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Effects of Propionibacteria and Yeast Culture Fed to Steers on Nutrient Intake and Site and Extent of Digestion[1]

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ABSTRACT

The effects of feeding *Propionibacterium* strain P169 (P169), yeast culture (XPY), and their combination on nutrient intake, site and extent of digestion, and ruminal kinetics were evaluated in a completely randomized experimental design. Ruminally and duodenally cannulated Angus × Hereford steers (n = 12) were assigned to 1 of 4 treatments in each of 2 periods: 1) control, fed a sorghum silage-based total mixed ration; 2) P169, fed the control plus P169 (6×10^{11} cfu/steer per d); 3) XPY, fed the control plus XPY (56 g/steer per d); and 4) P169 + XPY, fed the control plus P169 and XPY (at 6×10^{11} cfu/steer per d and 56 g/steer per d, respectively). Each period lasted 21 d; d 1 to 15 were used for diet adaptation and d 16 to 21 were used for fecal, duodenal, ruminal, and blood sample collection. Steers were individually housed and fed. Feeding XPY tended to decrease intake of organic matter, acid detergent fiber, and N, and decreased intake of neutral detergent fiber. However, feeding XPY alone tended to increase total tract digestibility of organic matter, N, neutral detergent fiber, and acid detergent fiber. Ruminal digestibility, duodenal flow, microbial N synthesis, microbial efficiency, and fluid and particulate passage rates were not affected by dietary treatments. Feeding P169 tended to decrease molar proportion of acetate, increased molar proportion of propionate (by 9.7%), and tended to decrease acetate:propionate ratio compared with control steers. No other effects of XPY or P169 on ruminal fermentation were observed. Plasma glucose and insulin concentrations were not affected by dietary treatment. Our results suggest that feeding P169 alters ruminal metabolism toward increased propionate without affecting feed intake or ruminal kinetics, whereas feeding XPY alone tended to increase total tract digestibilities of nutrients.

Key words: cattle, digestibility, propionibacteria, yeast culture

INTRODUCTION

Ruminal propionate is the single most important substrate for gluconeogenesis in lactating dairy cows (Drackley et al., 2001). Estimates by Seal and Reynolds (1993) indicate that propionate supplies 32 to 73% of glucose demands. Both drenching (Grummer et al., 1994) and feeding propylene glycol (Christensen et al., 1997) have increased ruminal propionate and plasma insulin and have decreased blood NEFA concentrations, all of which are beneficial to combating the extent and duration of negative energy balance, fatty liver, and ketosis (Gerloff, 2000; van Knegsel et al., 2005). Effects of propylene glycol are partially mediated through the observed increases in ruminal propionate (Grummer et al., 1994; Christensen et al., 1997), providing a reason to feed propionate substrate during the transition period. Feeding the propionate-producing bacteria *Propionibacterium* strain 169 (**P169**) to Holstein dairy cows increased the proportion of ruminal propionate and milk production (Stein et al., 2006), but little evidence exists in the literature regarding the effects of feeding P169 on DMI, digestibility, or microbial CP synthesis.

Yeast and yeast cultures have been fed to dairy cattle for more than 60 yr with varied responses (Schingoethe et al., 2004). In some studies, yeast cultures increased DMI (Wohlt et al., 1991) and milk production (Wang et al., 2001), whereas other studies (Arambel and Kent, 1990; Soder and Holden, 1999) have shown no response to yeast cultures. In vitro experiments have reported that in some cases, *Saccharomyces cerevisiae* favorably altered the mixed ruminal microorganism fermentation and stimulated lactate uptake and cellulose digestion by pure cultures of predominant bacteria (Callaway and Martin, 1997). Even though the effects of yeast and yeast cultures are not always consistent (Martin and Nisbet, 1992), several modes of action have been proposed regarding their stimulatory effects on ruminal

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fermentation (Wallace, 1994; Beauchemin et al., 2006) and increased milk production (Wohlt et al., 1991).

Recently, Stein et al. (2006) fed P169 in conjunction with yeast culture and reported an 8% increase in milk production, an increased proportion of ruminal propionate, and an increased percentage of milk protein by Holstein dairy cows compared with control cows. However, it was not determined whether P169 and yeast culture increased the flow of microbial cell protein to the duodenum, spared glucogenic AA, or both to increase milk protein. The objective of the present study was to determine whether yeast culture (**XPY**), P169, or their combination would improve DMI, the site and extent of digestion, microbial protein synthesis, and ruminal fermentation in mature steers.

