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Effect of live yeast supplementation on ruminal polysaccharidase activities in goats fed a high concentrate diet

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Abstract. There is scarce information on the effect of yeast supplementation in dairy goats. The aim of this study was to determine the effect of live yeast supplementation on ruminal polysaccharidase activities in 12 mid-lactation goats receiving a high-concentrate diet. After three weeks of adaptation to the diet, six goats were yeast-supplemented (group Y) twice daily via rumen cannula for five weeks (10 g/d, $2.2 \cdot 10^{10}$ CFU/g *Saccharomyces cerevisiae* CBS 493.94, Alltech); the other animals were not supplemented (group C). Fibrolytic activity was lower in rumen contents after feeding than before and in nylon bags containing wheat than in those containing hay; the opposite results were obtained for amylolytic activity. Yeasts had no effect on amylase and xylanase activities in rumen contents or nylon bags and in cellulase activity in rumen contents, but tended ($P = 0.07$) to decrease cellulase activity in bag residues.

Keywords. Yeast – Polysaccharidase activities – High concentrate diet – Goats.

Effet de l'apport des levures vivantes sur les activités polysaccharidases ruminales chez les caprins recevant une ration riche en concentré

Résumé. Peu d'informations sur les effets des levures chez les chèvres sont disponibles. Le but de cette étude était de déterminer les effets de levures vivantes sur les activités polysaccharidases ruminales de 12 chèvres laitières recevant un régime riche en concentré. Après trois semaines d'adaptation au régime, six chèvres (groupe Y) ont reçu 10 g/j d'un supplément comprenant $2,2 \cdot 10^{10}$ CFU/g *Saccharomyces cerevisiae* (CBS 493.94, Alltech) pendant cinq semaines, via la canule, en deux apports journaliers. Les autres animaux (groupe C) n'ont pas été supplémentés. L'activité fibrolytique du contenu ruminal a été inférieure après le repas par rapport à avant, et pour les sachets contenant du blé par rapport à ceux contenant du foin ; des résultats inverses ont été obtenus pour l'activité amylolytique. Les levures n'ont pas modifié les activités amylasique ou xylanasique dans le rumen et les sachets, et l'activité cellulosique dans le rumen, mais ont eu tendance ($P = 0,07$) à diminuer l'activité cellulosique dans les sachets.

Mots-clés. Levures – Activités polysaccharidases – Régimes riches en concentrés – Chèvres.

I – Introduction

A major negative consequence of feeding high concentrate diets to high producing ruminants is the occurrence of sub-acute ruminal acidosis. Yeast supplementation may modify rumen fermentation and limit rumen pH decreases associated with these diets (Giger-Reverdin *et al.*, 2004; Sauvant *et al.*, 2006). The effects of yeast supplementation on intake, milk production and ruminal parameters are, however, variable and seem to be influenced by factors related to the animal (physiological state, days in milk, species), to the diet (type and percentage of concentrate, mode of distribution) and to the yeast (strain, dose and mode of distribution) (Brossard, 2004; Sauvant *et al.*, 2004). The effects of acidosis and yeast supplementation on digestion and metabolism are frequently studied,

however there is less information on rumen microbial parameters and scarce information on the effect of yeast supplementation, in dairy goats.

The aim of this study was to determine if live yeast supplementation can influence rumen polysaccharidase activities (amylase, xylanase and cellulase) in dairy goats receiving a high-concentrate diet.

