EFFICIENCY OF PROTEIN UTILIZATION OF FORMALDEHYDE TREATED RAPESEED MEAL BY SHEEP AND ITS INFLUENCE ON CATTLE'S PERFORMANCE

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Summary

This study was purposed to investigate the efficiency of protein utilization of rapeseed meal (RSM) and formaldehyde-treated RSM (TRSM) by sheep, and their influence on performance of growing heifers. Experiment 1 was conducted according to a double 3 × 3 Latin square design involving six yearling Hu Sheep and three experimental diets. All diets contained 600 g ammoniated rice straw and 200 g concentrate mixture. Three dietary treatments were (1) 100 g RSM + 40 g soybean meal (URUS), (2) 100 g TRSM + 40 g soybean meal (TRUS) and (3) 100 g TRSM + 40 g treated soybean meal (TRTS). Apparent nitrogen digestibility was significantly higher for diet TRUS than that for URUS or TRTS ($p < 0.05$), but with no significant difference between URUS and TRTS ($p > 0.05$). Proportion of nitrogen retention (NR) to the digestible nitrogen intake for diet TRUS and TRTS was 25.57 ($p < 0.05$) and 23.44% ($p < 0.05$) higher than that for URUS respectively. As a result, proportion of NR to nitrogen intake for diet TRUS and TRTS was 34.74 ($p < 0.05$) and 23.78% ($p < 0.05$) higher than that for URUS respectively. Experiment 2 was conducted with 59 Holstein heifers. They were 12-20 months of age at the start of the trial. The experiment was a 2 × 2 factorial trial in which the heifers were given the ammoniated rice straw *ad libitum* and 1.5 kg hay, and supplemented with either RSM or TRSM at a daily allowance of 1.2 or 1.8 kg per day. The live weight gains for heifers receiving 1.2 and 1.8 kg/d of RSM or TRSM were 0.491 and 0.556 or 0.564 and 0.665 kg/d, respectively. The results suggest that formaldehyde treatment can effectively improve the efficiency of protein utilization of rapeseed meal and cattle's performance.

(Key Words: Rapeseed Meal, Formaldehyde, Ammoniated Rice Straw, Nitrogen Retention, Daily Gain)

Introduction

Ammonia treatment has been recognized to be an efficient process to upgrade cereal straws. Because of high degradation of the ammoniated straw, the microbial fermentation in the rumen of animals given the ammoniated straw alone can not supply sufficient protein for high production. Thus, an increased protein supply to host animals can only be obtained when a protein source of low degradability such as treated-protein meal or fish meal is supplemented (ørskov and Hovell, 1986; Preston, 1986).

Several studies (Burgess and Nicholson, 1973; Reoke et al., 1983) have shown that formaldehyde (HCHO)-treated soybean or rapeseed meal supplement to a silage diet can increase the amounts of non-ammonia N entering the small intestine. Crooker et al. (1986) observed that HCHO treatment was effective in preserving the original amino acid of soybean meal.

With the development of feed industry in China, the protein-rich oilmeal have recently increased in importance as a feedstuff. Our region is abundant in rapeseed meal, recently only 30 % of which is, however, used as feeds, mainly for swine and poultry.

The present study was proposed to investigate the efficiency of protein utilization of untreated (RSM) and formaldehyde-treated rapeseed meal (TRSM) by sheep (Expt. 1), and their influence on the performance of Holstein heifers (Expt. 2).

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Materials and Methods

Experiment 1

Animals

Animals used were 6 yearling male Hu sheep (mean initial liveweight, 25.8 kg), three of which were equipped with a rumen fistula. They were individually kept in a metabolism cage. Feeds were offered in two equal meals every day (08:00 and 16:00 h). The sheep had *ad libitum* access to drinking water and mineralized salt block.

Experimental diets

Experiment was conducted with a double 3 × 3 Latin square design involving three experimental diets. All animals were offered to meet the ME requirement for 1.3 times maintenance (ARC, 1980). All diets contained 600 g ammonia bicarbonate-treated rice straw and 200 g concentrate mixture. They were supplemented with RSM, TRSM, soybean meal (SBM) or formaldehyde-treated soybean meal (TSBM). Three dietary treatments were: (1) 100 g RSM + 40 g SBM (URUS), (2) 100 g TRSM + 40 g SBM (TRUS), and (3) 100 g TRSM + 40 g TSBM (TRTS). The TRSM or TSBM was prepared by treatment of RSM or SBM with HCHO (0.6 or 0.8%/meal CP), respectively, as described elsewhere (Yao et al., 1992). Ingredient and composition of experimental diets are shown in table 1.

