THE RUMINAL AND INTESTINAL DEGRADATION ESTIMATES OF EITHER UNTREATED OR PHYSICALLY TREATED RAPESEED MEALS MEASURED BY NYLON BAG TECHNIQUES

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INTRODUCTION

The degradability of feed protein in the rumen is an important indicator of protein value in ruminant feed evaluation. With appropriate physical or chemical treatment it is possible to decrease the rumen degradability of protein in order to increase the availability of protein in the small intestine. However, especially for treated proteins it is necessary to have an assesment of the digestibility of the undegraded protein (Hvelplund and Madsen 1990). The mobile nylon bag technique has been described as a promising method in evaluating the digestibility of undegraded feed protein in the intestine (e.g. Hvelplund 1985, DeBoer et al. 1987), although some more clarification may be needed, before it can be used as a routine method (Hvelplund and Madsen 1990).

The aim of this experiment was to study the effect of commercial heat-moisture treatment (hmt) and the variety of rapeseed (Brassica campestris) cultivar on ruminal and intestinal degradation estimates of rapeseed meals (RSM) by nylon bag technique. Also the importance of pepsin-HCl-treatment (pht) in the mobile bag method was studied.

MATERIALS AND METHODS

The experimental feeds were either untreated or heat-moisture-treated (hmt, Öpex®) rapeseed meals A, B, C, D and soyabean meal (SBM) E as a control. RSMs A (0, untreated) and B (00, hmt) originated from black-seeded varieties and RSMs C (00, untreated) and D (00, hmt) from a yellow-seeded variety. SBM was untreated. In the text the RSMs A and B are referred as black-seeded RSMs and RSMs C and D as yellow-seeded RSMs (see also Aronen and Vanhatalo 1991).

Four rumen-cannulated Finnish Ayrshire bulls were used to estimate the effective protein degradability (EPD) of the feeds in the rumen and to prepare the rumen-undegraded residue of each feed for the mobile bag measurements. The RSMs were incubated in a 4x4 Latin square with feeding periods of 21 d. The rumen degradation of SBM was measured afterwards with the same animals in one period. The animals were fed with two equal portions a day at the level of 80 g dry matter (DM)/kg $W^{0.75}$. On dry matter basis 60 % of the diet was grass silage (crude protein (CP) 170 and crude fibre (CF) 289 g/kg DM), 34 % barley (CP 134 and CF 53 g/kg DM) and 6 % experimental feed.

For rumen degradation studies the feeds were incubated in the rumen for 2, 4, 8, 16, 24 and 48 h. For subsequent mobile bag studies feeds were incubated in the rumen for 10 h. Prior to rumen incubation experimental feeds were milled (2 mm mesh) and weighed (2.5 g DM) in 6 x 12 cm polyester bags with a ratio of pore size (μm) to open cloth surface (% of total cloth area) of 41:33. After withdrawal bags were machine washed for 20 minutes with cold water and the feed residues were oven-dried at 60 °C for 24 h and weighed.

The intestinal degradation of intact feeds as well as rumen-undegraded feed residues was measured by mobile bag technique with four non-lactating Finnish Ayrshire cows equipped with duodenal t-shaped cannula. The composition of the diet, fed at maintenance level, was similar to that of bulls the protein supplement consisting of mix of the experimental feeds.

In the mobile bag technique 1.1 g of feed or rumen-undegraded feed residue was weighed in 3.5 x 5.0 cm heat-sealed polyester bags (10 μm:2%). The bags were introduced into the duodenum either directly or after treatment with pepsin (EC 3.4.23.1.)-HCl-solution (536 units/ml in 0.01 M HCl; 2 h; 37 °C). After collecting bags from the faeces they were machine washed (40 °C) for 50 minutes and further treated as rumen bags described above. For each occacion 15 bags were collected to form one sample for chemical analysis.

Experimental feeds and feed residues after ruminal and intestinal exposure were analysed for DM, Kjeldahl-N, amino acids (Näsi and Huida 1982), neutral detergent fibre (NDF) (Van Soest and Wine 1967) and Kjeldahl-N in NDF (NDF-N).

Rumen degradation charasteristics of protein were calculated by fitting the data to nonlinear equation by Ørskov and McDonald (1979) and true digestibility of protein in the small intestine according to Hvelplund and Madsen (1990). The effect of hmt and variety and with the intestinal data also the effect of pht with appropriate interactions were statistically analysed with analysis of variance. The differences between the treatment means were studied by using orthogonal contrasts.

RESULTS

The protein content of the four RSMs was on an average 395 g/kg DM (Table 1). The total amino acid (TAA) content of hmt RSMs was higher than that of untreated RSMs. The content of NDF and NDF-N in black-seeded RSMs was higher than in yellow-seeded RSMs. However, the CP and TAA contents of SBM were clearly higher and NDF content much lower than in RSMs.

