J. Dairy Sci. 101:1–21
https://doi.org/10.3168/jds.2017-13241

Effect of supplemental yeast culture and dietary starch content on rumen fermentation and digestion in dairy cows

A. L. G. Dias,*† J. A. Freitas,*[1] B. Micai,* R. A. Azevedo,* L. F. Greco,* and J. E. P. Santos*‡[2]
*Department of Animal Sciences, and
†DH Barron Reproductive and Perinatal Biology Research Program, University of Florida, Gainesville 32611
‡Department of Animal Sciences, State University of Maringá, PR, Brazil, 87020-900

ABSTRACT

The objectives of this experiment were to evaluate the effect of feeding a culture of *Saccharomyces cerevisiae* on rumen metabolism and digestibility when cows are fed diets varying in starch content. Four lactating Holstein cows were assigned to a 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments. Treatments were low starch (LS; 23% of diet DM) and no yeast culture (YC; LS-control), LS and 15 g of YC/d (LS-YC), high starch (HS; 29% of diet DM) and no YC (HS-control), and HS and 15 g of YC/d (HS-YC). Periods lasted 28 d, with the last 9 d for data collection. Days 20 to 24 were used to determine production, nutrient flow, and digestibility. On d 25, 3 kg of corn grain DM was placed in the rumen 1 h before the morning feeding, and yields of milk and milk components were measured after the challenge. Blood was sampled −1, 3, 7, and 11 h relative to the morning feeding on d 24 and 25. Rumen pH was measured continuously on d 24 and 25. Rumen papillae were collected on d 24 and 28 to quantify mRNA expression of select genes. Supplementing YC increased yields of milk (26.3 vs. 29.6 kg/d), energy-corrected milk (ECM; 26.5 vs. 30.3 kg/d), fat (0.94 vs. 1.08 kg/d), true protein (0.84 vs. 0.96 kg/d), and ECM/dry matter intake (1.15 vs. 1.30) compared with the control but did not affect dry matter intake (22.6 vs. 22.9 kg/d). Cows fed HS had increased milk true protein percentage (3.18 vs. 3.31%) and yield (0.87 vs. 0.94 kg/d) compared with cows fed LS. Feeding HS-YC increased the proportion of dietary N incorporated into milk true protein from 24.9% in the other 3 treatments to 29.6%. Feeding HS increased the concentration of propionate (21.7 vs. 32.3 m*M*) and reduced that of NH_3-N (8.3 vs. 6.7 mg/dL) in rumen fluid compared with the control, and combining HS with YC in HS-YC tended to increase microbial N synthesis compared with LS-YC (275 vs. 322 g/d). Supplementing YC to cows fed HS reduced plasma haptoglobin and rumen lactate concentrations, increased mean rumen pH, reduced the time with pH <6.0, and prevented the decrease in rumen neutral detergent fiber digestion caused by HS. Cows fed HS had less total-tract digestion of organic matter (73.9 vs. 72.4%) because of reduced acid detergent fiber (57.6 vs. 51.7%) and neutral detergent fiber (60.9 vs. 56.7%) digestibility. Production performance after the challenge was similar to that before the challenge, and YC improved yield of ECM. After the challenge, supplementing YC tended to reduce rumen lactate concentration compared with the control and reduced haptoglobin in cows fed HS. Feeding HS but not YC increased expression in rumen papillae of genes for receptors (*FFAR2* and *FFAR3*) and transporter (*SLC16A3*) of short-chain fatty acids but did not affect genes involved in transport of Na^+/H^+ or water or in inflammatory response. Supplementing YC to dairy cows improved lactation performance in diets containing low or high starch, and mechanisms might be partially attributed to improvements in rumen pH, digestion of fiber, microbial N synthesis, and reduction in acute phase response.

Key words: digestion, rumen fermentation, starch, yeast culture

INTRODUCTION

Supplementing yeast culture (**YC**) to dairy cattle diets is a common practice because of the potential beneficial effects on yields of milk and milk components (Poppy et al., 2012). Nevertheless, the effects of YC are heterogeneous and dependent, among other factors, on the stage of lactation when supplementation starts (Poppy et al., 2012). One of the reported benefits of YC is the improvement in efficiency of feed utilization (Schingoethe et al., 2004), presumably because supplementing diets with *Saccharomyces cerevisiae* improves

Received May 27, 2017.
Accepted September 9, 2017.
[1]Present address: Department of Animal Sciences, Federal University of Paraná, Palotina, PR, Brazil, 85950-000.
[2]Corresponding author: jepsantos@ufl.edu

OM digestion (Desnoyers et al., 2009), results in a more stable rumen pH (Bach et al., 2007), and might increase microbial N yield (Erasmus et al., 1992).

