

NUTRITIVE VALUE OF FORMALDEHYDE-TREATED RAPESEED MEAL FOR DAIRY CALVES

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ABSTRACT

Treatment of oilseed meals with formaldehyde (FA) and glutaraldehyde (GA) significantly ($P < 0.01$) reduced the solubility of protein in 0.02 N NaOH and the production of NH_3 in the artificial rumen. Ten Holstein and Holstein \times Brown Swiss calves of both sexes were fed two test rations containing either 26% untreated or formaldehyde-treated (5.6 g FA per 100 g protein) rapeseed meal (FA-treated RSM) for 14 weeks. Plasma urea nitrogen (N) and rumen NH_3 levels were significantly ($P < 0.01$) lower in the FA-treated RSM calves compared with the control calves during the first 8 weeks of the growth trial. No significant difference ($P > 0.05$) in dry matter consumption, daily gain, or feed effi-

ciency was observed. Total volatile fatty acids (VFA) (mmoles/100 ml) concentration was significantly higher ($P < 0.05$) in rumen fluid from the control calves compared with those receiving treated RSM. Molar percentages of the VFA's were not significantly different ($P > 0.05$) between the two groups. In the N balance and digestibility trial, dry matter consumption did not differ significantly ($P > 0.05$); however, the FA-treated RSM resulted in decreased ($P < 0.05$) dry matter and crude protein digestibility. Calves receiving the treated RSM had reduced ($P < 0.01$) urinary N excretion; however, there was no significant effect ($P > 0.05$) on N consumption and retention.

RESUME

Le traitement de tourteaux à l'aldéhyde formique (FA) ou glutarique (GA) a abaissé de façon significative ($P < 0.01$) la solubilité de la protéine au NaOH à 0.02 N, ainsi que le dégagement de NH_3 en rumen artificiel. Dix veaux Holstein de race pure ou croisés avec la Brune des Alpes (Suisse brune), ont reçu pendant 14 semaines deux rations expérimentales contenant, à raison de 26%, du tourteau de colza respectivement traité (5.6 g FA par 100 g de protéine) ou non à l'aldéhyde formique. Le niveau de l'azote uréique du plasma et du NH_3 du rumen a été significativement ($P < 0.01$) moindre chez les veaux nourris au tourteau traité que chez les veaux témoins au cours des 8 premières semaines de l'essai de croissance. On n'a noté aucune différence significative ($P > 0.05$) quant à la consom-

mation de matière sèche, le gain quotidien ou l'indice de conversion. La concentration totale en acides gras volatils (AGV) en mmoles/100 ml était significativement plus forte ($P < 0.05$) dans le liquide du rumen des veaux témoin que de celui des veaux recevant le tourteau traité. Il n'y a pas eu de différence significative ($P > 0.05$) entre les deux groupes quant aux pourcentages molaires d'AGV. Dans l'essai de bilan azoté, la consommation de matière sèche n'a pas différé significativement ($P > 0.05$) mais le tourteau traité a entraîné une baisse significative de la digestibilité de la matière sèche et de la protéine brute. Les veaux nourris au tourteau traité ont manifesté un moindre taux d'excrétion d'azote urinaire mais on n'a constaté aucun effet significatif sur la consommation et la rétention azotées.

INTRODUCTION

Previous studies in ruminant nutrition have indicated that proteins of high solubility are rapidly hydrolyzed in the rumen and may result in elevated ruminal ammonia levels that the microflora cannot utilize efficiently for protein synthesis, and thus a sizeable portion of the dietary N is lost through ruminal absorption. Chemical modification of dietary protein can be brought about by treating with vegetable tannins (Leroy et al. 1965) or formaldehyde (FA) (Ferguson et al. 1967). Both these treatments have been shown to decrease the solubility of protein and increase its resistance to bacterial degradation. Ferguson et al. (1967) and Reis and Tunks (1969) reported that FA-treated casein was well utilized by sheep and resulted in a marked improvement in wool growth. Peter et al. (1971) also obtained similar results with FA-treated soybean meal (SBM).

measured according to Conway (1957). Observations were made on 4 different days.

