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Short communication

Growth performance and macronutrient digestion in goats fed a rice straw based ration supplemented with fibrolytic enzymes

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ABSTRACT

Supplementation of rice straw based rations (30% rice straw, dry matter basis) with fibrolytic enzymes is of potential interest to improve nutrient utilization and hence animal performance, but its efficacy is not yet demonstrated in growing goats. In a parallel design, eighteen young goats were fed a total mixed ration (TMR) based on rice straw either with or without supplemental fibrolytic enzymes. Addition of fibrolytic enzymes to the TMR increased the apparent digestibility of neutral and acid detergent fiber by 10.0 and 9.1%, respectively. Enzyme supplementation raised concentrations of total volatile fatty acids in rumen fluid with an associated increase in the proportion of acetate and total bacteria counts. Fortification of TMR with fibrolytic enymes increased average daily weight gain by 34.7% and the efficiency of feed utilization by 28%. It is concluded that the nutritive value of rice straw based rations can be upgraded by supplementation with fibrolytic enzymes, leading to enhanced ruminant production.

1. Introduction

In South-East Asian countries, rice straw serves as a major roughage source for the feeding of ruminants (Van Soest, 2006). However, the nutritive value of rice straw is inferior as it is low in protein and high in neutral- and acid detergent fiber (Van Soest, 2006). The high neutral- and acid detergent fiber (NDF and ADF) content in rice straw adversely influences rumen fermentation, leading to a low apparent digestibility of this feedstuff (Van Soest, 2006).

The use of exogenous fibrolytic enzymes, such as glucanases and xylanases, may be of interest. Indeed, Eun et al. (2006) demonstrated that a mixture of supplemental glucanases and xylanases increased the degradability of rice straw under *in-vitro* conditions. Furthermore, McAllister et al. (1999) and Beauchemin et al. (2003) have shown that supplementation of fibrolytic enzymes to barley hay based rations, increased apparent fiber digestibility in dairy cows. However, to the authors knowledge, there are yet no reported studies on the use of exogenous fibrolytic enzymes in goat rations based on rice straw. This prompted us to carry out the present study with young goats fed a rice straw based ration without or with added fibrolytic enzymes.

2. Materials and methods

The current experiment was approved by the Animal Ethics Committee of Rajamangala University of Technology Isan, based on the Ethics of Animal Experimentation of the National Research Council of Thailand.

2.1. Animals, experimental design and experimental rations

Eighteen, non-cannulated, 4.5 month old, Anglonubian x native crossbred male goats were used. The goats were housed in individual pens with slatted floors. The trial had a parallel design with an experimental period of 90 days. The animals were allocated at random to the experimental rations; i.e. a total mixed ration (TMR) with or without fibrolytic enzymes.

Rice straw was used as roughage source. The TMR had roughage to concentrate ratio of 30:70. Details about the ingredient- and analyzed composition are provided in Table 1. The enzyme preparation consisted of xylanase (6.1×10^6 units/kg) and glucanase (3.5×10^6 units/kg) derived from *Aspergillus* spp. and *Thichoderma* and 50 mg (Yang et al., 2000) of this preparation was added to the TMR. Thus, the TMR

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Table 1
Ingredient- and analyzed composition of the total mixed ration.

Ingredient composition, g/kg		Analyzed composition, g/kg	
Rice straw[a]	300	Dry matter	912
Cassava chips	300	Ash	89
Tomato pomace, dried	200	Crude protein	143
Soybean meal	100	Ether extract	39
Molasses	50	Neutral detergent fiber	423
Tallow	30	Acid detergent fiber	272
Urea	10		
Dicalcium phosphate	5		
Sodium chloride	5		

[a] The chemical composition of the rice straw was as follows (g/kg): dry matter, 925; ash, 123; crude protein, 23; ether extract, 16; neutral detergent fiber, 757; acid detergent fiber, 547.

supplemented with fibrolytic enzymes contained 305 and 175 units/kg DM xylanase and glucanase, respectively. The goats had free access to unrestricted amounts of TMR, clean water and a mineral block. Feed intake was measured daily and the animals were weighed at the start and the end of the experiment to monitor body weights.

