

The effect of a high forage diet and different oil blends on rumen fermentation *in vitro*^{*}

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ABSTRACT

The experiment was carried out in a Rusitec system. The effect of diet (control-fresh lucerne plus maize, 60:40%) and fat sources (linseed LO, rapeseed RO, fish FO oils) as oil blends (LO+RO, FO+LO, FO+LO+RO, 5%wt.wt⁻¹) on rumen fermentation was studied. The experiment lasted 13 days. To ensure a steady state within the Rusitec vessels a 7-day adaptation period preceded a 6-day collection period. The diet with a 5% addition of oil blends, LO+RO, LO+FO, LO+FO+RO, was added to the fermentation vessels daily. Supplementation with blends (LO+RO, LO+FO, LO+FO+RO) did not affect some basal parameters of rumen fermentation (pH, total VFA production, dry matter digestibility) in comparison with the control. Detergent fibre digestibility was significantly reduced, mainly with LO+RO+FO (NDF, ADF, cellulose) and LO+RO (ADF). The oil blends significantly reduced the mol% of acetate, n-butyrate, A/P ratio, and increased the mol% of propionate. The oil blends supplemented to the high forage diet significantly ($P < 0.005$) decreased the efficiency of microbial protein synthesis.

KEY WORDS: artificial rumen, lucerne, maize, oil blends, rumen fermentation

INTRODUCTION

Diets for ruminants should usually be improved in energy using oils as fat supplements. Commercial quantities of oils are obtained from animals, plants, algae, yeasts, filamentous fungi, and bacteria, although vegetable oils are the major sources. Recent

^{*} Supported by the Grant Agency of the Slovak Academy of Sciences, Grant No. 2/6174/6 and the State Committee for Scientific Research (Poland), Grant No. 3 P06Z 05923

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results of many numerous studies support the hypothesis that oils should be supplemented to the ration of ruminants as blends (AbuGhazaleh et al., 2004). In this study, the effect of a high forage diet (fresh lucerne plus maize 60:40%) and its supplementation with fat (rapeseed oil RO, linseed oil LO, fish oil FO as blends: RO+LO, FO+LO, RO+LO+FO) on rumen fermentation in an artificial rumen was studied.

MATERIAL AND METHODS

Animals and diets

The rumen simulation technique and rumen fluid supply of Rusitec equipment and chemical composition of feed was described by Jalč et al. (2006a).

The animals were fed with fresh lucerne (960 g of DM) and crushed maize (240 g of DM) daily. In the Rusitec, all of the fermentation vessels were supplied with 18 g (5.4 g DM) of fresh lucerne and 4.13 g (3.6 g DM) of crushed maize together with the addition of oil blends, 5% wt·wt⁻¹: LO+RO, LO+FO, and LO+FO+RO.

Measurements and chemical analyses

To ensure a steady state within the vessels, a 7-day adaptation period preceded a 6-day collection period. On days 8-13, the samples were collected and analysed for volatile fatty acids (VFA), nitrogen, and ammonia nitrogen (NH₃-N) in effluent; dry matter, NDF and ADF, ash and nitrogen in feed and refusals, respectively. Other fermentation variables, i.e. fermentation efficiency (E), 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 were 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

The fermentation of the diets was carried out at pH 6.88-6.95 (Table 1). The results showed that the NH₃-N concentration was significantly higher in vessels

supplemented with oil blends. The rumen degradation of dry matter (DMD) after 48 h of incubation in fermentation fluid was slightly ($P < 0.05$) reduced with the oil blends supplemented to the high forage diet. Also the apparent digestibility of dry matter and organic matter did not differ significantly when sheep were fed fat ($60 \text{ g} \cdot \text{kg}^{-1}$ fatty acids) from different sources, i.e. linseed, fish oil, linfish (linseed+fish oil; Wachira et al., 2000). In our experiment, the oil blends LO+RO and LO+FO slightly (NS) reduced, and LO+FO+RO significantly reduced, NDF and ADF digestibility (about 7 and 9 percentage units) in the diet. Cellulose and hemicellulose digestibilities were slightly decreased (about 1-4 percentage units) with LO+RO, LO+RO+FO blends and slightly increased with LO+FO blends (about 2-3 percentage units). The oil blend (LO+RO) significantly, and the other oil blends (FO+LO, FO+LO+RO) slightly, reduced acetate production in the high forage diet. The molar proportions of acetate were, however, significantly reduced with all oil blends (Table 1). Supplementation with the LO+FO blend significantly

Table 1. Effect of the diet consisting of fresh lucerne and maize (60:40%) supplemented with oil blends on the rumen fermentation pattern in a Rusitec ($n=6$)