In vivo Studies

In vitro ammonia release and solubility of protein indicated that a 1% FA solution was sufficiently effective in protecting the protein from bacterial degradation and decreasing the solubility of RSM protein. Therefore, one part of the commercial RSM was thoroughly mixed with 2 vol (w/v) of a 1% FA solution and allowed to react in a closed container for 1 hr. The mixture was dried at 80 C in a forced-air oven and reground through a 3-mm sieve in a Wiley mill and kept in burlap bags for mixing in the ration. Aliquots of the unground commercial RSM and reground FA-treated RSM were tested through standard sieves no. 10, 20, and 40 on a shaker for 10 min. Most of the material passed through the no. 10 sieve in both instances. About 14% of the untreated and 32% of the treated RSM were retained on sieve no. 20. Equal amounts of the meals passed through sieve no. 40.

GROWTH TRIAL. Reground FA-treated RSM and commercial RSM were used in feeding 10 dairy calves (Holstein and Holstein × Brown Swiss) of both sexes for 14 weeks. Calves were weaned from milk at 32 days of age and placed on experiment at 55–63 days of age. All calves were randomly distributed into two groups. Calves were housed in separate pens with feed and water freely available at all times. Animals were fed experimental rations (Table 1) at 10:30 AM. Rumen samples for ammonia and volatile fatty acids (VFA) were taken by stomach tube from each calf (3–4 hr after feeding) before putting the calves on test diets and at the end of 1, 2, 4, 6, and 8 weeks on test. Blood samples for urea N were also taken at the same time from the jugular vein in potassium oxalate tubes. Blood plasma and rumen fluid samples were stored at –20 C for further analyses.

Table 1. Composition of experimental rations

Item	Rations	
	RSM	FA-treated RSM
Ingredients (%)		
Rapeseed meal† (RSM)	26	—
Formaldehyde (FA) – treated RSM	—	26
Rolled barley	30	30
Corn starch	20	20
Barley straw	7.55	7.55
Ground hay	5.0	5.0
Corn oil	2.0	2.0
Cane molasses	8.0	8.0
Trace mineral salt	0.5	0.5
Calcium carbonate	0.72	0.72
Vitamin A and D ₃ ‡	0.20	0.20
Aurofac-50	0.03	0.03
Total	100.0	100.0
Crude protein	16.4	16.5
Acid detergent fiber	13.2	13.7

†Commercial rapeseed meal was supplied by Co-op Vegetable Oils Ltd, Altona, Manitoba.
‡Vitamin A 2740 IU/kg, vitamin D₃ 274 IU/kg of final ration.

Table 3. Ammonia levels† (mg N/100 ml) found after incubating 200 mg of meals in the *in vitro* rumen for 24 hr

Meals‡	Treatments							
	Control	Heated	1.25% GA	2.5% GA	1% FA	2% FA	3% FA	4% FA
RSM	88.3±2.0	40.5±1.6	45.6±1.4	38.5±1.1	37.5±2.9	37.0±2.5	31.6±2.6	29.7±1.5
LSM	59.7±1.9	31.2±0.1	35.8±2.0	31.9±0.1	33.2±1.6	-	-	-
SBM	71.2±1.6	31.1±0.4	32.7±2.4	30.5±2.0	33.0±3.0	-	-	-

†Initial ammonia N level in rumen fluid = 41.0 mg/100 ml.
‡RSM rapeseed meal, LSM linseed meal, SBM soybean meal.

system. The 3 and 4% FA solutions resulted in a further decrease in ammonia release, such that no increase in ammonia level was noticed after fermentation for 24 hr. A 1% FA solution decreased the ammonia release from 88.3 to 37.5 mg N/100 ml showing a substantial influence on the microbial deamination and protecting the RSM protein from bacterial attack in the artificial rumen; therefore, in the *in vivo* experiment a 1% FA solution (2 v/w) was used for treating the commercial RSM.

In vivo Growth Experiment

Untreated (commercial) and 1% FA-treated RSM were used in rations for young dairy calves. One of the animals in the FA-treated group bloated several times after about 8 weeks on test and was dropped from the experiment at 10 weeks. Total dry matter intake was slightly higher (Table 4) in the treated group than the control, but the difference between the two was not significant ($P > 0.05$).