Due to ruminal exposure the NDF content of all feeds was increased (Table 1). The CP content of untreated RSMs were decreased, but not that of hmt RSMs or SBM. The TAA content of rumen-undegraded feeds was increased with untreated RSMs but sligthly decreased with hmt RSMs and SBM.

The disappearance of DM, CP and TAA in the rumen was decreased ($P<0.001$) by hmt, but not affected by variety (Table 2). The disappearance of NDF in the rumen was higher ($P<0.001$) with black-seeded RSMs than with yellow-seeded RSMs. The hmt decreased ($P<0.001$) NDF disappearance of RSMs in the rumen. There were no significant differences in the ruminal DM disappearance between the RSMs and SBM, but in general the CP and TAA disappearance of SBM were lower and the NDF diappearance higher than those of RSMs.

Calculated degradation charasteristics of protein (Ørskov and McDonald 1979) based on several rumen incubation times indicated, that the instantly degradable protein fraction (a) was greater ($P<0.001$) and the slowly degradable fraction (b) was smaller ($P<0.001$) in untreated RSMs compared to hmt RSMs (Table 2). The rate of degradation of slowly degradable fraction (c) as well as the EPD was decreased ($P<0.001$) by

Table 1. Chemical composition of experimental feeds before and after 10 h ruminal exposure in nylon bags

Feed..	A(1)	B(2)	C(3)	D(4)	E(5)
Before exposure					
Dry matter (DM), g/kg	928	925	918	920	922
Crude protein (CP), g/kg DM	404	390	401	385	500
Neutral detergent fibre (NDF), g/kg DM	350	333	276	265	132
NDF-N, g/kg N	153	178	79	88	27
Soluble N, g/kg N	120	68	157	81	96
Total amino acids (TAA), g/kg CP	702	769	698	774	921
After ruminal exposure					
Dry matter, g/kg	945	941	934	937	962
Crude protein, g/kg DM	327	403	328	400	705
NDF, g/kg DM	630	590	634	579	242
NDF-N, g/kg N	342	175	239	174	46
Total amino acids, g/kg CP	745	768	731	769	903

(1) Rapeseed meal (RSM), untreated, black-seeded 0-variety
(2) RSM, heat-moisture treated, black-seeded 00-variety
(3) RSM, untreated, yellow-seeded 00-variety
(4) RSM, heat-moisture treated, yellow-seeded 00-variety
(5) Soyabean meal, untreated

Table 2. Disappearance of experimental feeds from nylon bags incubated in the rumen for 10 h and degradation characteristics of protein

Feed..	A	B	C	D	E	SEM df15	V(1)	H(2)
g/kg								
DM	696	611	711	648	675	13.8	NS	***
CP	753	592	768	646	581	17.9	NS	***
NDF	452	306	341	236	403	26.2	***	***
TAA	752	609	766	674	635	21.6	NS	***
Degradation characteristics of protein								
a(3)	249	140	317	177	133	28.0	NS	***
b(4)	654	756	602	724	889	26.7	NS	***
c(5)	.180	.105	.157	.118	.084	.0013	NS	***
EPD(6)	700	570	712	605	587	12.3	NS	***

(1) Statistical significance of variety;
NS, not significant; ** P<0.01; *** P<0.001
(2) Statistical significance of heat-moisture treatment
(3) constant for the instantly degradable protein fraction
(4) constant for the slowly degradable protein fraction
(5) rate of degradation of b
(6) effective protein (N x 6.25) degradability calculated with k=0.08
For other abbreviations see Table 1.

hmt. However, the c and EPD values of SBM were lower compared to the values of any RSMs. There were no significant (P>0.05) interactions between variety and hmt for any rumen degradation parameters measured.

The pepsin-HCl-treatment (pht) increased the disappearance of feed CP and TAA from mobile bags, but not the disappearance of CP and TAA of rumen-undegraded feeds. Although the effect of pht on protein and TAA disappearance with intact feeds was statistically significant (P<0.05), the difference between the treatment means was small, only on an average 1.5 %. With rumen-undegraded feeds the effect of pht was insignificant. In addition all interactions between pht and other treatments were insignificant. Therefore, the data concerning the pht is not shown.

Disappearance of intact feed DM and CP from mobile bags during transit through the intestine was not affected by variety, but was decreased by hmt (P<0.05) (Table 3). However, the disappearance of TAA of yellow-seeded RSMs was higher (P<0.001) than that of black-seeded RSMs. Disapperance of NDF of black-seeded RSMs from mobile bags was higher (P<0.001) than that of yellow-seeded RSMs and it was decreased (P<0.001) by hmt.

