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Effects of yeast culture addition on digestion in sheep fed a high concentrate diet

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ABSTRACT

Effects of yeast culture on intake, rumen parameters, digestibility and passage rate were studied in 12 sheep (average BW 59.3 ± 3.5 kg). A high concentrate diet was supplemented with 0 (control), 20 (Y20) or 40 (Y40) g/d of yeast. DMI tended to be higher ($P<0.06$) for Y20 and Y40 diets. Yeast supplements decreased rumen pH ($P<0.05$) and increased total VFA concentration ($P<0.05$) and did not affect the distribution of VFA and acetate to propionate ratio. There were no differences in DM, CP, NDF and ADF digestibility. Ruminal turnover rate and retention time were similar for the diets.

Key words: Yeast; Sheep; Concentrate diet; Passage rate

INTRODUCTION

Improvement of feed efficiency by farm animals depends on suitable utilization of nutrients throughout the digestive tract. The need to meet the nutrient requirements of high producing animals requires the administration of high energy diets which do not always result in an ideal fermentative pattern in the rumen (Clark and Davis, 1983) or in a balanced flow of nutrients to the small intestine. Solutions must, therefore, be adopted when feeding high concentrate diets in order to limit the appearance of digestive disorders.

Inclusion of yeast culture to alleviate these problems in dairy cattle fed high concentrate rations has been investigated (Arambel and Kent, 1990; Kellems at al., 1990). The probiotic effects of yeast in ruminants are still unclear, likely resulting from a combination of several factors. Yeast cells may provide nutrients (nucleotides, amino acids and vitamins) to rumen microorganisms through the autolytic process in the forestomach (Guerzoni and Succi, 1972;

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Hough and Maddox, 1970). Fermentation activity of the bacteria, especially of cellulolytic strains, appears to be increased by feeding yeast (Wiedmeier et al., 1987), leading to higher cell wall and DM digestibility (Adams et al., 1981; Fallon, 1987; Wiedmeier et al., 1987; Males, 1990;).

Limited knowledge is available for the inclusion of yeast culture in diets for sheep. The objective of the present study was to investigate effects of the addition of yeast on intake, rumen fermentation characteristics, digestibility, solid and liquid passage rate in adult sheep, fed a high energy content diet.

MATERIALS AND METHODS

Animals and diets

The trial was carried out using adult sheep of the Lamon breed in three categories: six wethers, three ewes and three rams. The 12 animals were housed in individual metabolic cages equipped with specific floor to obtain the immediate separation of urine from the feces. During an adaptation period of 2 weeks all the animals were fed a basal diet composed of 50% corn silage and 50% pelleted supplement on DM basis, plus 40 g ryegrass hay/kg of silage as fed.

The main components of the supplement were barley, dried sugar beet pulp and roasted soybean, resulting in a CP content of 22.4% and NDF of 26.7% (Table 1). CP was the major component of yeast with 45.8%. Average composition of the diets was 15.2% CP, 4.5% ether extract, 7.4% ash, 40.9% NDF and 22.2% ADF. Animals had ad libitum access to mixed diet in a single meal at 8:00 a.m.

At the beginning of the experimental period, the animals were weighed and then assigned to three balanced groups according to category, body weight and intake. For 3 weeks, each group received the basal diet supplemented with 0 (control), 20 (Y20) or 40 (Y40) g/d of yeast, respectively.

TABLE 1

Chemical composition of the feedstuffs

	Corn silage	Supplement[1]	Ryegrass hay	Yeast
Dry matter (%)	32.8	89.2	89.7	95.7
Crude protein (% DM)	6.9	22.4	8.2	45.8
Ether extract (% DM)	3.9	5.5	2.0	1.7
Ash (% DM)	3.7	10.9	8.2	5.1
NDF (% DM)	54.8	26.7	60.3	-
ADF (% DM)	33.1	11.5	35.8	1.4

[1]Supplement feed composition (% as fed): 40% barley meal, 25% roasted whole soybean meal, 15% dried sugar beet pulp, 5.3% wheat bran, 5% meat meal, 5% molasses, 4.2% minerals and 0.5% vitamins.

The yeast culture, which was mixed with the other components of the diet, was a commercial additive (Lisomix, Centro Sperimentale del latte, Milan, Italy) consisted of 33% of *Saccharomyces cerevisiae* strains and media.

Experimental observations

Ad libitum intake was maintained throughout the trial by keeping orts to about 10% of the total diet and recorded daily. Ruminal fluid samples were taken from each animal 2 d before the end of the adjustment period and on d 1, 2, 5, 7, 9, and 19 of the experimental phase. Each sample was taken 3 h after the meal using an esophageal probe and strained through three layers of cheese cloth and analyzed for pH. Metaphosphoric acid (1 ml) was added per subsample, which was stored at $-18°C$ for further analyses.

Apparent digestibility of the diet was measured from d 12 to d 19 of the experimental period by means of total feces collection.