Daily gains in the untreated and FA-treated RSM groups were not significantly ($P > 0.05$) different. Feed conversion was slightly lower for calves receiving the treated RSM. However, this difference was not significant ($P > 0.05$).

Ammonia levels in the rumen fluid of the calves were significantly ($P < 0.01$) less for those animals receiving FA-treated RSM compared with the control animals (Table 5). During the 8-week sampling period, blood urea ranged from 4.6 to 9.0 mg and 3.5 to 6.2 mg per 100 ml of plasma for calves receiving the untreated and FA-treated RSM, respectively. Blood plasma urea N was significantly ($P < 0.01$) lower for calves receiving FA-treated RSM compared with those

Table 4. Effects of treating rapeseed meal with 1% formaldehyde solution on the growth and performance of dairy calves

Growth trial (14 weeks)	Ration		
	Control	Formaldehyde-treated	SE
No. calves†	5	4	
Initial wt (kg)	79.5	88.8	
Daily gain (kg)	0.87 a	0.87 a	±0.25
Total DM intake (kg)	311.3 a	344.0 a	±16.3
Feed/gain	3.7 a	4.1 a	±0.3

a Figures with similar letters are not significantly different ($P > 0.05$).

†One of the animals in FA-treated group bloated several times and was therefore dropped from the experiment.

Table 6. Influence of treating rapeseed meal with 1% formaldehyde solution on digestibilities of dry matter (DM), crude protein (CP), and nitrogen retention in young calves

Nitrogen balance trial (7 days)	Rations		SE
	Control	Formaldehyde-treated	
No. observations	6	6	
DM intake (kg)	36.9 a	39.4 a	±1.2
DM digestibility (%)	75.4 a	70.6 b	±1.3
N intake (g)	969.3 a	1043.5 a	±27.6
N in feces (g)	248.6 A	421.5 B	±18.8
N in urine (g)	408.4 A	257.9 B	±27.4
N retained (g)	312 a	364 a	±20
CP digestibility (%)	74.5 A	59.3 B	±2.1

a,b Figures with different letters are significantly different ($P < 0.05$).

A,B Figures with different letters are significantly different ($P < 0.01$).

in the treated group but did not differ significantly ($P > 0.05$) from the untreated RSM group. Excretion of N in the feces and urine was significantly different ($P < 0.01$) in the untreated and FA-treated RSM groups. Nitrogen excreted in the feces as a percent of N intake was 25.6 and 40.4 in the untreated and FA-treated RSM groups, respectively. Urinary N excretion was 42.1 and 24.7% of the N consumed in the untreated and treated RSM groups, respectively. The decrease in the urinary N ($P < 0.01$) and increase in fecal N ($P < 0.01$) with FA treatment resulted in no significant difference ($P > 0.05$) in the total N retained as a percent of N intake.

DISCUSSION

The solubility of RSM protein in NaOH was decreased from 64.7 to 5.4% by treating RSM with 1% FA (2 v/w). FA treatment (1, 2, 3, and 4%) reduced the solubility of protein to zero as measured after a 1-hr fermentation in rumen fluid. The present findings are in agreement with those of Peter et al. (1971) in which the protein solubility of SBM was depressed ($P < 0.01$) by treatment with FA, GA, and glyoxal. Ferguson et al. (1967) reduced the solubility of casein from 83 to 8% by treating the casein with 4% FA (10 v/w, or 40 g FA per 100 g casein).

Treating RSM, LSM, and SBM with heat or various levels of FA and GA solutions significantly ($P < 0.01$) decreased deamination in the artificial rumen as measured by ammonia levels after a 24-hr fermentation period. Zelter et al. (1970) obtained total inhibition of the bacterial deamination of peanut protein after treating with 0.6% formol and 1.5–1.8% glyoxal or GA. Peter et al. (1971) reported similar results. These studies indicate that the higher levels of FA and GA treatments resulted in only slightly greater inhibition of the bacterial degradation of treated RSM protein in the artificial rumen. This suggests that the lower levels of the aldehydes are enough to cause a maximum depression of the microbial degradation of the treated oil meals in *in vitro* studies.

No appreciable difference in weight gain was noticed in young calves fed on FA-treated or untreated RSM for a 14-week period. Feed intake, weight gain, and feed efficiency did not differ significantly ($P > 0.05$) for the two groups.

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