Item	The type of added oil blend (5% wt·wt ⁻¹)			
	control ^a	LO + RO ^b	FO + LO ^c	FO + LO + RO ^d
pH	6.88 ± 0.05	6.91 ± 0.04	6.95 ± 0.06	6.94 ± 0.04
DMD, %	78.91 ± 2.12	72.17 ± 2.21	77.20 ± 2.14	76.65 ± 2.41
NDF, %	82.02 ± 2.32 ^d	75.85 ± 2.35	80.58 ± 2.12	75.08 ± 2.26
ADF, %	82.59 ± 2.31 ^b	75.17 ± 2.14	78.54 ± 2.36	73.15 ± 2.45 ^a
Hemicellulose, %	81.47 ± 2.48	76.82 ± 2.36 ^{c,d}	83.25 ± 2.52	83.25 ± 2.41
Cellulose, %	85.55 ± 2.32	84.26 ± 2.38	88.04 ± 2.42 ^d	82.51 ± 2.35 ^a
NH ₃ -N, mg.100ml	19.35 ± 2.41 ^{b,c,d}	21.83 ± 2.52 ^c	29.03 ± 2.45	24.16 ± 2.38 ^{b,c}
VFA, mmol.day ⁻¹	46.84 ± 1.39	39.32 ± 2.02 ^a	44.83 ± 1.49	43.91 ± 1.07
Acetate	26.76 ± 0.66 ^b	18.27 ± 0.91	23.84 ± 0.78 ^b	24.73 ± 0.64 ^b
Propionate	8.91 ± 0.44 ^c	9.57 ± 0.73 ^c	11.6 ± 0.29 ^d	9.08 ± 0.39
n-butyrate	7.02 ± 0.28 ^c	5.99 ± 0.34	5.32 ± 0.44	6.28 ± 0.23
A/P ratio	3.02 ± 0.07 ^{b,c,d}	1.93 ± 0.07 ^d	1.93 ± 0.07	2.73 ± 0.06 ^c
Acetate, mol%	57.50 ± 0.40 ^{b,c,d}	46.48 ± 0.22 ^{c,d}	53.18 ± 0.11 ^d	56.31 ± 0.12
Propionate, mol%	19.07 ± 0.39 ^{b,c}	24.23 ± 0.88 ^d	25.95 ± 0.53	20.65 ± 0.46 ^c
n-butyrate, mol%	15.0 ± 0.25 ^c	15.24 ± 0.38	11.79 ± 0.68 ^b	14.32 ± 0.50 ^c
E, %	75.05 ± 0.42 ^{b,c}	78.21 ± 0.56 ^d	77.70 ± 0.35	75.68 ± 0.52 ^c
OMF, g.day ⁻¹	4.57 ± 0.21	4.03 ± 0.21	4.30 ± 0.18	4.29 ± 0.22
N _M , mg.day ⁻¹	124.37 ± 4.05 ^{b,c,d}	88.13 ± 3.92 ^c	65.14 ± 3.85 ^d	86.81 ± 4.22
EMS, mg.g ⁻¹	27.33 ± 1.12 ^{b,c,d}	22.21 ± 1.25 ^c	15.26 ± 1.38 ^d	20.28 ± 1.27

LO+RO -mixture of linseed and rapeseed oil; FO+LO - mixture of fish and linseed oil; FO+LO+RO - mixture of all three oils; 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 in a row with different superscripts (^{a,b,c,d}) differ at $P < 0.05$

increased propionate production ($\text{mmol}\cdot\text{day}^{-1}$). The molar proportions of propionate were significantly increased with LO+RO (about 5.2%) and FO+LO (about 6.9%) in comparison with the control diet. The LO+FO blend also caused a decrease in n-butyrate production and its molar proportion in the diet. The calculation data for acetate to propionate production showed a significant ($P<0.005$) decrease of the A/P ratio in the experimental diets. The energetic efficiency of VFA (E,%) significantly increased, mainly with LO+FO and LO+RO. Several reports have indicated both a beneficial effect of PUFA on microbial protein synthesis (Broudiscou et al., 1994) as well as a negative one (Czerkawski et al., 1975). According to our results, all of the oil blends supplemented to the high forage diet significantly decreased EMS (%).

CONCLUSIONS

It can be stated that the oil blends (LO+RO, LO+RO, LO+RO+FO) added at 5% in DM to the high forage diet did not affect rumen fermentation parameters (pH, dry matter, total VFA production); the same oil blends significantly reduced the mol% of acetate (LO+RO, LO+FO), n-butyrate (LO+FO), A/P ratio (all oil blends), and increased the mol% of propionate (LO+RO, LO+FO). Finally, all of the oil blends significantly decreased the efficiency of microbial protein synthesis in the experimental diets.

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