II – Materials and methods

1. Animals, housing and diet

Twelve rumen-fistulated dairy goats (Saanen and Alpine) in mid lactation (35 ± 4.4 days in milk), averaging 65 ± 6.5 kg body weight and producing 3.5 ± 0.54 kg milk per day at the start of the experiment were used. They were allocated into two groups according to the previous lactation, body weight after parturition, breed and intake kinetics measured during gestation. The experimental design had a 3-week period of adaptation to the high-concentrate diet (P1), followed by a 5-week yeast supplementation period (P2) during which the yeast group (Y) received 10 g of yeast daily via rumen cannula (2.2×10^{10} CFU/g *Saccharomyces cerevisiae* CBS 493.94, Alltech) given as two separate 5 g doses at each feeding, whereas the control group (C) was not yeast-supplemented. A final 3-week period (P3) during which the two groups were still fed the high-concentrate diet ended the design. Goats were housed in 2×1 m individual pens during experiment with free access to water. A total mixed ration of grass hay (25%), sugarbeet pulp silage (25%) and concentrate (50%) was offered *ad libitum* twice a day after milking, in the proportion of two thirds at 16:00 h and one third at 08:00 h. The concentrate was composed of wheat (25%), barley (25%), maize (30%), soyabean meal (15%) and a vitamin and mineral mixture.

2. Sampling procedure

Samples of rumen content were taken before (T0) or four hours after (T4) the morning feeding. Nylon bags containing ground wheat grain or gramineae hay were incubated in the rumen for 4 and 24 h respectively. Gramineae hay was incubated for 24 h because differences between polysaccharidase activities measured in nylon bags and polysaccharidase activities measured in rumen digesta are lower after 23 h incubation than after 2 h (Nozière and Michalet-Doreau, 1996). Ground wheat grain was only incubated for 4 h because after 4 h the whole ground grain would have been degraded. Samplings of rumen content and incubations of bags were performed during four one-week periods, one before yeast supplementation, two during supplementation and one after supplementation. Solid-associated amylase, xylanase and cellulase activities were measured in both rumen content and nylon bag residues according to the method described by Martin and Michalet-Doreau (1995). Enzyme activities were expressed as μmol reducing sugar released per mg protein per hour.

3. Statistical analysis

Statistical analyses were carried out using the mixed model procedure of SAS (2002) with animal as a random effect. Effects of group (Y or C), rumen content sampling time (T0 or T4) or type of substrate incubated in nylon bags (wheat or hay) and their interactions were tested during the supplementation period (P2). Analysis included the values obtained for each goat during the first period (P1 without supplementation) as a covariable in the model. Significance was declared at $P < 0.05$ and trends were discussed at $P < 0.10$.

III – Results and discussion

Daily variation of intake (41.2 ± 9.09 g DM/kg body weight), milk production (3358 ± 857.5 g) and

rumen pH (6.2 ± 0.24 with $0.6 \pm 4.57\%$ of the time below pH = 5.0) showed that most goats experienced acidosis bouts during the experiment. However, there was a marked individual variability with some animals being more susceptible than others, independent of treatment.

1. Feeding effects of a high-concentrate diet on ruminal polysaccharidase activities

Solid-associated amylolytic activity extracted from rumen contents increased after feeding, and the opposite was observed for fibrolytic activities (cellulase and xylanase) (Table 1). These results are in accordance with those reported in sheep and cows (Martin *et al.*, 1993, 2001; Michalet-Doreau *et al.*, 2002; Brossard, 2004) and indicate that starch-degrading micro-organisms develop rapidly after feeding a cereal-rich diet, whereas plant cell wall degrading micro-organisms, producers of fibrolytic enzymes, grow more slowly.

Table 1. Effect of feeding (T0: before and T4: 4 h after) on solid-associated polysaccharidase activities (μmol reducing sugar/mg protein/h) in the rumen of 12 lactating dairy goats fed a high-concentrate diet

	T0	T4	SEM	P
Amylase	8.8	11.8	0.89	**
Xylanase	5.9	2.1	0.35	***
Cellulase	0.7	0.3	0.07	**

*P < 0.05; **P < 0.01; ***P < 0.001; NS: P > 0.1.

For the solid-associated polysaccharidases present in nylon bags, fibrolytic (cellulase and xylanase) activities were higher in bags containing hay than in those containing wheat, and the opposite was observed for amylolytic activity (Table 2). Our results show that fibrous substrates are colonized more by fibrolytic micro-organisms and that starchy substrates are colonized more by amylolytic microorganisms, which support those of Martin *et al.* (2001).