TABLE 1. INGREDIENT AND COMPOSITION OF THE DIETS

	URUS	TRUS	TRTS
Ingredient (g/d)			
Ammoniated rice straw	600	600	600
Concentrate mixture	200	200	200
Rapeseed meal (RSM)	100		
HCHO-treated RSM	–	100	100
Soybean meal (SBM)	40	40	–
HCHO-treated SBM	–	–	40
Composition			
Dry matter (%)	86.1	86.1	86.1
Crude protein (% DM)	15.0	15.0	15.0

Measurements and sampling

Rumen degradation characteristics

Degradation of dry matter (DM) and N for individual diet ingredient and the untreated meals in the rumen was determined with nylon bag technique (Ørskov, 1985) in three rumen-fistulated sheep. The detail of measurement has been given by Yao et al. (1992).

Digestion and N balance trial

Total feces and urine were collected to determine apparent digestibility of nutrients and N balance over 7 days (from days 13 to 19). During the collection period of 7 days, daily sample of diet offered was taken and daily residues were removed and weighed before morning feeding. Feeds and feces were analyzed for DM and CP with the methods described by AOAC (1970). Content of N in urine was analyzed by Kjeldahl method.

Rumen measurements

On d 20, rumen fluid samples were withdrawn by a tube through the rumen cannulae at 0, 1, 3 and 6 h after the morning feeding. The samples were strained through four layers of cheesecloth. Rumen ammonia concentrations were determined by steam distillation into boric acid and titration with dilute hydrochloric acid (10 mmol).

Statistical analysis

The results were analyzed as a double 3 × 3 Latin square (Steel and Torrie, 1960).

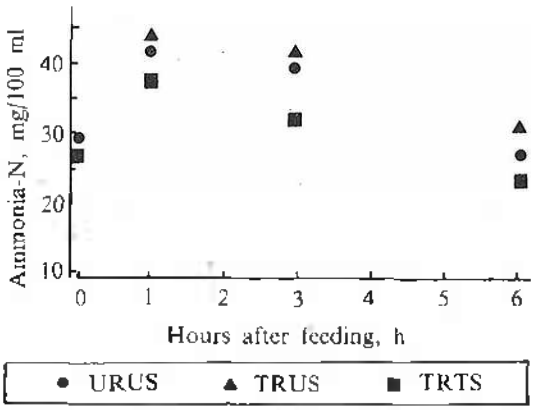

Figure 1. Change with time after feeding in ammonia-N concentration in the rumen of sheep receiving different diets.

Experiment 2

Animals and design

Fifty-nine heifers of Holstein breed were used. They were 12-20 months of age, and were allocated at random to receive one of 4 treatments in a 2 × 2 factorial design. In all four treatments, each heifer was given ammonia bicarbonate-treated rice straw *ad libitum*, and supplemented with either RSM or TRSM at a daily allowance of either 1.2 or 1.8 kg. In order to ensure the supply of vitamins and minerals, each animal was offered 1.5 kg hay and 5 g vitamin premix, and drinking water and mineralized salt block were freely available at all times.

Feeding trial

The heifers for each treatment were fed in groups. Care was taken to see that the supplement was well distributed along the trough to ensure that all animals had an equal share. Daily intake of each group was measured, and the heifers were weighed once every month.

Statistical analysis

Results were analyzed as a two-way factorial design by the method of Steel and Torrie (1960).

Results and Discussion

The constants in the exponential equation $p = a + b(1-e^{-ct})$ and the 48 h degradability (D48) are given in table 2 for individual feeds. The HCHO treatment greatly influenced the degradation characteristics of DM and N for RSM and SBM. As seen in the D48, the HCHO treatment could effectively protected the oilmeal's protein from the rumen degradation. With the HCHO treatment, the rapidly digestible fraction (a) of oilmeal's protein significantly decreased ($p < 0.05$), and slowly digestible fraction (b) increased ($p < 0.05$) along with the decreased fractional rate (c). In the previous study, we found that the reduced protein degradability of HCHO-treated RSM was mainly resultant from the decrease in the fast degradable fraction (Yao et al., 1992).

TABLE 2. THE CONSTANTS OF THE EQUATION $p = a + b(1 - e^{-ct})$ TOGETHER WITH 48 H DEGRADABILITY VALUE (D48) OF THE INDIVIDUAL FEED

	Treated rice straw	Concentrate mixture	Rapeseed meal		Soybean meal	
			RSM	TRSM	SBM	TSBM
Dry matter						
a (%)	15.9	45.8	29.8[a]	23.2[b]	41.4[a]	31.0[b]
b (%)	55.1	52.6	65.3	71.5	58.6	56.0
c (%/h)	4.08	4.35	2.78	2.09	4.77[a]	2.86[b]
D48 (%)	65.0	89.6	81.0	73.4	88.1	79.3
Crude protein						
a (%)	35.2	40.7	28.0[a]	14.4[b]	31.8[a]	17.4[b]
b (%)	53.1	58.0	72.0[a]	85.6[b]	68.2[a]	82.5[b]
c (%/h)	3.95	3.28	2.48[a]	1.69[b]	4.35[a]	0.99[b]
D48 (%)	72.0	92.6	88.3	75.5	91.3	59.4

[a,b] Means with different superscripts within same meal differ ($p < 0.05$), indicating the effect of formaldehyde treatment.

