{a} ± 8.0	50.3^{b} ± 9.0	48.0^{a} ± 9.3	60.1^{c} ± 11.0
TAL	44.2 ± 7.6	43.3 ± 7.0	45.1 ± 6.7	43.4 ± 6.8

^{a,b,c} – $P \leq 0.05$

added to meadow hay, but the differences were not significant. According to Ben Salem et al. (1993) negative effects of lipids on rumen digestion were less important when fibre intake was high, whereas addition of LSO to concentrate-hay rations increased ED from 46.19 in a control diet to 50.30, 48.01 and 60.10, respectively in the 2nd, 3rd and 4th diets; the differences were significant ($P \leq 0.05$).

Addition of fat rich in saturated fatty acids has a less detrimental effect on cellulose degradability. In our experiments addition of TAL had no effect on ED in the rumen of sheep. Also according to Weigel et al. (1997) tallow, which contains mostly saturated fatty acids, can be fed without affecting ruminal fermentation and nutrient digestibility.

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STRESZCZENIE

Wpływ dodatku tłuszczu i rodzaju skarmianej diety na efektywną degradację celulozy w żwaczu owiec

Przeprowadzono sześć doświadczeń na czterech trykach z trwałymi kaniulami żwaczowymi, w których testowano wpływ rodzaju diety składającej się z siana (100%) bądź siana i mieszanki treściwej (40:60%) oraz dodanego tłuszczu w postaci oleju rzepakowego (doświadczenie I i II), oleju lnianego (doświadczenie III i IV), lub łoju (doświadczenie V i VI), w ilości 0, 4, 8 lub 10% w suchej masie, na efektywną degradację (ED) celulozy w żwaczu owiec. Otrzymane wyniki wskazują, że rodzaj skarmianej diety oraz dodanego tłuszczu wpływają na efektywny rozkład celulozy w żwaczu. Dodatek oleju rzepakowego obniżył ED w obydwóch doświadczeniach, z tym, że w doświadczeniu, w którym podstawę diety stanowiło siano łąkowe różnice były statystycznie istotne ($P \leq 0,05$). Podobnie, dodatek oleju lnianego do diety składającej się wyłącznie z siana łąkowego obniżył ED, jednakże różnice nie były statystycznie istotne. Dodatek oleju lnianego do dawki, której podstawę stanowiła mieszanka treściwa zwiększył natomiast istotnie ($P \leq 0,05$) ED w grupie drugiej i trzeciej. W przeprowadzonych doświadczeniach nie stwierdzono wpływu dodatku łoju na efektywną degradację celulozy w żwaczu owiec.