MATERIALS AND METHODS

Animals and Treatments

This experiment was conducted at the Nutrition Physiology Research Center, Stillwater, Oklahoma, in accordance with an approved Oklahoma State University Animal Care and Use Committee protocol. Twelve ruminally and duodenally cannulated Angus × Hereford crossbred steers (initial BW = 534 ± 32 kg) were randomly allotted to 1 of 4 treatments (n = 3 steers/treatment) in a completely randomized experimental design replicated in two 21-d periods. In period 2, steers were reallocated to treatments such that no steer received the same treatment twice. During the experiment, steers were housed in individual indoor pens (3 × 4 m) with ad libitum access to fresh water. Treatments included 1) a control, in which steers were fed a sorghum silage-based TMR (Table 1); 2) P169, in which steers were fed the control plus P169 (6×10^{11} cfu/steer per d; Agtech Products Inc., Waukesha, WI); 3) XPY, in which steers were fed the control plus Diamond V-XP Yeast Culture (Diamond V Mills Inc., Cedar Rapids, IA; 56 g/steer per d); and 4) P169 + XPY, in which steers were fed the control plus P169 and XPY (at 6×10^{11} cfu/steer per d and 56 g/steer per d, respectively). Yeast culture and P169 were mixed with 4.5 kg of TMR and fed to steers each morning. Following complete consumption of the 4.5 kg (approximately 2 h), steers were offered additional TMR for ad libitum intake.

During each of the 2 experimental periods, d 1 through 15 were used for diet adaptation and d 16 through 21 were used for sample collection. On d 1 of each period, animals were weighed and returned to their respective pens. Ten days before duodenal digesta sampling, gelatin capsules containing 7.5 g of chromic oxide (indigestible marker) were placed directly in the rumen at 0800 and 1700 h (15 g/steer per d) to enable prediction of duodenal flow and fecal output (Merchen, 1988). Steers were moved into individual metabolism stanchions 2 d before sample collection in each period.

Table 1. Ingredient and chemical composition of the basal TMR (DM basis)

Item	Amount
Ingredient, % (DM basis)	
Sorghum silage	19.6
Alfalfa	24.5
Grain mix	47.9
Whole cottonseed	7.35
Megalac-R[1]	0.65
Grain mix, % of grain mix (DM basis)	
Ground corn	60.7
Wheat middlings	15.8
Soybean meal	14.3
Extruded-expeller soybean meal	5.6
Calcium carbonate	1.0
Sodium bicarbonate	1.0
Magnesium oxide	0.5
Salt	0.5
Zinpro 4-Plex[2]	0.1
Vitamin and trace mineral premix[3]	0.5
Chemical composition,[4] %	
DM	65.2
CP	16.7
NDF	40.6
ADF	25.5
Ash	8.10
Ca	0.90
P	0.40

[1]Church & Dwight Co. Inc., Princeton, NJ; Megalac-R contains: fat (as fatty acids), 82.5%; Ca, 8.5%; IOD (moisture), 3 to 4%.

[2]Zinpro Corp., Eden Prairie, MN; Zinpro 4-Plex contains: Zn, 2.58%; Mn, 1.43%; Cu, 0.90%; Co, 0.18%; Met, 8.21%; Lys, 3.8%.

[3]Contents per kilogram: vitamin A (1,650,000 IU), vitamin D_3 (517,000 IU), vitamin E (8,800 IU), biotin (352 mg), Ca (15.4%), Mn (1.0%), Zn (8,600 mg/kg), Fe (6,000 mg/kg), Cu (1,500 mg/kg), I (250 mg/kg), and Se (110 mg/kg).

[4]All values except for DM are expressed on a DM basis. Percentages of DM, CP, NDF, ADF, and ash were analyzed values, whereas Ca and P were calculated.

Sample Collection and Preparation

Diets were weighed out daily and fed to steers on an individual basis to allow for ad libitum intake. Samples of the diet were collected at feeding and frozen (–20°C) until analysis. Orts were weighed, recorded, and sampled daily for each steer. At the end of each period, diet and orts were composited by steer, subsampled, and stored frozen (–20°C). Diet and orts samples were dried in a forced-air oven (60°C) for 72 h and ground in a Wiley mill (Thomas Scientific, Swedesboro, NJ) to pass through a 1-mm screen. On d 16 through 20, fecal grab samples were collected twice daily at 0800 and 1700 h, frozen (–20°C), oven-dried (60°C for 72 h), composited by animal within period, ground (Wiley mill, 1-mm screen), and stored at room temperature for subsequent analyses. Samples of duodenal digesta (250 mL) were