2.2. Collection of samples

The experimental TMR's were sampled monthly and then pooled, dried at 60 °C for 72 h, ground and stored in sealed plastic bags at ambient temperature (25 °C) until analysis. During the last five days of the experimental period, feces were quantitatively collected from individual goats with the use of a plastic sheet spread below the slatted floors. The daily feces production of each goat was stored at −18 °C. At the end of the collection period, the stored daily feces collections were thawed, mixed thoroughly and sampled. The samples were dried at 60 °C for 72 h, ground and stored in sealed plastic bags at ambient temperature (25 °C) until analysis. On the last day of the experiment, rumen fluid samples were collected 4 h after the morning feeding by means of a stomach tube connected to a vacuum pump. Immediately after collection, pH of rumen fluid was recorded. Rumen samples for total microbial counts were processed as described by Yuangklang et al. (2010). For each goat, the rumen samples were divided into two aliquots of rumen fluid samples and each aliquot was acidified with a sulfuric acid solution (1*M*) and stored at −18 °C until analysis.

2.3. Chemical analyses

The ash content of the experimental rations was analyzed by combustion at 550 °C for 16 h. Nitrogen contents were determined by the macro Kjeldahl method (AOAC, 1995); a factor of 6.25 was used to convert nitrogen into crude protein (CP). The NDF and ADF contents of the rations were analyzed according to the method of Van Soest et al. (1991).

In acidified rumen fluid samples, volatile fatty acids (VFA) were determined as described by Wongnen et al. (2009). Ammonia nitrogen in rumen fluid was measured according to Bremner and Keeney (1965) and total bacteria and protozoa counts were determined by the method of Galyean (1989).

2.4. Statistical analyses

Prior to statistical analysis, protozoa and bacteria counts were logarithmically transformed. All data were subjected to one way ANOVA and Fisher's *t* test (SPSS, 1997) was used to separate means between control and test group. Differences between treatments were considered statistically significant when $P < 0.05$.

Table 2
Growth performance of goats fed a total mixed ration (TMR) either without or with fibrolytic enzymes.

	Experimental treatments		SEM[a]	P value
	Control TMR	TMR + Fibrolytic enzymes		
Initial BW[b], kg	19.3	18.9	0.20	0.90
Final BW, kg	24.1	25.4	0.07	0.02
ADG[c], g/day	53.3	71.8	1.51	0.02
DMI[d], g/day	352	369	2.59	0.12
ADG:DMI, g/kg	152	195	1.88	0.03

[a] Standard error of mean.
[b] Body weight.
[c] Average daily gain.
[d] Dry matter intake.

3. Results

3.1. Growth performance and dry matter intake

Initial body weights of the two groups of goats were similar, but final body weight was greater ($P < 0.05$) in the group fed the TMR supplemented with fibrolytic enzymes (Table 2). Consequently, average daily gain (ADG) increased ($P < 0.05$) by the supplementation of fibrolytic enzymes. The intake of dry matter (DMI) was not affected by the experimental treatment, but the ADG:DMI ratio was 28% greater ($P < 0.05$) when the TMR was supplemented with fibrolytic enzymes.

3.2. Apparent digestibility

Apparent digestibility of both dry and organic matter, were greater ($P < 0.05$) after feeding of the TMR fortified with fibrolytic enzymes (Table 3). The digestibility of NDF and ADF was greater ($P < 0.05$) for the group that was fed TMR with supplemental enzymes, the group means increased by 5.8 and 4.8% units for NDF and ADF respectively. In contrast, the apparent digestibility of CP was not affected by the supplementation of fibrolytic enzymes.

3.3. Rumen fermentation

Fortification of the TMR with fibrolytic enzymes caused greater concentrations total volatile fatty acids ($P < 0.05$) but did not influence rumen fluid pH (Table 4). Furthermore, the feeding of enzymes affected the VFA profile in rumen fluid; the proportion of acetate was raised ($P < 0.05$) but that of butyrate was lowered ($P < 0.05$). The proportion of propionate was not influenced by the supplementation of fibrolytic enzymes. Total bacteria, but not protozoa, counts in rumen fluid were greater ($P < 0.05$) in the goats fed fibrolytic enzymes. The concentration of ammonia nitrogen (NH_3—N) in rumen fluid was greater ($P < 0.05$) after feeding the TMR with enzymes.

Table 3
Apparent digestibility of macronutrients by goats fed a total mixed ration (TMR) either without or with fibrolytic enzymes.

