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The effect of a forage diet and different fat sources on rumen fermentation *in vitro*[*]

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ABSTRACT

An experiment lasting 13 days was carried out using a Rusitec system (rumen simulation technique). The effect of a forage diet (100% fresh lucerne - control) and sources of fat supplements (linseed LO, rapeseed RO, fish FO oils, 5% wt.wt^{-1}) on rumen fermentation was studied. To ensure a steady-state within the fermentation control vessel, a 7-day adaptation period preceded the 6-day collection period. Every day portions of a fresh lucerne diet with a 5% addition of LO, RO or FO were supplied to the fermentation vessels. Oil supplementation (LO, RO, FO) did not affect the basal parameters of rumen fermentation (pH, total VFA production, dry matter and detergent fibre digestibility) in comparison with the control. The oils, mainly LO and FO, significantly reduced the mol% of acetate and n-butyrate, and increased the mol% of propionate, while rapeseed oil only slightly (NS) affected these parameters of rumen fermentation. The oils (LO, FO, RO) supplemented to the forage diet did not affect the efficiency of microbial protein synthesis.

KEY WORDS: artificial rumen, lucerne, oils, rumen fermentation

INTRODUCTION

Fat is supplemented to the diets of ruminants to increase energy density, improve nutrient utilization, enhance milk and meat yields, and affect fatty acid composition (Bauman et al., 2003). The type of diet fed to ruminants influences

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rumen fermentation and many studies suggest different relationships between diet, ruminal pH and digestion parameters when ruminants are fed fresh pasture compared with a total mixed ration (TMR) (Wales et al., 2004). In the present study, the effect of forage diets supplemented with rapeseed, linseed and fish oils (5% wt·wt^{-1}) on rumen fermentation in an artificial rumen was studied.

MATERIAL AND METHODS

Animals and diets

The rumen simulation technique (Rusitec) described by Czerkawski and Breckenridge (1977) was used in this experiment.

Three ruminally cannulated Slovak Merino sheep (mean body weight 43.6±2.5 kg) were used as the donor. The animals were fed a fresh lucerne diet - control (1200 g of DM daily). In the Rusitec, all fermentation vessels were supplied with 30 g (8.94 g DM) of fresh lucerne together with the addition of fat supplements, 5% wt·wt^{-1}: LO, RO, and FO. The chemical composition of fresh lucerne was as follows, %: dry matter 30.0; nitrogen 4.74%; ash 15.86; NDF 22.13; ADF 14.75; cellulose 13.88; hemicellulose 7.38 and lignin 0.86. The rapeseed, linseed and fish oils were obtained from commercial sources.

Measurements and chemical analyses

The experiment in the Rusitec lasted 13 days. To ensure a steady state within the vessels, a 7-day adaptation period preceded the a 6-day collection period. On days 8-13 the samples were collected and analysed for volatile fatty acids (VFA), nitrogen and ammonia nitrogen (NH_3-N) in effluent and dry matter, NDF and ADF, ash and nitrogen in feed and residual feed (undigested feed samples), respectively. Other fermentation variables, i.e. fermentation efficiency, organic matter fermented (OMF), nitrogen incorporated by microflora (N_M), efficiency of microbial protein synthesis (EMS), were calculated according to the stoichiometry of rumen fermentation. These procedures are described in a previous study (Jalč and Čertík, 2005).

Statistical analysis

Means of results from treatments were compared with one-way analysis of variance (ANOVA). Treatment means were statistically compared by the Tukey-Kramer multiple comparison test. The tables give the group means and the standard error of the mean.

RESULTS AND DISCUSSION

Fermentation of the diet was carried out at pH 7.11-7.19 and the pH values were slightly lower in all oil-supplemented diets compared with the control (Table 1). The NH_3-N pool produced by degradation of feed nitrogen is the main source of nitrogen used by bacteria for protein synthesis. In this experiment, the concentration of NH_3-N remained about 40 mg ·100 ml^{-1} and was not affected by oil supplementation. The rumen degradation of dry matter (DMD) after 48 h

Table 1. Effect of the diet consisting of fresh lucerne (100%) and supplemented with different oils on the rumen fermentation pattern in a Rusitec (n-6)