Solid and liquid passage rates were estimated during the digestibility trial with Cr-mordanted hay and Co-EDTA as solid and liquid phase markers, according to Uden's procedure (Uden et al., 1980). On d 12 of the experimental period, a pulse dose of 40 g of Cr mordanted hay fiber and of Co-EDTA solution providing 6 mg/kg of BW of Co, was given to each animal.

The Co-EDTA solution was administered into the esophagus by a 30-cm nalgene tube connected to a syringe, while the solid marker was fed mixed with 20 g of ground supplement. Feces were collected at 24, 30, 36, 48, 54, 60, 72, 96 and 120 h postdosing, weighed and subsampled for Cr and Co determinations and the remaining fraction was used to estimate digestibility.

Chemical analyses

Feed and fecal samples were analyzed for DM, CP, ash and ether extract content according to AOAC (1984). The fiber fraction composition was estimated using the Goering and Van Soest (1980) procedure. VFA content in the rumen fluid samples was determined according to Hamada et al. (1968) and NH_3-N was measured with a specific ion electrode (AOAC, 1984).

Fecal sample preparation for Cr and Co analyses was carried out according to Murthy et al. (1971) using an atomic absorption spectrophotometer (Perkin-Elmer Norwalk, CT). The fecal Cr and Co concentrations were fitted adopting the one-compartment model proposed by Grovum and Williams (1973):

$$y = A\, e^{-k_1 t}$$

where: A = adjusted marker concentrations in fecal dry matter; k_1 = rate-costant (%/h); t = sampling time (min).

Statistical analysis

Feed intake, digestibility and passage rate data were subjected to ANOVA (Harvey, 1990), including in the model two factors: dose of additive and category of animals. Statistical analysis of rumen VFA, NH_3 and pH were computed excluding the samples taken on d 1 and 2 of the experimental period. Rumen parameters obtained before the beginning of the experimental phase were used as covariate. Sum of squares of the dose factor was divided into two orthogonal contrasts: control vs. Y20+Y40 and Y20 vs. Y40.

RESULTS AND DISCUSSION

On average, DMI increased about 200 g by adding yeast (Table 2). Because of the high variability within groups, the contrast between control and yeast supplemented diets was significant only at $P<0.06$. DMI, expressed as percent of BW, also increased from 2.65% of the control diet to 2.98% and 2.70% for the Y20 and Y40 diets, respectively, but without significant difference.

Higher intake when feeding yeast may derive both from an incresed palatability of the diet and from a stimulation of the microbial fermentative activity in the rumen especially by the cellulolytic microrganisms (Wiedmeier et al., 1987). Increasing DMI was found by Andrighetto et al. (1990), when adding 60 g per head per day of yeast culture to a hay based diet fed to sheep.

Feeding yeast decreased ($P<0.05$) rumen fluid pH compared to that of the control diet (Table 3). This result may depend on higher microbial activity in the forestomach as also indicated by the total VFA production which increased ($P<0.05$) from 97.7 nM/l of the control diet to 108.2 and 111.7 nM/l of the Y20 and Y40 diet, respectively. This is in line with results obtained by Gray and Ryan (1988) in an in vitro study and those of Andrighetto et al. (1990) in a study done on sheep.

TABLE 2

Animal body weight and dry matter intake

	Diets[1]			Contrasts[2]		SE
	control	Y20	Y40	A[3]	B	
Average BW (kg)	59.0	61.4	57.6	NS	NS	6.1
Metabolic BW (kg)	20.95	21.70	20.73	NS	NS	1.64
DMI total (g/d)	1370	1661	1490	0.06	NS	145
DMI/BW (%)	2.65	2.98	2.70	NS	NS	0.46
DMI/$BW^{0.75}$ (g)	70.1	80.6	73.0	NS	NS	10.8

[1]Y20=control diet+20 g/head/d of yeast culture; Y20=control diet+40 g/head/d of yeast culture;
[2]Level of significance; NS=$P>0.10$.
[3]A=control vs. Y20+Y40; B=Y20 vs. Y40.

TABLE 3

Rumen parameters

	Diets[1]			Contrasts[2]		SE
	control	Y20	Y40	A[3]	B	
pH	6.44	6.08	6.13	0.05	NS	0.2
VFA						
Total (mM/l)	97.7	108.2	111.7	0.05	NS	6.7
Acetic (%)	62.3	63.5	64.5	NS	NS	1.8
Propionic (%)	21.7	21.0	20.0	NS	NS	1.8
Isobutyric (%)	0.7	0.6	0.6	NS	NS	0.1
N-butyric (%)	12.4	11.5	11.5	NS	NS	0.7
Isovaleric (%)	1.5	1.4	1.4	NS	NS	0.4
N-valeric (%)	1.5	1.9	2.0	NS	NS	0.6
C2/C3	2.96	3.16	3.29	NS	NS	0.34
N-NH3 (mg/l)	244	225	241	NS	NS	33

