J. Dairy Sci. 100:1–9
https://doi.org/10.3168/jds.2016-11452

Effects of feeding betaine-containing liquid supplement to transition dairy cows

A. P. A. Monteiro,* J. K. Bernard,* J.-R. Guo,*[1] X-S. Weng,* S. Emanuele,† R. Davis,† G. E. Dahl,‡ and S. Tao*[2]
*Department of Animal and Dairy Science, University of Georgia, Tifton 31793
†Quality Liquid Feeds, Dodgeville, WI 53533
‡Department of Animal Sciences, University of Florida, Gainesville 32611

ABSTRACT

Betaine is a natural compound found in sugar beets that serves as a methyl donor and organic osmolyte when fed to animals. The objective was to evaluate the effect of feeding betaine-containing molasses on performance of transition dairy cows during late summer in 2 trials. In early September, cows were randomly assigned to betaine (BET) or control (CON) groups either shortly after dry off (trial 1; n = 10 per treatment) or 24 d before calving (trial 2; n = 8 per treatment) based on parity and previous mature equivalent milk yield. Cows were fed common diets supplemented either with a liquid supplement made of molasses from sugar cane and condensed beet solubles containing betaine [BET, 89.1 g/kg of dry matter (DM)] or a sugar cane molasses-based liquid supplement without betaine (CON) until 8 wk postpartum. The liquid supplements had similar nutrient contents and were fed at a rate of 1.1 and 1.4 kg DM/d for pre- and postpartum cows, respectively. Starting at their entry in the studies, cows were housed in the same freestall barn without a cooling system. After calving, all cows were housed in the same barn cooled by misters and fans and milked thrice daily. Intake was recorded daily and body weight and body condition score were assessed every 2 wk. Milk yield was recorded at each milking and composition was analyzed weekly. Blood samples were collected weekly from a subset of cows to assess concentrations of metabolites and AA. No treatment effects were apparent for DM intake and body weight in the prepartum and postpartum periods. For cows enrolled at dry off, BET supported higher milk yield (45.1 vs. 41.9 kg/d) and fat content (4.78 vs. 4.34%) and elevated plasma concentrations of nonesterified fatty acids and β-hydroxybutyrate in early lactation compared to CON. However, no differences were observed for milk yield, most milk component contents and yields, and blood metabolites between treatments for cows enrolled during the close-up period. Compared to cows in the CON group, BET cows enrolled during the far-off period tended to have lower plasma concentrations of Met, Thr, and Trp during the pre- and postpartum periods. They also had lower plasma concentrations of Lys and Phe before calving but higher plasma Gly concentration after parturition. In conclusion, feeding a betaine-containing liquid supplement from far-off through early lactation improves lactation performance but increases adipose tissue mobilization and production of ketone bodies in early lactation.
Key words: betaine, dairy cow, milk production

INTRODUCTION

Betaine, also called trimethylglycine, is a natural compound either produced endogenously by choline oxidation (Zeisel, 2013) or found naturally in feed ingredients, such as sugar beet solubles, which have the most abundant betaine content (Eklund et al., 2005). Betaine has 2 main functions in an animal's body. It serves as an organic osmolyte, helping to reduce dehydration, stabilize protein structure, and preserve enzyme function when a cell is under osmotic stress. Additionally, it functions as a methyl donor when fed to animals and is a key component in one-carbon metabolism (Eklund et al., 2005; Bertolo and McBreairty, 2013). By providing the methyl group to the universal methyl donor, *S*-adenosylmethionine, through methionine, betaine influences many key functions in the body, such as growth, liver health, and lactation (Eklund et al., 2005; Ratriyanto et al., 2009).

In nonruminants, betaine has been used for several decades as a nutritional supplement to improve animal performance. In swine and poultry, betaine supplementation increases weight gain and feed efficiency and modifies the body composition by reducing the fat content and increasing the lean content of the carcass

Received May 12, 2016.
Accepted October 13, 2016.
[1]Current address: College of Animal Science and Veterinary Medicine, Heilongjiang Bayi Agricultural University, Daqing, China, 163319.
[2]Corresponding author: stao@uga.edu

