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Comparison of non-encapsulated and encapsulated active dried yeast on ruminal pH and fermentation, and site and extent of feed digestion in beef heifers fed high-grain diets☆

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ABSTRACT

The objective of this study was to determine whether feeding ruminally protected active dried yeast (ADY) exhibits postruminal activity in comparison with feeding non-protected ADY assessed by measuring feed intake, ruminal pH and fermentation, and site and extent of feed digestion in finishing heifers. A combination antibiotic was used as a positive control. Five Angus beef heifers with ruminal cannulas (body weight of 650 ± 48.8 kg) were used in a 5 × 5 Latin square design with 21-d periods and 1 week of washout between each period. The five treatments were: 1) control (no ADY and no antibiotics), 2) antibiotics (ANT; 300 mg monensin + 110 mg tylosin/d), 3) ADY (1.5 g ADY/d), 4) encapsulated ADY (EDY; 3.5 g/d containing 1.5 g ADY and 2 g capsule), and 5) mixture of ADY and EDY (MDY; 1.5 g ADY + 3.5 g EDY/d). The ADY was encapsulated using barley hordein and glutelin extracted from barley grain. The stability of encapsulated yeast in the rumen and its release in the intestine were validated in vitro. Intake (kg/d) of dry matter (DM) was not affected by treatments. Ruminal pH, total volatile fatty acid (VFA) concentration, and NH_3-N concentration did not differ among treatments, whereas molar proportion of acetate and ratio of acetate to propionate were greater with yeast addition than ANT. No treatment effects on flows of organic matter (OM) and starch to the omasum were observed, whereas flows of neutral detergent fibre (NDF) were greatest with ANT, lowest with EDY and intermediate with control, ADY and MDY ($P < 0.02$). Digestibility of OM in the rumen tended ($P < 0.09$) to be less with EDY or MDY than control or ANT, but no difference in ruminal digestibility of NDF and starch was observed among treatments. In contrast, greater postruminal digestibility of OM ($P < 0.01$) and NDF ($P < 0.03$) was observed with either EDY or MDY versus control and ANT. Digestibility of OM and NDF in the total digestive tract was also greater ($P < 0.01$) with EDY or MDY than control. No treatment effect was observed on the flows of N to the omasum or microbial protein synthesis. Although digestibility of N in the rumen was not different, the digestibility of N in the total digestive tract was greater ($P < 0.02$) with EDY or MDY than control or ANT. Supplementation of ADY or MDY tended ($P < 0.10$) to have greater

Abbreviations: AP, ratio of acetate to propionate; ADF, acid detergent fibre; ADY, active dried yeast; ANT, antibiotics; CP, crude protein; DM, dry matter; EDY, encapsulated ADY; MDY, mixture of ADY and EDY; aNDF, neutral detergent fibre; OM, organic matter; TMR, total mixed ration; VFA, volatile fatty acids

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gene copy numbers of *R. flavefaciens* compared with ANT. Total protozoa counts were greater ($P < 0.01$) in the rumen of heifers supplemented with ADY or MDY compared with control or ANT. These results demonstrate the postruminal activity of ADY and indicate the potential of feeding protected yeast to ruminants to increase intestinal digestibility of nutrients.

1. Introduction

Using an antimicrobial as a growth promoting feed additive in diets fed to high-producing cattle is a conventional practice in North American feedlot operations. Monensin is an ionophore that is widely used to improve feed efficiency and decrease the risk of acidosis in finishing beef cattle. However, the use of antibiotics in livestock husbandry has been under serious scrutiny in recent years due to the public concern of increasing antimicrobial resistance in people. Therefore, establishing an economically competitive alternative to antibiotics that does not compromise end-product quality is of interest.

Probiotics are living microorganisms of yeast and bacterial original that are generally considered safe when fed to animals (Marteau, 2001). Probiotic yeasts are increasingly used in ruminant nutrition as feed additives to improve animal health and production efficiency (Vohra et al., 2016). Studies in the literature on the effects of feeding yeast to beef cattle are limited in comparison to the considerable research that has been conducted in lactating dairy cows (Desnoyers et al., 2009). There is now overwhelming evidence that including probiotic yeasts in dairy cow diets can improve milk production and feed efficiency (Poppy et al., 2012). Responses attributed to yeast are usually related to stimulation of cellulolytic and lactate-utilizing bacteria in the rumen that help stabilize ruminal pH (Thrune et al., 2009). However, the use of probiotic yeasts to improve beef production has been variable, possibly due to the diet composition, strain of yeast or yeast viability (McAllister et al., 2011).

In addition, most research using probiotic yeasts has focused on rumen fermentation such as stabilizing rumen pH, stimulating the growth and metabolism of lactate-utilizing bacteria, scavenging oxygen present in the ingested feed particles, promoting growth of ruminal protozoa, or improvement in fibre digestion (Vohra et al., 2016). Many other beneficial effects of yeasts including their ability to improve the immune system, suppression of gut disorders and potential to reduce bloating have also been documented (Liong, 2007). A number of mechanisms whereby probiotic yeasts may improve gut health, intestinal microbial balance and nutrient digestibility have been proposed (McAllister et al., 2011), but to our knowledge, no studies have directly examined these mechanisms in beef cattle. With ruminants, the challenge is to deliver probiotic yeasts with high activity postruminally due to the highly proteolytic environment of the rumen. Little is known about the effects that live yeast may have postruminally, or whether yeast remains viable as it passes through the rumen and the gut. There is little work on strategies to protect live yeast to reach the lower gut

Table 1
Ingredients and chemical composition of the experimental diet.

Ingredient, g/kg DM	
Barley silage[a]	100
Barley grain,[b] dry-rolled	670
Corn DDGS[c]	200
Barley, ground	16.4
Canola meal	2.9
Calcium carbonate	7.3
Molasses	0.7
Salt	1.5
Feedlot premix[d]	0.3
Urea	0.6
Vitamin E (500,000 IU/kg)	0.02
Canola oil	0.3
Chemical composition	
Dry matter (DM), g/kg	759
Organic matter, g/kg DM	953
Neutral detergent fibre (aNDF), g/kg DM	274
Acid detergent fibre (ADF), g/kg DM	104
Starch, g/kg DM	383
Crude protein, g/kg DM	179

[a] Composition was DM 312 g/kg, aNDF 509 g/kg, ADF 318 g/kg, starch 183 g/kg, CP 136 g/kg based on 5 samples composited by period.
[b] Composition was DM 912 g/kg, NDF 218 g/kg, ADF 61 g/kg, starch 578 g/kg, CP 141 g/kg based on 5 samples composited by period.
[c] Composition of distillers grains with solubles (DDGS) was DM 907 g/kg, NDF 405 g/kg, ADF 167 g/kg, starch 13 g/kg, CP 302 g/kg based on 5 samples composited by period.
[d] Supplied per kilogram of dietary DM: 15 mg Cu, 65 mg Zn, 28 mg Mn, 0.7 mg I, 0.2 mg Co, 0.3 mg Se, 6000 IU vitamin A, 600 IU vitamin D, and 47 IU vitamin E.