The disappearance of rumen-undegraded feed DM and NDF was higher (P<0.01) from black-seeded RSMs than from yellow-seeded RSMs (Table 3). The CP and TAA disappearance from mobile bags was not affected by variety. Diasappearance of all nitrogenous components of rumen-undegraded RSMs from mobile bags was increased (P<0.001) due to hmt. However, there was an interaction (P<0.05) between variety and hmt for all estimates mentioned except for TAA. The disappearance of intact feed or rumen-undegraded feed components from mobile bags was higher (P<0.001) for SBM than for RSMs (Table 3).

Table 3. Disappearance of intact feeds and rumen-undegraded feeds from mobile bags and estimated true digestibility of protein in the small intestine

Feed..	A	B	C	D	E	SEM df30	V	H
g/kg								
<u>Intact feeds</u>								
DM	678	655	687	667	861	8.4	NS	***
NDF	411	343	312	245	385	10.1	***	***
CP	855	845	855	847	967	5.9	NS	*
TAA	888	885	900	902	969	6.4	***	NS
<u>Rumen undegraded feeds</u>								
DM	421	503	419	487	805	4.4	**	***
NDF	222	150	140	137	290	7.0	***	***
CP	667	766	653	787	967	5.1	NS	***
TAA	778	855	787	848	975	5.8	NS	***
TD (1)	516	639	498	612	920	17.6	NS	***

(1) True digestibility of protein in the small intestine
For other abbreviations see Table 1 and Table 2.

True digestibility of protein in the small intestine (TD) calculated according to Hvelplund and Madsen (1990), was increased (P<0.001) by hmt, but was not affected by variety (Table 3).

DISCUSSION

The most pronounced differences in chemical composition of RSMs was related to the fibre fraction of the feeds. The NDF content of black-seeded RSMs was clearly higher than that of yellow-seeded RSMs. Also the fibre bound N (NDF-N) was higher in black-seeded RSMs.

Due to hmt the CP and NDF contents of feeds were sligthly decreased. The hmt seemed to alter the protein fraction of the RSMs by sligthly increasing the proportion of NDF-N and TAA in total nitrogen. However, the hmt decreased the solubility of RSM protein, the proportion of water-soluble N in total N of hmt RSMs being lower than that of untreated RSMs.

In order to reduce the feed protein degradation in the rumen the most succesful physical treatment has been heat treatment (Walz and Stern 1989). However, many application methods have been used. Accordingly in this study protein degradability of hmt RSMs was reduced (P<0.001) compared to untreated RSMs (EPD 588 v. 706 g/kg). Also Mir et. al. (1984) reported, that the heat treatment reduced significantly protein degradability of canola meal, although the method was not effective to protect soya bean meal from microbial attack in the rumen.

Calculated true digestibility of protein in the small intestine in terms of TD (Hvelplund and Madsen 1990) was significantly increased by hmt but was generally much lower for RSMs than for SBM (566 v. 920 g/kg). Also De Boer et. al. (1987) observed higher intestinal disappearance of UDP for SBM than for canola meal (99 v. 79 %) measured by mobile bag method. In this study almost all the protein in SBM was potentially degradable, whereas a proportion of approximately 0.10 of RSM protein was resistant to degradation obviously due to higher proportion of cell wall bound nitrogen in RSMs.

According to Hvelplund and Madsen (1990) amino acid digestibility in undegraded protein may vary, and especially if the protein sources are treated to protect the protein against degradation. In this study the TAA disappearance of intact RSMs from mobile bags was rather high and affected by variety but not by hmt indicating that the hmt had no negative effect on protein digestibility. The exposure of RSMs to rumen degradation of 10 h prior to mobile bag measurements resulted in significantly higher (P<0.001) CP and TAA disappearance in the intestine from hmt RSMs than from untreated RSMs. This suggests that it is possible to shift the site of protein digestion of feed from forestomachs to post-ruminal tract by the hmt.

The absence of effect of pht on intestinal disappearance of rumen-undegraded feed CP was in accordance with results of Hvelplund (1985).

CONCLUSIONS

Heat-moisture treatment appears to be an effective processing technique to increase the availability of rumen-undegraded RSM protein to the small intestine without harmful effect on intestinal protein degradation. Probably due to the greater proportion of totally unavailable feed protein in RSMs compared to SBM, the intestinal protein degradation estimates of RSMs were lower than those of SBM.

The variety of RSMs or pepsin-HCl-treatment of rumen-undegraded feeds prior to mobile bag measurements had no marked influence on intestinal protein degradation estimates.

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