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Effect of Abomasal Pectin Infusion on Digestion and Nitrogen Balance in Lactating Dairy Cows

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ABSTRACT

Two experiments were conducted to test the hypothesis that increasing carbohydrate fermentation in the large intestine would increase intestinal conversion of blood urea N to microbial protein, thereby reducing urinary N output. In experiment 1, 3 multiparous Holstein cows were used in an incomplete 4 × 4 Latin square with 14-d periods. Cows were fed the same basal diet and treatments were the abomasal infusion of 0, 0.5, or 1 kg/d of citrus pectin, or the addition of 1 kg/d of molasses to the basal diet. Experiment 2 used 6 cows in a double reversal design with four 21-d periods. Cows were fed one basal diet and treatments were the abomasal infusion of either 0 or 1 kg/d of pectin. In experiment 1, pectin infusion linearly decreased basal ration intake from 25.0 to 23.2 kg/d. This was prevented in experiment 2 by restricted feeding, and basal ration intake was 22.2 kg/d. Abomasal pectin caused numeric decreases in total tract apparent digestibility of neutral detergent fiber and neutral detergent solubles in experiment 1 and significantly decreased starch digestibility in experiment 2, suggesting that pectin may have reduced postruminal nutrient digestibility. Pectin infusion did not affect milk yield but decreased milk fat percentage from 3.69 to 3.53% in experiment 2. Increasing abomasal pectin tended to decrease urinary N and increase fecal N in experiment 1 and these effects were significant in experiment 2. For both experiments, urinary N decreased 26 g/d, approximately 10% of daily urine N output. Abomasal pectin did not affect fecal pH or DM content; however, in experiment 2, pectin decreased fecal ammonia from 19.8 to 13.4 mmol/kg of DM and increased fecal purines from 13.8 to 15.8 mmol/kg of DM. In both experiments, excretion of fecal purines was increased from 15 g/d for 0 kg/d pectin to 18 g/d for 1 kg/d pectin, although this increase was only significant in experiment 2. These results suggest that manipulating dairy diets to increase postruminal fermentation may reduce urinary N and consequently manure ammonia losses. However, abomasal pectin tended to decrease both ruminal ammonia concentration and urinary purine derivative output in experiment 2, suggesting that postruminal pectin fermentation may have compromised rumen microbial protein production.
(**Key words:** feces, nitrogen, pectin, urine)

Abbreviation key: 0 Pectin = abomasal infusion of saline only, **0.5 Pectin** = abomasal infusion of 0.5 kg/d pectin in saline, **1 Pectin** = abomasal infusion of 1.0 kg/d pectin in saline, **1 Mol** = abomasal infusion of saline only and 1.0 kg/d of dried molasses was added to ration, **GalA** = galacturonic acid, **MCP** = microbial crude protein, **NDS** = neutral detergent solubles, **NDSF** = neutral detergent-soluble fiber, **TESC** = total 80% ethanol-soluble carbohydrates.

INTRODUCTION

Ammonia emissions from dairy manure reduce air quality and can be detrimental to human and animal health (James et al., 1999). Between 57 and 78% of urinary N is in the form of urea (de Boer et al., 2002). In the presence of feces, urinary urea N is rapidly converted into ammonia due to urease activity of fecal bacteria (Varel et al., 1999). However, fecal N is relatively stable during collection and storage (Varel et al., 1999).

On average, half of dairy cow manure N comes from feces and half comes from urine (Wright et al., 1998; Hristov and Ropp, 2003; Wattiaux and Karg, 2004); however, this ratio is affected by nutritional manipulation. Wright et al. (1998) fed cows diets containing 10.5, 17.0, or 23.5% CP at either 80 or 90% of ad libitum intake. Increasing CP from 10.5 to 23.5% increased fecal N by 30 g/d and urinary N by 253 g/d. Consequently, urinary N as a percentage of excreted N increased from 31% on the low CP diet to 64% on the high CP diet. Although less dramatic than the effects of dietary CP, forage source and dietary NDF also appear to shift the relative excretion of urinary and fecal N. Wattiaux and Karg (2004) reported that cows excreted 56% of N in the urine when fed diets containing 41% alfalfa silage and 14% corn silage, and this was

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increased to 63% when diets contained 41% corn silage and 14% alfalfa silage. When Hristov and Ropp (2003) increased dietary NDF from 26.1 to 34.1%, urinary N numerically decreased from 61.5 to 52.7% of total excreted N. Continued study of nutritional impacts on the pattern of N excretion may expose practical strategies to reduce ammonia emissions from manure and improve air quality.

