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Ruminal and blood responses to propylene glycol during frequent feeding

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ABSTRACT

The objective of the current experiment was to study the responses of ruminal and blood metabolites of Holstein dairy cows to propylene glycol (PG) under different methods of delivery during frequent feeding. By providing the same amount (200 mL or 200 g) of PG, delivery methods for PG were assessed: 1) control treatment: no PG; 2) dietary treatment: 200 g of PG as a dry product (65% purity; corresponded to 308 g of the dry product) mixed into the TMR; 3) oral-drench treatment: 200 mL of liquid PG (100% purity) orally drenched; and 4) rumen-drench treatment: 200 g of PG as a dry product drenched via the rumen cannula to mimic top dressing. Eight multiparous (lactation = 3 ± 1.1 SD) ruminally cannulated Holstein dairy cows (DIM = 204 ± 104.5 SD) were fed PG for 4 d (d 11 to 14) in a replicated 4 × 4 Latin square design with an experimental length of 14 d for each period. On the last day of each period, serial blood samples were removed from an indwelling catheter placed in the right jugular vein immediately before and for 4 h after PG administration. Cows were fed at 12× feeding/d for 2 d before entering the serial sampling period to minimize postprandial influences on blood metabolites. Ruminal content was also sampled hourly for 4 h on d 14. Milk was sampled from 2 consecutive milkings on d 13 during each period. Dry matter intake and milk yield were not affected by PG. Percentages of milk lactose were increased by PG delivered by all methods tested in the current experiment. Ruminal concentrations (as percentages of total volatile fatty acids) of acetate were decreased and concentrations of propionate and isovalerate were increased by PG, regardless of the delivery method; however, total volatile fatty acid concentration was not affected by PG. Ruminal concentrations of butyrate were decreased and concentrations of valerate were increased by PG drench, via either an oral or ruminal drench. The degree of reduction in butyrate concentration or increase in valerate concentration was affected by PG dose. Serum insulin peaked more rapidly and at a greater concentration for cows receiving PG via drenching, but not when PG was provided as a part of the TMR. Plasma glucose, however, tended to peak more rapidly at a greater concentration for cows receiving PG, regardless of the delivery method. Propylene glycol for the amount drenched (orally or ruminally) or fed (incorporated into the ration) shifted ruminal fermentation toward a more glucogenic environment. Drenching demonstrated a better efficacy than feeding PG because of the amount of PG that was available to the animal at the time of sampling. Effects of drenching dry PG into the rumen were comparable with orally drenching liquid PG.

Key words: propylene glycol, ruminal fermentation, plasma glucose, serum insulin

INTRODUCTION

Propylene glycol (**PG**) via drenching or feeding was demonstrated by Johnson (1954) to treat ketosis effectively in dairy cows because of its glucogenic property (Hanzlik et al., 1939). Propylene glycol has been shown to increase the concentration of propionate and decrease the ratio of acetate to propionate, thereby resulting in a ruminal VFA pattern that is more glucogenic (Clapperton and Czerkawski, 1972; Czerkawski and Breckenridge, 1972). Supplementation of PG to cows has been shown to increase blood insulin and glucose concentrations (Studer et al., 1993; Grummer et al., 1994; Christensen et al., 1997). A drench dose of approximately 500 mL/d or more is often used as a prophylactic treatment for clinical ketosis in dairy cows (Herdt and Emery, 1992). A lower amount of PG (e.g., 118 mL/d), however, is often drenched to cows after parturition as a preventive for subclinical ketosis. Replacing routine drenching with feeding can reduce stress on the cow and on the person who does the drenching, reduce the cost of labor, and ultimately improve the overall health and production of dairy cows. Results from our previous experiments (Chung et al., 2009a,b) showed that supplementing 162.5 g/d (as a preventive dose) of PG either as a top dressing or as a part of the TMR (by mixing PG into the TMR) reduced plasma BHBA concentrations without changing serum insulin and plasma glucose. Bassett (1975) suggested that the

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magnitude of the response in blood insulin concentration is highly dependent on the amount of food ingested. Armentano et al. (1984) reported that cattle fed 12× feeding/d were in a steady state for glucose production and utilization. Therefore, to minimize postprandial effects on blood insulin and glucose responses to PG, a 12× feeding/d frequent feeding schedule was used in the current experiment. Opportunities exist for a dry form of PG to be fed or drenched to cows. A dry form of PG is easier to store on the farm and maintains the consistency of the diet if it is top dressed or mixed into the ration compared with PG in liquid form. It was hypothesized that a dry form of PG provided as a top dressing would be as effective as liquid PG provided as a drench in stimulating blood insulin and glucose responses. To ensure complete consumption of dry PG by cows, dry PG was ruminally drenched. The objectives of the current experiment were to study the effects of PG, as a dry product, via different methods of delivery on serum insulin and plasma glucose concentrations and ruminal VFA patterns for cows during frequent feeding.

