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Evaluation of propylene glycol and glycerol infusions as treatments for ketosis in dairy cows

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ABSTRACT

To evaluate propylene glycol (PG) and glycerol (G) as potential treatments for ketosis, we conducted 2 experiments lasting 4 d each in which cows received one bolus infusion per day. Blood was collected before infusion, over 240 min postinfusion, as well as 24 h postinfusion. Experiment 1 used 6 ruminally cannulated cows (26 ± 7 d in milk) randomly assigned to 300-mL infusions of PG or G (both ≥99.5% pure) in a crossover design experiment with 2 periods. Within each period, cows were assigned randomly to infusion site sequence: abomasum (A)-cranial reticulorumen (R) or the reverse, R-A. Glucose precursors were infused into the R to simulate drenching and the A to prevent metabolism by ruminal microbes. Glycerol infused in the A increased plasma glucose concentration the most (15.8 mg/dL), followed by PG infused in the R (12.6 mg/dL), PG infused in the A (9.11 mg/dL), and G infused in the R (7.3 mg/dL). Infusion of PG into the R increased plasma insulin and insulin area under the curve (AUC) the most compared with all other treatments (7.88 vs. 2.13 μIU/mL and 321 vs. 31.9 min × μIU/mL, respectively). Overall, PG decreased plasma BHBA concentration after infusion (−6.46 vs. −4.55 mg/dL) and increased BHBA AUC (−1,055 vs. −558 min × mg/dL) compared with G. Plasma NEFA responses were not different among treatments. Experiment 2 used 8 ruminally cannulated cows (22 ± 5 d in milk) randomly assigned to treatment sequence in a Latin square design experiment balanced for carryover effects. Treatments were 300 mL of PG, 300 mL of G, 600 mL of G (2G), and 300 mL of PG + 300 mL of G (GPG), all infused into the R. Treatment contrasts compared PG with each treatment containing glycerol (G, 2G, and GPG). Propylene glycol increased plasma glucose (14.0 vs. 5.35 mg/dL) and insulin (7.59 vs. 1.11 μIU/mL) concentrations compared with G, but only tended to increase glucose and insulin concentrations compared with 2G. Propylene glycol increased AUC for glucose (1,444 vs. 94.3 mg/dL) and insulin (326 vs. 6.58 min × μIU/mL) compared with G, and tended to increase insulin AUC compared with 2G. Propylene glycol was not different from GPG for glucose, insulin, or BHBA responses. Propylene glycol decreased plasma BHBA concentration (−10.3 vs. −4.21 mg/dL) and increased BHBA AUC (−1,578 vs. −1.42 min × mg/dL) compared with G, but not compared with 2G. In general, and compared with G, GPG decreased plasma NEFA concentrations after infusions and PG decreased plasma NEFA concentrations early but not late after infusions. We conclude that a 300-mL dose of PG is more effective at increasing plasma glucose concentration than G and at least as effective as 600 mL of G or a combination of G and PG when administered in the cranial reticulorumen.

Key words: fresh cows, glucose precursors, ketosis, postpartum

INTRODUCTION

Insulin resistance and low plasma insulin concentration in the peripartum period stimulates fat mobilization, elevating plasma NEFA concentration. Greater NEFA supply stimulates hepatic oxidation of FA, increases hepatic export of ketone bodies, and increases the risk of hepatic lipidosis. Increased hepatic oxidation of NEFA likely induces satiety, decreasing feed intake and increasing fat mobilization even more during this period of high metabolic demands (Allen et al., 2009). Elevated concentration of ketone bodies in body fluids, referred to as ketosis, is indicative of excessive fat mobilization, and is often associated with inappetence and decreased milk yield and alertness.

Incidence of clinical ketosis in dairy farms can range from 2 to 15% during the first month after parturition (Duffield, 2000). Costs associated with ketosis include treatment costs, loss in milk production, decreased reproductive efficiency, increased culling risk, and increased risk of other diseases (Walsh et al., 2007; Duffield et al., 2009; McArt et al., 2012). In an attempt to decrease lipomobilization in cows and the incidence

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and severity of ketosis on farms, evaluation of gluconeogenic precursor supplementation in transition cow diets has received a great deal of attention (Fisher et al., 1971, 1973; DeFrain et al., 2004; Chung et al., 2007). However, experiments directly comparing potential treatments for ketosis in lactating dairy cows are more limited (Gordon et al., 2013).