(Ratriyanto et al., 2009). Further, it also improves animal's resistance to diseases under nonoptimum raising conditions (Ratriyanto et al., 2009). In ruminants, betaine alters rumen fermentation (Mitchell et al., 1979) and improves nutrient digestibility (Wang et al., 2010). Similar to growing nonruminants, feeding betaine to lambs during the growing phase reduces subcutaneous fat thickness but does not change the weight gain or BW at slaughter (Fernández et al., 1998). In contrast, in finishing steers, supplementing betaine increases ADG as well as subcutaneous fat thickness (Bock et al., 2004). During lactation, feeding betaine also increases milk production of dairy cows (Wang et al., 2010; Peterson et al., 2012) and goats (Fernández et al., 2004). However, the effect of feeding betaine to transition dairy cows has never been studied. Thus, we hypothesized that feeding betaine-containing liquid supplement during the transition period would improve performance postpartum. The objective of the present study was to examine the effect of feeding betaine-containing liquid supplement from either far-off (trial 1) or close-up (trial 2) periods until 8 wk postpartum on lactation performance and blood metabolites of multiparous Holstein dairy cows.

MATERIALS AND METHODS

Animals, Experimental Design and Sampling

This study was conducted at the Dairy Research Center of the University of Georgia-Tifton campus from September to December 2014. The Institutional Animal Care and Use Committee of the University of Georgia approved the animal handling and procedures before beginning the trial.

Beginning in early September, multiparous Holstein cows were randomly assigned to betaine (**BET**) or control (**CON**) groups either shortly after dry-off (trial 1; 60 d before expected calving, BET: n = 10; CON: n = 10) or close-up (trial 2; 24 d before expected calving, BET: n = 8; CON: n = 8) based on their previous mature equivalent milk yield and parity. At the entry in the trials, the parity of BET and CON cows was 2.1 and 1.9 (SEM = 0.2, $P = 0.51$) for those enrolled during far-off and 2.7 and 2.4 (SEM = 0.7, $P = 0.64$) for those enrolled during close-up, respectively. Cows were fed common diets (Table 1) supplemented with molasses-based liquid supplements made from sugar cane (CON) or from sugar cane and condensed beet solubles (BET) until 8 wk in lactation. Both liquid supplements had similar DM (~70.4%), CP (~39.9% of DM), and NE_L (~1.95 Mcal/kg of DM), but only the one fed to BET cows contained betaine (89.1 g/kg of DM). Diets were formulated to provide 1.1 and 1.4 kg DM/d of liquid supplement for dry and lactating cows, respectively, resulting in 9.98, 10.18, and 5.17% of DM feeding rate of liquid supplements in the far-off, close-up, and lactating cow diets, respectively (Table 1). Following their entry in trials either at dry-off or close-up, cows were housed in the same dry or lactating pens during the pre- and postpartum periods, respectively. The pen for milking cows had a cooling system, but dry cows were only provided with shade. The cooling system for lactating cows included foggers attached to the front face of fans over the feed bunks and free stalls. Fans ran continuously whenever ambient temperature was above 18.3°C, and foggers were activated whenever ambient relative humidity was below 85%.

Sample Collection and Analyses

To evaluate the environmental heat stress, the ambient temperature and relative humidity in the barn were measured by Hobo Pro Series Temp probes (Onset Computer Corp., Pocasset, MA) every 15 min and the temperature-humidity index (**THI**) was calculated based on Dikmen et al. (2008): $THI = (1.8 \times T + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T - 26)]$, where T = air temperature (°C) and RH = relative humidity (%). Cows were weighed every 2 wk and at calving, and the BCS was evaluated at the same time by the same individual. After calving, cows were milked 3 times (0800, 1600, and 2400 h) each day, and the milk weight at each milking was recorded electronically (Alpro, DeLaval, Kansas City, MO). Milk samples were collected weekly from 3 consecutive milkings using bronopol-B-14 as a preservative to analyze milk concentrations of fat, protein, lactose, SNF, MUN, and SCC by Dairy One Cooperative (Ithaca, NY) using a Foss 4000 instrument (Foss North America, Eden Prairie, MN).

Cows were individually fed once a day at 1400 h during the dry period and at 0900 h during lactation. Daily DMI was measured by Calan Gate system (American Calan Inc., Northwood, NH) during the entire experimental period. Dietary ingredients and TMR were sampled 3 times each week to determine the DM content, and rations were adjusted to account for any changes in DM content of each ingredient. The TMR samples were composited every 2 wk and ground to pass through a 1-mm screen using a Wiley mill (Thomas Scientific, Swedesboro, NJ) and analyzed (Table 2) for ash, CP, ADF, NDF adjusted for ash, sugar, and starch by Cumberland Valley Analytical Services (Hagerstown, MD), and ether extract (AOAC International, 2000).

Blood samples were collected from coccygeal vessels into sodium-heparinized Vacutainers (Becton Dickin-