MATERIALS AND METHODS

Experimental Design, Animal Care, and Treatments

This experiment was conducted under the approval of The Pennsylvania State University Animal Care and Use Committee. Eight multiparous (lactation = 3 ± 1.1 SD) ruminally cannulated Holstein dairy cows (average DIM = 204 ± 104.5 SD) were allocated into 2 groups and used in a 4 × 4 Latin square design (2 replications) to study responses of ruminal and blood metabolites of Holstein dairy cows to PG under different methods of delivery. Allocation of cows was balanced for lactation number, predicted 305-d mature equivalent milk production for the current lactation, DIM, BW, feed intake, and milk yield and composition from the previous DHI testing result. Cows were housed in a tunnel-ventilated tie-stall barn located at the Pennsylvania State University Dairy Research and Education Center (University Park, PA). Cows were moved into this facility at least 1 wk before the initiation of the experiment.

The experiment consisted of 4 periods of 14 d each, with the last day (d 14) as the serial blood and ruminal sample collection day. During each experimental period, d 1 to 9 was the adaptation period, during which cows were milked twice daily at approximately 0630 and 1830 h and fed a basal lactating cow diet as a TMR (Table 1) once daily at approximately 0800 h after the morning milking. The TMR was formulated based on NRC (2001) guidelines for Holstein dairy cows at 660 kg of BW and producing 41 kg of milk/d with 3.7% of milk fat. Cows had access to an open dry lot for 2 h before each milking. Days 11 to 14 of each experimental period was the treatment period, during which treatments were administrated and cows were gradually adapted to a frequent feeding schedule to minimize postprandial influences attributable to feeding. During the treatment period, cows were milked at 0500 and 1700 h and brought back to the tie-stall barn directly from the milking parlor after each milking.

By providing the same amount (200 mL or 200 g/cow per day) of PG, delivery methods for PG were assessed: 1) control treatment: no PG; 2) dietary treatment: 200 g/d of PG as a dry product (65% purity; corresponded to 308 g of the dry product) mixed into the TMR; 3) oral-drench treatment: 200 mL/d of liquid PG (100% purity) drenched orally by using a 200-mL drench gun (Nasco, Fort Atkinson, WI); and (4) rumen-drench treatment: 200 g/d of PG as a dry product drenched via the rumen cannula. For the rumen-drench treatment, dry PG was first dissolved into 500 mL of 38°C distilled water and drenched into the cavity of the reticulum via the rumen cannula by using a tubing connected to a funnel. The tubing and funnel were rinsed with 250 mL of 38°C distilled water to remove any residue. Ruminal drenching was completed within 3 to 5 min. Cows on the control treatment were not drenched or provided PG in the diet. The liquid PG used contained 99.9% of PG. The dry PG used was a nonacidogenic dry product (Gly-Tran 65, NutriLinx, LLC, Montpelier, VT; NE_L = 2.6 Mcal/kg) that was composed of 65% PG and 35% silicon dioxide as the carrier.

Frequent Feeding

Starting at 1000 h on d 10, one day before the start of each experimental treatment period, cows were gradually adapted to a frequent feeding schedule at 6×, 6×, 12×, 12×, and 12× feeding/d on d 10, 11, 12, 13, and 14, respectively. Cows were fed at 12× feeding/d for 2 d before entering the serial sampling period on d 14. The basal lactating cow TMR fed to each cow was weighed into smaller equal portions and fed frequently to each cow. Feed refusals from the previous day were weighed and the amount of feed offered was adjusted daily to allow a 10% refusal. Feed was pushed up to cows approximately 4 to 6 times per day. Treatments were administrated accordingly immediately after the first feeding of fresh feed. After the conclusion of the serial sampling period at 1400 h on the last day of each experimental period, feed refusals were weighed and cows were returned to 1× feeding/d.