The results of digestion and N balance trial are presented in table 3. The apparent digestibility of DM and N for diet TRUS was significantly higher ($p < 0.05$) than that for URUS and TRTS, suggesting that HCHO treatment does not decrease the digestibility of nutrients of rapeseed meal. This is consistent with the results observed by Rooke et al. (1983).

The efficiency of N utilization of rapeseed meal was greatly improved by HCHO treatment. Proportion of N retained (NR) to N digested for diet TRUS and TRTS was 25.57% ($p < 0.05$) and 23.44% ($p < 0.05$) higher than that for URUS, respectively. As a result, proportion of NR to nitrogen intake (NR/NI) for diet TRUS and TRTS was 34.74 ($p < 0.05$) and 23.78% ($p < 0.05$) higher than that for URUS, respectively, with slightly higher NR/NI value for diet TRUS than TRTS ($p > 0.05$).

It is considered that protein supply to host animals would increase when the HCHO-treated meal was given instead of the untreated. With a silage diet, Burgess and Nicholson (1973) and Rooke et al. (1983) observed that treated SBM or TRSM supplementation increased the amount of non-ammonia N entering the small intestine.

As shown in figure 1, there existed great difference among diets in ammonia-N levels in the rumen fluids. The rumen ammonia levels for diet TRTS was significantly lower than those for URUS or TRUS ($p < 0.01$), with slightly lower values for TRUS than for URUS ($p > 0.05$). The average ammonia-N concentrations in the rumen fluids were 34.6, 33.1 and 29.1 mg/100 ml, for sheep receiving diet URUS, TRUS and TRTS respectively. These results were in keeping with ruminal protein degradation and efficiency of N utilization (table 3).

Results of feeding trial are summarized in table 4. The heifers receiving the diet containing 1.2 kg of RSM had slowest daily liveweight gain ($p < 0.05$), while the feeding of TRSM at the same level resulted in an improvement (on average, 14.9%) in daily gain ($p < 0.05$) along with

TABLE 3. APPARENT DIGESTIBILITY OF DRY MATTER AND CRUDE PROTEIN, AND NITROGEN UTILIZATION IN SHEEP

	URUS	TRUS	TRTS
Digestibility (%)			
Dry matter	54.25^{b}	59.66^{a}	56.21^{b}
Crude protein	56.09^{b}	60.08^{a}	56.34^{b}
Nitrogen utilization (%)			
Retained/ingested	25.99^{b}	35.02^{a}	32.17^{ab}
Retained/digested	46.07^{b}	57.85^{a}	56.87^{a}

^{a,b} Means with different superscripts within a row differ ($p < 0.05$).

TABLE 4. LIVE WEIGHT GAIN, STRAW INTAKE, FEED CONVERSION AND FEED COST OF HOLSTEIN HEIFERS

Rapeseed meal supplement	Untreated		HCHO-treated	
Amount (kg/d)	1.2	1.8	1.2	1.8
Initial liveweight (kg)	328.7	323.5	360.9	351.5
Daily gain (kg)	0.491^{bB}	0.556^{aB}	0.564^{bA}	0.665^{aA}
Straw intake (kg/d)	5.0	5.0	5.0	5.0
F.C.R. (DM basis)	13.5	12.9	11.6	10.6
Feed cost/kg gain (yuan)[1]	3.54	3.78	3.12	3.22

[1] Price (RMB yuan/kg): ammoniated rice straw 0.14, hay 0.18, rapeseed meal 0.60, HCHO-treated rapeseed meal 0.62, concentrate mixture 0.72.

^{a,b} Means with different superscripts within same supplement differ ($p < 0.05$), indicating the effect of supplementation level.

^{A,B} Means with different superscripts within same supplementation level differ ($p < 0.05$), indicating the effect of formaldehyde treatment.

a decreased feed cost per kg gain. The increase in the amount of rapeseed meal, either untreated or HCHO-treated, caused faster growth ($p < 0.05$), while the cost of liveweight gain became somewhat uneconomic. Nevertheless, introduction of TRSM in heifer's diet was more economic than that of RSM, according to both feed conversion rate (FCR) and feed cost per kg liveweight gain.

The growth rates and FCR obtained with diet containing 1.8 kg TRSM were in agreement with the results by Dolberg and Finlayson (1992), in which daily liveweight gain of Chinese Yellow Cattle receiving ammoniated wheat straw *ad libitum* and 2 kg cottonseed cake per day was 0.655 kg, with an FCR of 10.0.

From the above results, it is suggested that HCHO treatment can effectively improve the efficiency of protein utilization of RSM, and that the performance of cattle receiving the HCHO-treated RSM is superior to that fed on the untreated RSM.

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