Goals of ketosis treatment are to stimulate gluconeogenesis, increase plasma glucose, and decrease lipolysis (Herdt and Emery, 1992). A recent recommended base treatment for ketosis is 300 mL of propylene glycol (**PG**) administered orally once daily for 5 d (Gordon et al., 2013), and was based on a single study (McArt et al., 2011, 2012). However, the first reports evaluating PG as a gluconeogenic precursor to treat ketosis were presented decades ago (Johnson, 1954). Unfortunately, dosage of PG is restricted for its potential toxic effects (Johnson, 1954), which might be at least partially related to the production of sulfur-containing gases, emitted during fermentation of PG in the rumen (Trabue et al., 2007). Glycerol (**G**) is another gluconeogenic precursor that might be effective in the treatment of ketosis, and is safe to administer in larger amounts as a drench (Johnson, 1954; Osman et al., 2008). Until recently, the price of G was not competitive with PG. However, G is a byproduct of the processing of fats from the biodiesel or chemical industries, and its availability has increased from the expansion of the biodiesel industry, reducing its cost.

Christensen et al. (1997) determined that PG administered as a drench or top-dressed was more effective at increasing plasma insulin and decreasing plasma NEFA compared with PG mixed in a TMR. Because DMI of ketotic cows is often depressed, drenches rather than top-dressing is the preferred form of administration of gluconeogenic precursors when treating ketosis. The objective of these experiments was to evaluate the short-term effects of PG and G infusions on plasma glucose, insulin, NEFA, and BHBA responses to help assess their use as treatments for ketosis. We hypothesized that G would be more effective than PG (300 mL each) in increasing plasma glucose concentration when infused in the abomasum (**A**) but not when infused in the cranial reticulorumen (**R**) and that a combination of G and PG (300 mL of each) would be more effective than 300 mL of PG alone in increasing plasma glucose concentration when infused in the R.

MATERIALS AND METHODS

Animal Housing and Care

All experimental procedures were approved by the Institutional Animal Care and Use Committee at Michigan State University (East Lansing). Each cow was housed in the same tie-stall throughout the experiment. Cows were fed once daily (1000 h) at 115% of expected intake and milked twice daily (0500 and 1630 h). The amounts of feed offered and refused were weighed for each cow daily.

Design and Treatment Diets

Experiment 1. Six ruminally cannulated multiparous Holstein cows at the Michigan State University Dairy Field Laboratory (26 ± 7 DIM; 638 ± 63 kg of BW; 2.02 ± 0.3 BCS; mean ± SD) were used in a crossover design experiment. Cows were randomly assigned to stalls and to glucose precursor (**GP**) and infusion site (**IS**) sequences. Glucose precursor treatments were 300 mL of PG or 300 mL of G (both ≥99.5% pure) and IS treatments were A or R. Glucose precursors were infused in the A to prevent metabolism by ruminal microbes and in the R, through the ruminal cannula, to simulate drenching. Each cow received one infusion per day. Treatment sequences for GP were randomly assigned on d 1; cows received the same GP on d 1 and 2 and the other GP on d 3 and 4. Treatment sequences for IS were randomly assigned on d 1 and 3; on d 2 and 4, cows were dosed at the other IS rather than the one assigned on d 1 and 3. Each cow received all possible combinations of treatments. The ingredient and nutrient composition of the diet, fed as TMR, is reported in Table 1. The diet was formulated to meet requirements according to NRC (2001).

Experiment 2. Eight ruminally cannulated multiparous Holstein cows at the Michigan State University

Table 1. Ingredient and nutrient composition of diets fed during experiments 1 and 2

	Diet	
Item	Experiment 1	Experiment 2
Ingredient, % of DM		
Corn silage	29.1	34.5
Alfalfa silage	19.8	19.8
Alfalfa hay	9.90	9.90
Dry ground corn	21.9	16.8
Soybean meal	15.6	15.3
Vitamin-mineral mix[1]	3.67	3.67
Nutrient composition		
DM, %	50.1	46.9
Starch, % of DM	26.0	25.0
NDF, % of DM	28.8	31.0
Forage NDF, % of DM	25.6	28.4
CP, % of DM	17.0	16.5

[1]Vitamin-mineral mix contained (DM basis): 34.5% sodium chloride, 29.4% calcium carbonate, 13.4% magnesium oxide, 12.5% monocalcium phosphate, 5.40% soybean oil, and 4.85% trace minerals and vitamins.

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