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Effect of *Saccharomyces cerevisiae* fermentation product on ruminal fermentation and nutrient utilization in dairy cows

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ABSTRACT

The goal of this experiment was to investigate the effect of yeast culture (*Saccharomyces cerevisiae*) on rumen fermentation, nutrient utilization, and ammonia and methane emission from manure in dairy cows. Eight ruminally cannulated Holstein cows were allocated to 2 dietary treatments in a crossover design. Treatments were control (no yeast culture) and XP (yeast culture, fed at 56 g/head per day; XP, Diamond V Mills Inc., Cedar Rapids, IA). Dry matter intake, milk yield, milk composition, and body weight were similar between treatments. Milk urea nitrogen concentration was also not affected by treatment. Rumen pH was similar between the control and XP treatments, but rumen ammonia concentration tended to be lower with XP than with the control. Treatment had no effect on concentrations of total or individual volatile fatty acids, protozoal counts, polysaccharide-degrading activities (except amylase activity that tended to be increased by XP), or methane production in the rumen. Urinary N losses did not differ significantly between treatments, but allantoin and total purine derivative excretions and the estimated microbial N outflow from the rumen tended to be increased by XP compared with the control treatment. Total-tract apparent digestibility of dietary nutrients was not affected by XP. Milk fatty acid composition was also not altered by XP supplementation. Cumulative (253 h) ammonia and methane emissions from manure, measured in a steady-state gas emission system, were slightly decreased by XP. Overall, the yeast culture tested had little effect on ruminal fermentation, digestibility, or N losses, but tended to reduce rumen ammonia concentration and increase microbial protein synthesis in the rumen, and decreased ammonia and methane emissions from manure.

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INTRODUCTION

Yeast products (**YP**) based on *Saccharomyces cerevisiae* strains have been used with variable success to favorably modify the ruminal environment and promote microbial growth in ruminants. Recent meta-analyses have reported improvements in cow performance (Desnoyers et al., 2009; Robinson and Erasmus, 2009), but the mechanisms of the effect of YP are not completely understood. Provision of soluble growth factors (amino acids, organic acids such as malic acid, B vitamins) and oxygen scavenging may be involved (Newbold et al., 1996; Callaway and Martin, 1997). A recent report suggested stabilization of ruminal pH through decreased lactate production (Marden et al., 2008) by live yeast. Being aerobic organisms, however, yeast are unlikely to proliferate in the rumen and yet negligible amounts of yeast (live or not) are reportedly beneficial to the ruminal microbial population (Beauchemin et al., 2006). As a result, increased total viable and cellulolytic bacteria counts (Harrison et al., 1988; Newbold et al., 1995) and microbial protein synthesis and outflow from the rumen have been reported in some studies (Erasmus et al., 1992), but not in others (Firkins et al., 1990). In one study, yeast culture (**YC**; *Trichosporon sericeum*) decreased methane production in the rumen of sheep (Mwenya et al., 2004).

Rumen fibrolytic bacteria have a high preference for ammonia (Bryant, 1973) as their N source. Therefore, if the growth of fiber-degrading bacteria in the rumen is enhanced by YP supplementation, an increase in overall utilization of ruminal ammonia for microbial protein synthesis should be expected. In some studies such effects have been observed (Enjalbert et al., 1999, *S. cerevisiae* YC), but in others YP had no effect (Newbold et al., 1996; Mwenya et al., 2004; Longuski et al., 2009, *S. cerevisiae* or *T. sericeum*, live yeast or YC) or

even resulted in increased ruminal ammonia concentration (Newbold et al., 1998, YC). If ruminal microbial growth, specifically that of the fibrolytic bacteria, is enhanced by YP supplementation and this results in a more efficient conversion of ruminal ammonia into microbial protein, the overall utilization of dietary N in the ruminant animal may be improved. Such improvement may result in decreased urinary N losses. Because urinary urea is the primary source of ammonia emitted from cattle manure (Bussink and Oenema, 1998), a reduction in urinary urea excretion may mitigate ammonia emissions from manure. To our knowledge, the effect of YP on ammonia losses from cattle manure has not been studied.

Therefore, the objective of this experiment was to investigate the effect of an *S. cerevisiae* fermentation product on ruminal fermentation, urinary N losses, and the ammonia-emitting potential of manure in high-producing dairy cow. Our hypothesis was that the *S. cerevisiae* fermentation product would reduce ammonia concentration in the rumen and urinary N excretion, which would result in reduced manure ammonia emissions.

