J. Dairy Sci. 98:1–16
http://dx.doi.org/10.3168/jds.2014-8606

Effect of propylene glycol on adipose tissue mobilization in postpartum over-conditioned Holstein cows

V. Bjerre-Harpøth,*[1] A. C. Storm,* M. Eslamizad,†[2] B. Kuhla,† and M. Larsen*[3]
*Department of Animal Science, Aarhus University, Foulum, Blichers Allé 20, DK-8830 Tjele, Denmark
†Institute of Nutritional Physiology "Oskar Kellner," Leibniz Institute for Farm Animal Biology (FBN), Wilhelm-Stahl-Allee 2, 18196 Dummerstorf, Germany

ABSTRACT

Our objective was to investigate the quantitative and qualitative effects of propylene glycol (PG) allocation on postpartum adipose tissue mobilization in over-conditioned Holstein cows. Nine ruminally cannulated and arterially catheterized cows were, at parturition, randomly assigned to a ruminal pulse dose of either 500 g of tap water (n = 4) or 500 g of PG (n = 5) once a day. The PG was given with the morning feeding for 4 wk postpartum (treatment period), followed by a 4-wk follow-up period. All cows were fed the same prepartum and postpartum diets. At –16 (±3), 4 (±0), 15 (±1) and 29 (±2) days in milk (DIM), body composition was determined using the deuterium oxide dilution technique, liver and subcutaneous adipose tissue biopsies were collected, and mammary gland nutrient uptake was measured. Weekly blood samples were obtained during the experiment and daily blood samples were taken from –7 to 7 DIM. Postpartum feed intake and milk yield was not affected by PG allocation. The body content of lipid was not affected by treatment, but tended to decrease from 4 to 29 DIM with both treatments. Except for the first week postpartum, no difference in plasma nonesterified fatty acids concentration was noted between treatments in the treatment period. Yet, PG allocation resulted in decreased plasma concentrations of β-hydroxybutyrate (BHB) and increased plasma concentrations of glucose. In the follow-up period, plasma concentrations of nonesterified fatty acids, glucose, and BHB did not differ between treatments. Additionally, the change in abundance of proteins in adipose tissue biopsies from prepartum to 4 DIM was not affected by treatment. In conclusion, the different variables to assess body fat mobilization were concurrent and showed that a 4-wk postpartum PG allocation had limited effect on adipose tissue mobilization. The main effect was an enhanced glucogenic status with PG. No carry-over effect of PG allocation was recorded for production or plasma metabolites, and, hence, a new period of metabolic adaption to lactation seemed to occur with PG treatment after ceasing PG allocation. Thus, PG seemed to induce a 2-step adaption to lactation, reducing the immediate postpartum nadir and peak of plasma concentration of glucose and BHB, respectively; which is beneficial for postpartum cows at high risk of lipid-related metabolic diseases.
Key words: dairy cow, propylene glycol, body composition, proteomics

INTRODUCTION

The highest occurrence of disease in dairy cows is observed within the first few weeks of lactation (Ingvartsen, 2006). A prerequisite for cows to stay healthy through this period is that the interaction between hormonal regulation, feed intake, milk yield, and physical condition of the cows is balanced. After parturition, cows have a natural genetic drive to mobilize adipose tissue, increasing with increasing BCS (Garnsworthy and Topps, 1982; Friggens et al., 2007). Thus, cows that are over-conditioned at parturition will be at greater risk for excessive mobilization of adipose tissue after parturition. Excessive mobilization of adipose tissue in cows has been revealed to be problematic and may result in hepatic lipidosis and ketosis (Grummer 1993; Ingvartsen, 2006). Hence, it is of particular interest to monitor postpartum adipose tissue mobilization in over-conditioned cows and prevent excessive mobilization.

Acute treatment and prophylactic treatment of ketosis by oral dosing with propylene glycol (**PG**) has been used since the 1950s (Nielsen and Ingvartsen, 2004). The administration method seems to be of major importance for the metabolic response of PG within the cow, as typically no metabolic responses have been observed when mixing PG into a TMR (Chibisa et al.,

Received July 11, 2014.
Accepted August 18, 2015.
[1]Current address: Danish Veterinary and Feed Administration, Sønderskovvej 5, DK-8520 Lystrup, Denmark.
[2]Current Address: Department of Animal Science, Campus of Agriculture and Natural Resources, University of Tehran, Karaj, Iran.
[3]Corresponding author: Mogens.Larsen@anis.au.dk

2008; Lomander et al., 2012); whereas responses have been observed when allocating PG as an oral drench or in separately fed concentrate (Pickett et al., 2003; Lien et al., 2010). This suggests that the metabolic effects of PG is established by a fast ruminal uptake of the PG dose that causes a prompt increase in plasma concentrations of PG and ruminally formed PG metabolites (Christensen et al., 1997; Kristensen and Raun, 2007). Results from periparturient cows dosed with PG show an increase in the glucogenic status during the allocation period, concurrent with a decrease in the plasma concentrations of BHB and NEFA (e.g., Formigoni et al., 1996; Butler et al., 2006; Lien et al., 2010). The reduction in plasma NEFA concentrations suggests a decreased adipose tissue mobilization. Despite the numerous PG studies in dairy cows, only a few studies have measured changes in fat mobilization. With PG allocation in TMR to periparturient dairy cows, Chibisa et al. (2008) did not observe effects of PG on body composition and blood metabolites.

