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THE EFFECT OF RAPESEED OIL SUPPLEMENTATION OF WHEAT STRAW, WOOD CELLULOSE, AND TMR ON DRY MATTER, NDF, AND ADF RUMINAL DEGRADATION

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ABSTRACT

The effect of rapeseed oil supplementation of wheat straw (WS), wood cellulose (CEL) and Total Mixed Ration (TMR) on the degradation of dry matter, ADF and NDF in the rumen was determined using the *in sacco* method. Rapeseed oil addition resulted in a significant ($p<0.05$) reduction of degradation of fibre fraction (NDF and ADF) in the rumen, especially after 6- and 12-hour incubation and significant ($p<0.05$) decrease of effective (dg) degradability of NDF and ADF in wheat straw and wood cellulose. However, there were no significant ($p >0.05$) effect of oil supplementation on effective degradability (Dg) of dry matter of all the tested feeds. The differences between control (without oil) and lower level of oil of fat supplementation were much higher than the differences between lower and higher level of oil addition.

Key words: *Rapeseed oil, ADF, NDF, TMR, rumen degradation, in sacco.*

INTRODUCTION

An increased energy concentration in the feed ration, with no change in the ratio of concentrate to bulky feed, may be achieved by adding fat [8, 7, 24]. An advantageous effect of fat addition on milk yield increase has been observed in a series of experiments [11, 18], as well as on an increase in milk fat percentage content and on long-chain fatty acid content in milk [2]. However, an introduction of fat to the feed ration frequently results in disturbances in the rumen processes, inhibition of development of rumen microorganisms [9], reduction of structural carbohydrates digestibility [21], and in a decline in the content of non-fat milk components, primarily crude protein, casein, and non-fat dry matter [3]. According to some authors, it is possible to reduce the adverse effect that added fat unavoidably has on rumen metabolism, and consequently also on the production results, in the case of a high content of structural carbohydrates in the feed [25].

It is the aim of this study to assess an effect of an addition of varied amounts of rapeseed oil to wood cellulose, wheat straw and TMR on the degradation of dry matter and structural carbohydrates in the rumen.

MATERIALS AND METHODS

Two Jersey heifers with the average body weight of 450 kg, fitted with permanent cannulas to the rumen and duodenum, were used in the experiment. Both heifers were each fed *ad libitum* with meadow hay and 2 kg of protein concentrate (100g PDI kg^{-1}). During the experiment, the animals were kept separately in loose boxes with an easy access to automatic drinkers. Chopped wood cellulose (CEL), wheat straw (WS) and total mixed ration (TMR) were mixed with rapeseed oil in the following proportions: 0, 4 and 8% for wood cellulose and total mixed ration and 0, 5 and 10% for wheat straw (S).

The degradation rates for dry matter, NDF, and ADF were determined using the standard *in sacco* method [23]. Bags for rumen testing (280 x 100 mm) were made of Dacron with the mesh size of 46 microns. Feed samples of 5 g were placed in the bags (approximately 19 mg cm^{-2} of the active surface of the bag). Each sample was incubated in the rumen for 3, 6, 12, 24, and 48 hours. The procedure was repeated four times (twice per each heifer). After incubation, bags were transported to the laboratory and stored frozen. Prior to chemical analyses, rumen bags were defrosted and washed in running water until the fluid was clear, and then they were dried in a dryer at the temperature of 40°C. The same procedure was applied in case of control samples, which were not incubated.

The relationship between the disappearance of dry matter or structural carbohydrates from nylon bags (P) and the incubation time (t) was described by a model proposed by Ørskov and McDonald [23]: $P = a + b\,x\,(1 - e^{-c\,x\,t})$, where a is the rapidly soluble fraction; b is the slowly degradable fraction; c is the rate constant of disappearance of fraction b (per hour). Effective rumen degradation of dry matter or structural carbohydrates was calculated as: $Dg = a + (b\,x\,c) / (c + k)$, assuming the rumen outflow rates (k) of 6% h^{-1}. Degradation constants a, b and c were derived using the statistical package Statgraphics (version 5.0).

Dry matter and raw fat were calculated using methods described in AOAC [1]. ADF and NDF were determined by the Van Soest [28] method using the Tecator equipment.

The experiment results were analysed statistically using the one-way analysis of variance and calculating NIR at $\alpha \leq 0.05$ with the Statgrafics statistical package (version 5.0).