MATERIALS AND METHODS

Animals involved in this study were cared for according to the guidelines of the Pennsylvania State University Animal Care and Use Committee. The committee reviewed and approved the experiment and all procedures carried out in the study.

Animals and Experimental Design

Eight multiparous Holstein cows (639 ± 16.4 kg of BW; 91 ± 4.5 DIM at the beginning of the trial) fitted with 10-cm ruminal cannulas (Bar Diamond, Parma, ID) were used in this experiment. Cows were subjected to the experimental treatments in a 2-period, crossover design trial. Treatments were control (no YC) and *S. cerevisiae* fermentation product, fed at 56 g/head per day (**XP**). The *S. cerevisiae* fermentation product (Original XP), a fully fermented YC containing metabolites of yeast fermentation produced under a controlled production process was from Diamond V Mills Inc. (Cedar Rapids, IA). The basal diet fed in this experiment (as TMR; Table 1) was formulated (NRC, 2001) to meet the nutrient requirements (at 27.5 kg/d of DMI) of a Holstein cow yielding 47 kg of milk/d with 3.70% milk fat and 3.05% milk true protein. The TMR was mixed by using a Kuhn Knight Model 3142 Reel Auggie Mixer Wagon (Broadhead, WI) and fed at 0800 and 2000 h (half of the daily allowed feed at each feeding). The XP was top-dressed with the morning feed. Feeding was ad libitum to about 5% orts. Each experimental period consisted of 21 d for adaptation to the diet and 7 d for sampling. Cows were housed in a tiestall facility during the trial and were exercised for 1.5-h periods before each milking. Cows had free access to fresh water and received recombinant bovine somatotropin every 14 d starting at 63 DIM.

Table 1. Ingredient and chemical composition of the basal diet fed in the trial

Item	Amount
Ingredient, % of DM	
Corn silage[1]	34.8
Corn grain, ground	11.2
Alfalfa haylage[2]	9.8
Grass hay[3]	5.9
Canola meal, mechanically extracted	9.0
Soybean seeds, whole, heated	7.4
Cookie byproduct[4]	6.0
Turbo meal[5]	3.6
Cottonseed hulls	4.5
Sugar blend[6]	4.3
Mineral/vitamin premix[7]	3.5
Composition,[8] % of DM	
CP	15.9
Soluble protein	5.7
RDP[9]	9.6
NDF	31.0
ADF	20.4
NE_L, Mcal/kg	1.67
NFC[9]	45.2
Ca	0.96
P	0.39

[1]Corn silage was 34% DM and (% of DM) 39% NDF, 9% CP, and 39% starch.

[2]Alfalfa haylage was 43% DM and (% of DM) 41% NDF and 18% CP.

[3]Grass hay contained (% of DM) 70% NDF and 8% CP.

[4]Cookie byproduct (Bakery Feeds, Honey Brook, PA) contained (% of DM) 9% CP, 8% ether extract, and 5% crude fiber.

[5]Turbo meal is heat-treated soybean meal (J. L. Moyer & Sons Inc., Turbotville, PA) and contained (% of DM) 44% CP, 4% soluble CP, and 24% RUP.

[6]Sugar blend (Westway Feed Products, Tomball, TX) contained (% of DM) 3.9% CP and 66% total sugar.

[7]The premix contained (%, as-is basis) trace mineral mix, 0.88; MgO (54% Mg), 8.3; NaCl, 6.4; vitamin ADE premix, 1.73; limestone, 35.8; selenium premix, 1.09; and dry corn distillers grains with solubles, 45.8. Composition: Ca, 14.1%; P, 0.35%; Mg, 4.58%, K, 0.41%; S, 0.31%; Mn, 1,071 mg/kg; Cu, 358 mg/kg; Zn, 1,085 mg/kg; Fe, 181 mg/kg; Se, 6.67 mg/kg; Co, 5.4 mg/kg; I, 13.4 mg/kg; vitamin A, 262,101 IU/kg; vitamin D, 65,421 IU/kg; and vitamin E, 1,971 IU/kg.

[8]As analyzed by Cumberland Valley Analytical Services (Maugansville, MD).

[9]Estimated based on NRC (2001).

Measurements

Individual forage, TMR, and refusals samples were collected every other day and concentrate feeds were sampled weekly. Samples were composited and the composite samples were analyzed for DM (65°C in a