Neutral detergent-soluble fibers (**NDSF**) are plant carbohydrates that are unavailable to mammalian digestive enzymes but are soluble in neutral detergent solution, thus making them available for metabolism by gut bacteria (Hall et al., 1999). Pectin is one class of NDSF and studies in monogastrics have shown that dietary pectin is completely degraded by resident intestinal bacteria (Cummings et al., 1979; Buchanan et al., 1994). Because pectin primarily provides energy, bacteria also require N for growth on pectin. Blood urea transfers freely between the postgastric digestive tract and body fluids (Hoover, 1978) and gut bacteria are capable of converting blood urea N into ammonia and subsequently microbial protein. Therefore, growth of intestinal microorganisms using energy supplied by pectin can result in a net conversion of blood urea N into fecal microbial N, thereby reducing urinary N. This was demonstrated when pectin was fed to rats (Brunsgaard et al., 1995) or infused into the sheep cecum (Mason et al., 1981). However, these experiments were done on animals fed near maintenance and the effects of postruminal pectin in lactating dairy cattle with relatively rapid rates of intake and passage has not been determined.

Two experiments were conducted to determine whether abomasal pectin infusions could decrease urinary N in lactating dairy cows. The magnitude of any response will help determine whether altering practical diets to increase postruminal microbial growth could be used as a tool to reduce ammonia volatilization from manure. A secondary objective of these experiments was to identify fecal characteristics that are altered by pectin infusion, with the intent of identifying a marker that could be used to quickly evaluate differences in postruminal fermentation of practical diets. Finally, it was assumed that effects of abomasal pectin would be due to stimulating growth of intestinal microbes. Increasing energy supply to ruminal microbes or to animal tissues as absorbed VFA should not produce the same effects. This assumption was tested in experiment 1 by comparing responses in cows receiving abomasal pectin to those of cows fed molasses.

MATERIALS AND METHODS

Animals and Treatments

Cows used in both experiments were rumen cannulated (10 cm center diameter; Bar Diamond, Parma, ID) and housed in a stanchion barn with free access to water. Milking times were 0330 and 1530 h, and milk weight was recorded at each milking. Cows were injected with bovine somatotropin (500 mg of Posilac; Monsanto Company, St. Louis, MO) every 2 wk. The Animal Care and Use Committee for the College of Agriculture and Life Sciences at the University of Wisconsin-Madison approved all animal procedures.

Experiment 1. Four multiparous, late-lactation (215 to 329 DIM at start of trial) Holstein cows were assigned to a 4×4 Latin square with 14-d periods. All cows were fed the same basal diet (Table 1) containing alfalfa silage, corn silage, and steam-rolled corn. Steam-rolled corn was 0.39 kg of DM/L and 85% DM (Lake Mills Feed and Grain, Lake Mills, WI). Rations were fed as 4 equal portions at 0900, 1600, 2100, and 0400 h and refusals were removed at 0730 h. The basal diet was fed at 120% of intake for 2 wk immediately before the start of the experiment, and ad libitum DMI was estimated as the average DMI during the final 4 d of this pre-experimental period (mean of 26.4 kg/d). Each cow was offered the basal diet at 95% of its estimated ad libitum intake (mean of 25.1 kg/d) throughout the remainder of the experiment. Feeds were analyzed weekly for DM content and rations were adjusted accordingly.

Treatments were abomasal infusion of saline only (**0 Pectin**), abomasal infusion of saline containing 0.5 kg/d pectin (**0.5 Pectin**), abomasal infusion of saline containing 1.0 kg/d pectin (**1 Pectin**), or abomasal infusion of saline only, with 1 kg/d dried molasses on soy hull carrier (Westway Feed Products, New Orleans, LA) added to the basal diet (**1 Mol**). Infusions began at 0900 h on d 6 of each period and continued through d 14 (9 d of infusion). Weights of pectin and molasses were on an as-fed basis. Ingredient composition of the basal ration and nutrient contents of the basal ration, pectin, and molasses are listed in Table 1.

Studies using lactating cows with duodenal and ileal cannulas reported treatment means for large intestinal digestion ranging from 0.4 to 1.0 kg/d of OM (Younker et al., 1998), from 0.8 to 1.4 kg/d of OM (Callison et al., 2001), and from 0.8 to 3.5 kg/d of DM (Knowlton et al., 1998). Therefore, for each of these studies, the greatest differences in OM or DM digestion in the large intestine between the treatment means were 0.6, 0.6, and 2.7 kg/d, respectively. The 1 Pectin treatment was predicted to increase DM digestion in the large intestine by 1.0 kg/d compared with the 0 Pectin treatment. This amount was chosen to increase large intestinal DM digestion by an amount that could be obtained by other, more practical, dietary manipulations. To determine if