Studying the abundance of proteins by proteome analysis might be useful to elucidate cellular mechanisms balancing adipose tissue mobilization and fat accretion. Proteome studies on subcutaneous adipose tissue of beef cattle have been related to fat accretion (e.g., Zhao et al., 2010; Romao et al., 2014), demonstrating differences in expression of proteins in animals with different subcutaneous fat thickness. Most recently, Zachut (2015) identified 143 adipose tissue proteins of multiparous dairy cows that were differentially expressed between d 17 prepartum and d 4 postpartum, and 3 of them were related to the process of lipolysis. Thus, proteome analysis seems to be suitable approach to study the influence of PG allocation adipose tissue protein abundance.

Carry-over effects on adipose tissue mobilization and metabolism have been indicated with allocation of PG in the first 2 or 3 d after parturition (Stokes and Goff, 2001; Pickett et al., 2003). Yet, PG is often allocated for several weeks postpartum in dairy livestock with automatic milking systems, and investigations of the carry-over effects on metabolism in cows allocated with PG for a longer period are lacking.

The hypothesis of the present experiment was that a daily intraruminal allocation of PG to over-conditioned postpartum cows would decrease mobilization of adipose tissue, thereby reducing the risk of ketosis and hepatic lipidosis, and that the decrease in mobilization would be reflected by altered protein abundance in adipose tissues. The objectives were to investigate both quantitative (whole-body pools of fat and protein, and net mammary nutrient uptake) and qualitative (plasma concentrations of metabolites and hormones, liver content of lipids, and protein abundance in subcutaneous adipose tissue) effects of PG on adipose tissue mobilization, and to delineate the metabolic effect of prophylactic use of PG in cows at high risk of lipid-related metabolic diseases.

MATERIALS AND METHODS

All procedures involving animals were evaluated and approved by the Danish Animal Experiments Inspectorate and complied with the Danish laws concerning animal experimentation and care of experimental animals.

Animals, Diets, and Experimental Design

Ten ruminally cannulated and arterially catheterized over-conditioned Danish Holstein cows were used in a complete randomized design with repeated measurements. The experiment was subdivided into 3 periods: (1) prepartum, last 4 wk before expected calving, (2) treatment, wk 1 to 4 postpartum, and (3) follow-up, wk 5 to 8 postpartum (Figure 1A). Measurement of body composition and mammary gland nutrient uptake were conducted prepartum (−16 ± 3 d; mean ± SD), 4, 15, and 29 DIM. Cows were randomly assigned to ruminal infusion of either 500 g of tap water (**CON**; n = 5; 4 entering second and 1 entering third lactation), or 500 g of PG (**PPG**; Propylenglycol pcow aroma, Brenntag Nordic A/S, Hellerup, Denmark; n = 5; 4 entering second and 1 entering third lactation). Treatments were initiated at the day of calving (designated as 1 DIM) and were provided once a day during morning feeding (0800 h) until 29 DIM. Treatments were allocated using a ruminal cannula infusion device ending in the area between atrium and the ventral rumen sack at the sight of the cranial pillar, and regulated by a timer-controlled peristaltic pump (infusion rate: 3,000 g/h; Type 115/G42 with L-channels; Ole Dich Instrumentmakers ApS, Hvidovre, Denmark). The ruminal infusion device was made by drilling a hole in the cannula stopper in which a 24-cm long semifirm tube (internal diameter 14 mm; outer diameter: 24 mm) was attached. Within the tube, the infusion line (Silicone tube, 60 shore A, internal diameter: 6.0 mm; outer diameter: 9.0 mm, Ole Dich Instrumentmakers ApS) was secured. In case of calving between 0800 and 1700 h, a dose of water or PG was allocated manually just after calving. From 30 to 32 DIM, cows were gradually ceased from treatments (250 and 125 g of PG on d 30 and 31–32, respectively). Cows were subsequently followed until 57 DIM and slaughtered 17 to 19 wk postpartum.

The 10 over-conditioned cows used were selected from a group of 16 cows conditioned in the last 14 wk of the preceding lactation following the conditioning