Table 2. Polysaccharidase activities (μmol reducing sugar/mg protein/h) in wheat or hay incubated in nylon bags, for 4 and 24 hours respectively, in the rumen of 12 lactating dairy goats fed a high-concentrate diet

	Wheat	Hay	SEM	P
Amylase	11.6	1.4	0.55	***
Xylanase	0.9	13.1	0.69	***
Cellulase	0.2	0.8	0.10	***

*P < 0.05; **P < 0.01; ***P < 0.001; NS: P > 0.1.

2. Effect of yeast supplementation

When the two groups of animals (Y and C) were compared during the P2 period, yeast supplementation had no effect on the solid-associated amylase, xylanase and cellulase activities from rumen contents (P > 0.10) (Table 3).

Yeast supplementation also had no effect on the solid-associated amylase and xylanase activities from nylon bag residues (P > 0.10). However, it tended to decrease the solid-associated cellulolytic activity (P = 0.07) extracted from hay incubated in nylon bags (Table 4).

Table 3. Effect of live yeast supplementation on polysaccharidase specific activities (μmol reducing sugar/mg protein/h) in rumen contents sampled before (T0) or four hours after (T4) the morning feeding from 12 lactating goats fed a high-concentrate diet

	Yeast		Control		SEM	Significance [†]			
	T0	T4	T0	T4		G	T	G × T	P1
Amylase	8.5	13.1	10.4	11.8	2.1	NS	NS	NS	NS
Xylanase	4.9	2.1	6.4	2.4	0.8	NS	***	NS	0.07
Cellulase	0.5	0.5	0.8	0.6	0.2	NS	NS	NS	NS

[†]G: group; T: time of sampling; P1: results during the first period.

*P < 0.05; **P < 0.01; ***P < 0.001; NS: P > 0.1.

Table 4. Effect of live yeast supplementation on polysaccharidase specific activities (μmol reducing sugar/mg protein/h) in nylon bags containing wheat or hay sampled from 12 lactating goats fed a high-concentrate diet

	Yeast		Control		SEM	Significance [†]			
	Wheat	Hay	Wheat	Hay		G	S	G × S	P1
Amylase	13.1	0.0	15.1	0.0	1.4	NS	***	NS	*
Xylanase	1.8	13.6	2.1	13.6	1.6	NS	***	NS	NS
Cellulase	0.0	0.7	0.3	1.0	0.2	0.07	**	NS	NS

[†]G: group; S: substrate in nylon bag; P1: results during the first period.

*P < 0.05; **P < 0.01; ***P < 0.001; NS: P > 0.1.

Except for the latter, our results are similar to those of Brossard (2004) who found no effect of yeast supplementation on solid-associated amylase, cellulase or xylanase activities from the rumen of sheep fed a high-concentrate diet (60% wheat), before and three hours after the feed supply. In contrast, they differ from the results of Jouany *et al.* (1999) who showed, in sheep fed a mixed diet (45% concentrate), that cellulase and xylanase activities were stimulated by yeast supplementation before the morning meal and in hay incubated in nylon bags during 24 h.

The marked individual variability observed during this experiment for all the measured parameters, which seemed to be characteristic of experiments with goats experiencing sub-clinical acidosis (Giger-Reverdin *et al.*, 2005), might have limited the detection of yeast effects on the activity of rumen micro-organisms. Some of the goats also experienced acute acidosis bouts of short duration but the experiment was not designed to test the possible effect of acidosis bouts on polysaccharidase activities.

IV – Conclusions

Post-prandial evolution of polysaccharidase activities in the rumen of dairy goats fed a high-concentrate diet was similar to previous observations, and yeast ruminal supplementation had no effect on solid-associated amylase or xylanase activities isolated from rumen contents or nylon bags containing hay or wheat. Cellulase activity tended to be reduced by yeast supplementation in nylon bag residues but this result has to be confirmed.

The absence of an effect of yeasts on all the tested polysaccharidase activities could be due to the high individual variability observed and the low number of animals. Further analysis to characterise

the rumen microbial population as well as the physiology and behaviour of these animals are currently in progress.

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