[1]Y20 = control diet + 20 g/head/d of yeast culture; Y20 = control diet + 40 g/head/d of yeast culture.
[2]Level of significance; NS = $P > 0.10$.
[3]A = control vs. Y20 + Y40; B = Y20 vs. Y40

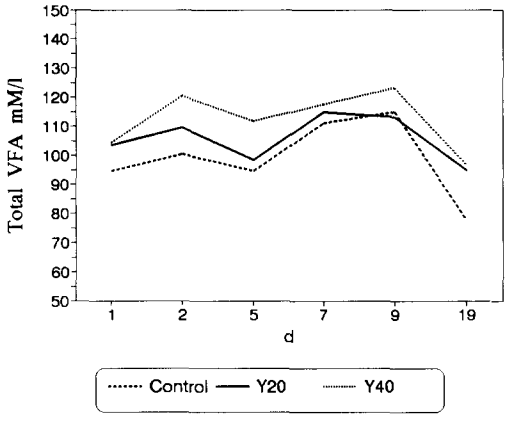

Fig. 1. Total rumen VFA across experimental periods. Y20 = control diet + 20 g/head/d of yeast culture; Y40 = control diet + 40 g/head/d of yeast culture.

Supporting these findings are also VFA concentrations, in particular of the diet Y40, which had the highest values throughout the trial (Figure 1). Regardless to the treatment, the daily variation of this parameter was primerily dependent on the time of sampling. Three hours after the meal is, in fact, a time of intense fermentative activity in the forestomachs which can result in greater variation of VFA concentrations in the rumen fluid even in an animal fed the same diet continuously. However, feeding yeast did not modify the

proportion of single VFA with only a slight increase in the acetate:propionate ratio.

Yeast culture is not cellulolytic, but may provide stimulatory factors for cellulolytic bacteria (Wiedmeier et al., 1987); under our experimental conditions the cellulolytic activity may have determined the maintenance of the acetate level in the VFA profile, avoiding its likely decrease caused by the lower pH.

Differences in rumen ammonia were limited and statistically not significant (Table 3). The overall average was 237 mg/l which, according to Mehrez et al. (1977), should have ensured maximum microbial activity.

The digestion coefficients of the different components of the diets were similar (Table 4). NDF, ADF, and cellulose had an average digestibility of 62.9, 56.9 and 64.3%, respectively, confirming the good quality of the forages utilized. The lack of yeast effects on digestibility in this trial is in agreement with results on lactating cows (Arambel and Kent, 1988, 1990; Harrison et al., 1988), lambs (Adams et al., 1981) and sheep (Chademana and Offer, 1990). In contrast, Wiedmeier et al. (1987) observed an increase in digestibility of protein and hemicellulose of a diet fed to lactating cows supplemented with 90 g/d of yeast, suggesting that adding yeast could have stimulated rumen fermentation.

Passage rate of Cr-mordanted hay marker should not be applied to those particles that significantly differ in chemical and physical characteristics from those of the marker (Faichney and Griffiths, 1978; Ellis et al., 1982; Dixon and Milligan, 1990). Therefore, a correct evaluation of the transit parameters should consider relative differences across treatments and not absolute values.

Rumen passage rate and retention time of fiber particles were similar in the three diets with an average of 2.80%/h and 35.7 h, respectively. Supplement-

TABLE 4

Digestibility coefficients of the diets

	Diets[1]			Contrast[2]		SE
	control	Y20	Y40	A[3]	B	
Dry matter (%)	73.7	71.3	73.1	NS	NS	1.8
Organic matter (%)	77.2	74.9	76.8	NS	NS	1.6
Crude protein (%)	77.2	75.6	77.7	NS	NS	1.7
NDF (%)	64.1	60.2	64.3	NS	NS	2.9
ADF (%)	58.3	54.1	57.2	NS	NS	3.4

[1]Y20 = control diet + 20 g/head/d of yeast culture; Y20 = control diet + 40 g/head/d of yeast culture.
[2]Level of significance; NS = $P > 0.10$.
[3]A = control vs. Y20 + Y40; B = Y20 vs. Y40.

ing the diet with yeast did not affect rumen turnover of the particulate phase, confirming the results of Wiedmeier et al. (1987).

Liquid passage rate was higher (4.44%/h) than the particulate one and similar to that obtained by Chademana and Offer (1990) feeding a high concentrate diet. As with the particulate phase, the liquid phase was not affected by feeding yeast, in agreement with other studies (Adams et al., 1981; Wiedmeier et al., 1987; Harrison et al., 1988; Malcolm and Kiesling, 1990). The discrepancy between higher intake of the yeast fed sheep and the results observed for solid and liquid rumen passage rate might be explained by the large variation within the categories of sheep used in the study which could have masked the treatment effects.

CONCLUSION

The addition of yeast culture to sheep fed a high concentrate diet seems to increase rumen activity, as shown by higher VFA concentration. More intensive fermentation promoted DM intake; however, digestibility, liquid and particulate passage rates were not affected by yeast inclusion in the diet. The two dosages of yeast adopted in this trial showed similar results on all parameters measured.

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