One of the potential sources of heterogeneity in response to YC is the composition of the diet (Williams et al., 1991). The authors observed an interaction between diet composition and supplementation with YC because the benefit in FCM yield was greatest when cows were fed a diet with 60% compared with 50% concentrate content (Williams et al., 1991). Diets with increased concentrate content are more prone to negatively influence rumen function because of the depression in rumination and salivation and the increase in acid load, which can depress pH. It is known that YC and live yeast products attenuate changes in rumen pH (Bach et al., 2007; Desnoyers et al., 2009), in part by reducing lactate accumulation in the rumen fluid because of stimulation of microorganisms that metabolize lactate into short-chain fatty acids (**SCFA**; Callaway and Martin, 1997). Thus, it is possible that potential improvements of dairy cow performance with YC supplementation to diets containing a large proportion of readily fermentable carbohydrates might be caused by a reduction in lactate concentration and an increase in rumen pH. In fact, one of the benefits reported with YC was that it prevented the reduction in milk fat yield when cows were fed more rumen-fermentable diets (Longuski et al., 2009), which would benefit yield of FCM (Williams et al., 1991). Also, it is possible that the benefits of YC might be greater in diets with increased starch content because such diets result in an increased acid load that demands increased physically effective fiber to maintain a proper rumen environment (Allen, 1997). The more stable rumen environment due to supplementing YC to diets high in starch might result in less need for physically effective fiber and justify increases in DMI that improve yields of milk and milk components.

Yeast culture also benefits rumen fiber digestion because of stimulation of growth of fibrolytic microorganisms (Callaway and Martin, 1997). Because of improved digestion of fiber and OM in the rumen (Williams et al., 1991) and total tract (Desnoyers et al., 2009), it is conceivable that benefits of YC supplementation might increase in diets with a larger forage component and more forage NDF. Yeast culture has been shown to increase DMI when supplemented in early lactation (Poppy et al., 2012), and an increase in rate and extent of forage NDF degradation may stimulate intake and productivity in dairy cows.

One of the issues with diet formulation is the inherent variability in nutrient content either because of changes in ingredient composition or because of mixing errors (Oelberg and Stone, 2014). Errors in carbohydrate formulation when diets are already high in starch can result in SARA (AlZahal et al., 2014), which often causes milk fat depression (Longuski et al., 2009). The hypothesis of this experiment was that YC influences dairy cow performance by improving digestion and attenuating fluctuations in rumen pH, particularly in diets rich in starch or those prone to rumen acidosis. Therefore, the objectives were to evaluate rumen metabolism, digestion, and performance in response to supplemental YC in Holstein cows fed diets varying in starch content.

MATERIALS AND METHODS

All procedures with experimental cows were approved by the University of Florida Institute of Food and Agriculture Science Animal Research Committee under protocol number 007-13ANS.

Cows, Housing, and Feeding

The experiment was conducted from September to December 2014. Four ruminally cannulated primiparous Holstein cows were used in the experiment. Cows averaged (±SD) 176 ± 18 DIM, 564 ± 51 kg of BW, and 26.0 ± 3.6 kg of milk/d at enrollment in the experiment. Cows were housed in a cross-ventilated tiestall barn with individual feed and water troughs. Stalls had gel mats that were bedded with shavings, and bedding material was cleaned and replaced twice daily. Cows were fed twice daily at approximately 0700 and 1330 h. The amounts of feed offered to individual cows were adjusted daily to result in at least 5% refusals, which were weighed once daily before the morning feeding. Twice weekly, diets and ingredients were sampled and dried at 55°C for adjustment of amounts of DM to be offered daily. Samples of dried feeds and orts were frozen and later dried at 105°C for calculation of DMI.

Experimental Design and Treatments

The experimental design was a 4 × 4 Latin square with a 2 × 2 factorial arrangement of treatments, resulting in 16 experimental units, with 4 per treatment and 8 per each main effect of level of starch and supplemental YC. The treatment sequence was balanced for carryover, and treatments were 2 levels of dietary starch (23 or 29% of the diet DM) without or with supplemental YC, resulting in 4 combinations: low starch (**LS**) and no YC (LS-control), LS with YC (LS-YC), high starch (**HS**) and no YC (HS-control), and HS with YC (HS-YC). Starch in the diet was increased