Item	The type of added oil (5% wt · wt^{-1})			
	control[a]	LO[b]	RO[c]	FO[d]
pH	7.19 ± 0.04	7.11 ± 0.03	7.13 ± 0.04	7.13 ± 0.04
DMD, %	77.15 ± 2.14	75.26 ± 2.11	76.82 ± 2.35	75.12 ± 2.25
NDF, %	84.11 ± 2.42	82.47 ± 2.56	84.97 ± 3.06	82.34 ± 2.89
ADF, %	83.83 ± 2.48	82.92 ± 3.07	83.74 ± 2.85	82.53 ± 2.56
Hemicellulose, %	84.65 ± 2.98	82.92 ± 3.22[c]	87.65 ± 2.46	82.14 ± 2.06
Cellulose, %	90.12 ± 2.48	89.33 ± 1.95	89.87 ± 2.42	89.19 ± 2.06
NH_3-N, mg · 100 ml	38.11 ± 0.86	39.73 ± 0.72	42.20 ± 0.94	36.27 ± 0.65[c]
VFA, mmol · day^{-1}	41.90 ± 2.42	39.85 ± 2.21	44.21 ± 2.52	42.30 ± 1.85
Acetate	26.10 ± 1.45	20.76 ± 1.82[a]	27.05 ± 1.48[b]	24.16 ± 1.71
Propionate	9.07 ± 0.42	10.88 ± 0.56	10.38 ± 0.54	12.38 ± 0.62[a]
n-butyrate	3.64 ± 0.09	3.91 ± 0.11[d]	3.54 ± 0.10[d]	2.67 ± 0.08[a]
A/P ratio	2.88 ± 0.10	1.90 ± 0.07	2.62 ± 0.09	1.95 ± 0.06
Acetate, mol%	62.3 ± 0.71[b]	52.1 ± 0.43	61.2 ± 0.42	57.1 ± 0.56[a]
Propionate, mol%	21.6 ± 0.72[b]	27.3 ± 0.65	23.4 ± 0.59	29.3 ± 0.72[a]
n-butyrate, mol%	8.7 ± 0.32[b]	9.8 ± 0.45	8.0 ± 0.29	6.3 ± 0.35[a]
E, %	74.95 ± 0.28[c]	78.30 ± 0.35[a]	75.66 ± 0.28[d]	78.12 ± 0.32[a]
OMF, g.day^{-1}	3.84 ± 0.22	3.79 ± 0.14	4.03 ± 0.18	3.92 ± 0.19
N_M, mg.day^{-1}	106.97 ± 4.28	101.54 ± 4.22	106.70 ± 5.02	101.90 ± 4.85
EMS, mg.g^{-1}	28.25 ± 1.06	25.68 ± 1.22	26.92 ± 1.35	26.0 ± 1.27

LO - linseed oil; RO - rapeseed oil; FO - fish oil; DMD - dry matter digestibility; NDF - neutral detergent fibre; ADF - acid detergent fibre; E - energetic efficiency of volatile fatty acids; OMF - organic matter fermented; N_M - nitrogen incorporated by microflora; EMS - efficiency of microbial protein synthesis; ±SEM (standard error of mean); values with the same letter are not significantly different (^{a,b,c,d} $P<0.05$)

of incubation in fermentation fluid was slightly lower ($P>0.05$) with the oils (Table 1). Lipid supplementation of diets mostly reduces rumen degradation of fibre due to physical coating of fibre by lipids (oils) and by inhibition of rumen microbial activity (Devendra and Levis, 1974). The digestibility of NDF, ADF, cellulose and hemicellulose showed no significant differences between control

and oil-supplemented diets. From the three oils used, mainly LO and FO showed a slightly depressive effect on fibre digestion. The molar proportions (mol%) of acetate and n-butyrate were significantly reduced mainly with LO, FO, whereas the mol% of propionate was significantly increased with LO and FO, respectively. The data for acetate and propionate production showed a significant (LO, FO) or slight (RO) decrease in the A/P ratio (Table 1). The energetic efficiency of VFA (E%) was significantly (FO, LO) or slightly (RO) increased. Some reports have indicated a beneficial effect of oils on microbial protein synthesis (Broudiscou et al., 1994), others have described a negative effect (Czerkawski et al., 1975). According to our results, the oils supplemented to the fresh lucerne diet did not affect OMF, N_M or the efficiency of microbial protein synthesis (EMS).

CONCLUSIONS

It can be stated that (a) supplementing oil (LO, RO, FO) at 5% in DM to a fresh lucerne diet did not affect parameters of rumen fermentation (pH, dry matter and detergent fibre digestibility, total VFA production); (b) supplemented LO and FO significantly reduced the mol% of acetate and n-butyrate, and increased the mol% of propionate, while RO only slightly (NS) affected these parameters of rumen fermentation; (c) LO, RO, and FO did not affect the efficiency of microbial protein synthesis.

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