RESULTS AND DISCUSSION

Wood cellulose, wheat straw and TMR were characterised by a various content of structural carbohydrates (Table 1). The level of NDF ranged from 94% in wood cellulose and 74% in wheat straw to 28% in TMR, whereas ADF content were from 87 and 46% to 21% respectively.

Table 1. Chemical composition (% dry matter) of wood cellulose, wheat straw and TMR

Items	Crude fat	NDF	ADF
Wood cellulose			
Control, no added oil	-	94.37	87.37
with 4% added oil	5.51	85.66	83.13
with 8% added oil	8.50	84.87	80.91
Wheat straw			
control, no added oil	2.54	73.82	45.92
with 5% added oil	7.12	70.56	42.90
with 10% added oil	12.46	66.67	40.02
TMR			
control, no added oil	4.20	28.38	21.06
with 4% added oil	7.70	27.34	19.61
with 8% added oil	11.05	27.67	18.87

The effect of oil addition on degradability of dry matter, NDF and ADF were measured by *in sacco* method. Madsen *et al*. [19] suggests that *in sacco* is an only adequate method for estimating ruminal degradability of structural carbohydrates. Site-of-digestion techniques have been instrumental in interpreting the influences of fat sources on ruminal digestion and ruminal biohydrogenation [20].

There were no significant ($p>0.05$) effects of oil supplementation on effective degradability (Dg) of dry matter of all the tested feeds: CEL, WS, and TMR (Table 2). However, higher level of oil (8%) decreased significantly, compared to the control, dry matter disappearance of CEL after 3, 6, and 12 hours of incubation. Also significant ($P<0.05$) reduction of rumen dry matter disappearance after 6 and 24 incubation both for 5% and 10% fat levels was observed when rapeseed oil was added to wheat straw (Table 2). Dry matter disappearance of TMR incubated 6 hours in rumen decreased significantly ($p<0.05$) respectively by 6.3 and 9.5% as an effect of 4 and 8% of oil addition. Also Kennely [13], adding 5% of fat to the diet indicated significant reduction in ruminal dry matter degradation. Similarly Tesfa [26] found negative effects of adding rapeseed oil to grass silage on *in sacco* degradabilities of dry matter, NDF and ADF. The obtained results are inconsistent with the observations made by Kalscheur *et al*. [12], who tested an addition of 3.7% of sunflower oil and found no negative effect on either apparent or effective dry matter degradability in the rumen. Ørskov *et al*. [22] reported that *in sacco* degradation was unaffected by 5, 10, 15% of tallow addition to dried grass. Similar results were also observed by other authors [14, 27].

Table 2. Ruminal dry matter degradability (%)

Hours of incubation	Cellulose (CEL)		
	control	4% oil	8% oil
3	1.2a	0.1b	0.2c
6	8.1a	7.8a	4.0b
12	35.0a	34.8a	26.1b
24	88.0	83.5	84.8
48	100	100	100
Dg	43.7	42.4	40.3
	Wheat straw (WS)		
	control	5% oil	10% oil
3	1.2	3.3	6.5
6	12.1a	10.3b	8.7c
12	23.6a	20.2ab	18.5b
24	40.8a	35.7b	32.1c
48	59.5	55.5	55.6
Dg	25.2	22.7	21.8
	TMR		
	control	4% oil	8% oil
3	48.9	49.8	44.5
6	56.7a	50.4b	47.2b
12	72.4a	67.3b	74.3a
24	80.6	81.0	80.4
48	82.9	83.8	82.0
Dg	66.7	64.7	64.5

a, b – $p \leq 0.05$.
Dg – effective rumen degradation.

After 48 hours of incubation, a complete degradation of wood cellulose was observed, while the degree of straw dry matter degradation did not exceed 60% and remained at the same level irrespective of the amount of added oil. This is consistent with the observations reported by Khorasani [14], who also showed that longer incubation time reduced the negative effect of the amount of added fat on dry matter degradation in the rumen.

An increase in fat concentration in wood cellulose, wheat straw and TMR resulted in a significant reduction of NDF degradation in the rumen (Table 3), especially after 3, 6, 12 and 24 hours of incubation (cellulose and straw) and 6, 12 hours of incubation (TMR). Higher level of fat supplementation (8%) decreased significantly effective NDF degradability of CEL, WS by 6.6, 3.6 %respectively.