	Experimental treatments		SEM[a]	P value
	Control TMR (% of intake)	TMR + Fibrolytic enzymes		
Dry matter	64.0	68.5	0.10	0.03
Organic matter	67.0	72.0	0.12	0.03
Neutral detergent fiber	58.2	64.0	0.11	0.04
Acid detergent fiber	52.8	57.6	0.10	0.04
Crude protein	73.3	74.0	0.18	0.35

[a] Standard error of mean.

Table 4
Selected indices of rumen fermentation in goats fed a total-mixed ration (TMR) either without or with fibrolytic enzymes.

	Experimental treatments		SEM[a]	P value
	Control TMR	TMR + Fibrolytic enzymes		
Rumen pH	7.01	7.02	0.01	0.89
Total VFA,[b] mM	60.1	63.6	0.06	< 0.05
Acetate, % of VFA	72.3	75.4	0.08	0.04
Propionate, % of VFA	19.3	19.6	0.11	0.10
Butyrate, % of VFA	8.3	5.0	0.08	0.03
Rumen NH_3–N, mg/dl	15.3	16.8	0.12	< 0.05
Total bacteria count, 10^{11} cell/ml	7.8	8.9	0.08	< 0.05
Total protozoa count, 10^5 cell/ml	9.5	9.0	0.15	0.10

[a] Standard error of mean.
[b] Volatile fatty acids.

4. Discussion

Supplementation of the rice straw based ration with fibrolytic enzymes enhanced growth performance and the nutrient utilization of the ration as indicated by the significantly greater ADG:DMI ratio (Table 2). This observation corresponds with the observation that fortification of the TMR with fibrolytic enzymes caused an increase in apparent digestibility of NDF and ADF. These results are corroborated by Yang et al. (2000) and Beauchemin et al. (1995). The increase in fiber digestibility was accompanied by greater concentrations of VFA in rumen fluid. This observation can be interpreted in that the enzyme-induced fiber hydrolysis had yielded additional substrates for bacterial synthesis of volatile fatty acids. This reasoning is in line with the observation that the feeding of fibrolytic enzymes was associated with significantly greater bacteria counts (Table 4). The higher bacterial activity was accompanied by a greater production of acetate and less of butyrate which is consistent with greater availability of breakdown products from cellulose and hemicellulose for bacterial metabolism (Van Soest, 1994).

Supplementation of the ration with fibrolytic enzymes produced an increase in both the number of rumen bacteria and volatile fatty acids while pH of the rumen fluid remained unchanged. However, concentrations of volatile fatty acids in the range of 60–64 mmol/l, can be considered relatively low (Houtert, 1993). It can therefore be suggested that the buffer capacity of the rumen fluid was not compromised by the increase of volatile fatty acids that was observed in the current study. Therefore, rumen pH could be maintained after the feeding of the TMR supplemented with fibrolytic enzymes.

Rumen NH_3–N was increased by the feeding of fibrolytic enzymes but the absolute difference between the dietary treatments was small. This observation is corroborated by Lewis et al. (2014) who reported a tendency towards greater rumen NH_3–N concentrations in beef steers when supplemental fibrolytic enzymes were fed. It may be speculated that the fibrolytic enzymes liberated some N that was bound to insoluble fiber. Moreover, mean daily CP intake was numerically greater when goats were fed the TMR with fibrolytic enzymes, i.e. 57.9 versus 55.3 g/day.

In the current study, the feeding of fibrolytic enzymes did not stimulate DMI. This result is corroborated by the outcome of several other studies in dairy cows fed TMR (Rode et al., 1999; Yang et al., 1999, 2000). On the other hand, Feng et al. (1996) reported that supplemental fibrolytic enzymes stimulated both DMI and passage rate of feed particles when grass hay based rations (80% hay DM basis) were fed. Clearly, the issue on the efficacy of fibrolytic enzymes to stimulate DMI is not settled yet. However, it can be speculated that the efficacy of fibrolytic enzymes to affect the disappearance rate of feed particles from the rumen, and therefore DMI, may depend on the source of roughage. Indeed, Beauchemin et al. (1995) demonstrated that the feeding of fibrolytic enzymes stimulated DMI when an all forage ration consisting of alfalfa hay was fed while DMI remained unchanged when barley silage was fed.

5. Conclusion

The nutritional quality of rice straw based TMR can be upgraded by supplementation with fibrolytic enzymes, leading to enhanced animal production. However, caution is warranted to generalize the outcome of the current study and further studies are needed to prove the efficacy of fibrolytic enzymes on growth performance in rice straw based rations.

Conflict of interest

The authors declare no conflict of interest.

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