Table 3. Ruminal NDF degradability (%)

Hours of incubation	Cellulose (CEL)		
	control	4% oil	8% oil
3	6.6a	0b	0b
6	14.0a	14.1a	11.9b
12	35.7a	22.7b	23.1b
24	92.8a	86.8b	82.2b
48	100	100	100
Dg	44.8a	39.5b	38.3b
	Wheat straw (WS)		
	control	5% oil	10% oil
3	8.7	7.6	8.0
6	14.1a	9.5b	9.2b
12	25.6a	20.2b	19.4b
24	32.6a	28.7b	27.4b
48	44.6	43.2	44.7
Dg	23.5a	20.1b	19.9b

Table 3 cont.

	TMR		
	control	4% oil	8% oil
3	15.7	13.8	15.5
6	22.7a	19.0ab	16.7b
12	39.0a	34.5b	33.0b
24	55.8	54.8	52.7
48	62.5	62.8	60.9
Dg	36.8	34.5	33.4

a, b – $p \leq 0.05$.
Dg – effective rumen degradation.

The oil supplementation also decreased significantly ($p<0.05$) ADF effective ruminal degradability of CEL and WS (Table 4). However, the decrease of ADF ruminal degradation was lower than decrease of NDF, which suggested that unsaturated fatty acids from rapeseed oil affected more hemicellulolytic than cellulolytic bacterial activity.

Table 4. Ruminal ADF degradability (%)

Hours of incubation	Cellulose (CEL)		
	control	4% oil	8% oil
3	8.4a	3.2b	4.5b
6	16.2a	14.5a	5.4b
12	39.6a	35.2b	25.4c
24	92.9	88.8	87.3
48	100	100	100
Dg	46.5a	43.3ab	39.2b
	Wheat straw (WS)		
	control	5% oil	10% oil
3	0	0	0
6	7.0a	1.4b	2.4b
12	20.4a	18.1ab	16.6b
24	27.5a	28.6a	23.2b
48	39.4	37.8	38.8
Dg	17.0a	15.3b	14.3c
	TMR		
	control	4% oil	8% oil
3	5.7	4.9	5.5
6	9.8	10.3	8.6
12	32.1a	26.3b	24.7b
24	49.7	46.6	48.2
48	54.8	55.9	52.9
Dg	27.8	26.2	25.5

a, b – $p \leq 0.05$.
Dg – effective rumen degradation.

Higher level of rapeseed oil supplementation significantly ($p<0.05$) decreased ADF ruminal disappearance of wood cellulose after 3, 6, and 12 h incubation, wheat straw after 6, 12 and 24 h incubation and TMR after 12 hours incubation. It confirms the observations made by Lough et al. [17], who noted a significant decrease in the structural carbohydrates digestibility after an addition of at least 8% of fat to wood cellulose. A reduction in the NDF degradation in the rumen was also observed in an experiment conducted by Michalak and Nowak [21], in which the effect of the addition of 3.8 and 9.5% of rapeseed oil to wheat middling was studied. Several mechanisms have been proposed to explain how fats affect structural carbohydrates digestibility in the rumen [4]. The lipid "coating" theory is proposed to cause detrimental effects by inhibiting close contact of microbial cells or their hydrolytic enzymes with feed particles [10], while Luvisetto [16] suggested that fatty acids inhibit ruminal bacteria growth by cytotoxic effects on the membrane disrupting its function.
The changes in fibre digestion when rapeseed oil is added to straw cellulose may arise from the fact that unsaturated fatty acids are more negative for microbial growth than saturated fatty acids. It needs to be noted that

the applied *in sacco* method enables observation of an effect of fat addition on the bacterial activity only. Protozoal action is not taken into account in *in sacco* measurement, because the size of most protozoa species is larger than bag pore size (46 μm). Doreau *et al*. [5] showed that decrease in organic matter and fibre digestibilities with addition of rapeseed oil was not related to a decrease in *in sacco* fibre degradation. Doreau [6] suggested that negative effects of rapeseed oil on protozoa number and activity could explain the lack of consistency. It could be postulated that in the present study the effect of rapeseed oil on fibre digestion could be more detrimental for fibre digestion than measured by the *in sacco* procedure.

CONCLUSIONS

It can be concluded that both levels of rapeseed oil supplementation decreased ruminal degradation of fibre fraction of all the tested feeds. The strongest negative effects were observed for NDF ruminal disappearance suggesting that rapeseed oil could decrease activity of hemicellulolytic bacteria. The application of unprotected fat (rapeseed oil) in feeding high yielding ruminants in order to increase the concentration of energy in the feed ration may significantly reduce the digestibility of structural carbohydrates of bulky feeds, thus resulting in reduced energy value of the ration.

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