J. Dairy Sci. 101:1–23
https://doi.org/10.3168/jds.2017-13327

Effects of supplementation with ruminally protected choline on performance of multiparous Holstein cows did not depend upon prepartum caloric intake

M. G. Zenobi, R. Gardinal,[1] J. E. Zuniga,[2] A. L. G. Dias,[3] C. D. Nelson, J. P. Driver, B. A. Barton,[4] J. E. P. Santos, and C. R. Staples[5]
Department of Animal Sciences, University of Florida, Gainesville 32611

ABSTRACT

Objectives were to evaluate the effect of prepartum energy intake on performance of dairy cows supplemented with or without ruminally protected choline (RPC; 0 or 17.3 g/d of choline chloride; 0 or 60 g/d of ReaShure, Balchem Corp., New Hampton, NY). At 47 ± 6 d before the expected calving date, 93 multiparous Holstein cows were assigned randomly to 1 of 4 dietary treatments in a 2 × 2 factorial arrangement. Cows were fed energy to excess [EXE; 1.63 Mcal of net energy for lactation/kg of dry matter (DM)] or to maintenance (MNE; 1.40 Mcal of net energy for lactation/kg of DM) in ad libitum amounts throughout the nonlactating period. The RPC was top-dressed for 17 ± 4.6 d prepartum through 21 d postpartum (PP). After calving, cows were fed the same methionine-balanced diet, apart from RPC supplementation, through 15 wk PP. Liver was biopsied at −14, 7, 14, and 21 d relative to parturition. Cows fed EXE or MNE diets, respectively, consumed 40 or 10% more Mcal/d than required at 15 d before parturition. Cows fed the MNE compared with the EXE diet prepartum consumed 1.2 kg/d more DM postpartum but did not produce more milk (41.6 vs. 43.1 kg/d). Thus, PP cows fed the EXE diet prepartum were in greater mean negative energy balance, tended to have greater mean concentrations of circulating insulin, fatty acids, and β-hydroxybutyrate, and had greater triacylglycerol in liver tissue (8.3 vs. 10.7% of DM) compared with cows fed the MNE diet prepartum. Cows fed RPC in transition tended to produce more milk (43.5 vs. 41.3 kg/d) and energy-corrected milk (44.2 vs. 42.0 kg/d) without increasing DM intake (23.8 vs. 23.2 kg/d) during the first 15 wk PP, and tended to produce more milk over the first 40 wk PP (37.1 vs. 35.0 kg/d). Energy balance of cows fed RPC was more negative at wk 2, 3, and 6 PP, but mean circulating concentrations of fatty acids and β-hydroxybutyrate did not differ from those of cows not fed RPC. Despite differences in energy balance at 2 and 3 wk PP, mean concentration of hepatic triacylglycerol did not differ between RPC treatments. Feeding RPC reduced the daily prevalence of subclinical hypocalcemia from 25.5 to 10.5%, as defined by concentrations of total Ca of <8.0 mg/dL in serum in the first 7 d PP. Pregnancy at first artificial insemination tended to be greater for cows fed RPC (41.3 vs. 23.6%), but the proportion of pregnant cows did not differ by 40 wk PP. Heifers born from singleton calvings from cows fed RPC tended to experience greater daily gain between birth and 50 wk of age than heifers from cows not supplemented with RPC. Feeding RPC for approximately 38 d during the transition period tended to increase yield of milk for 40 wk regardless of amount of energy consumed during the pregnant, nonlactating period.

Key words: choline, wheat straw, fatty liver, hypocalcemia

INTRODUCTION

For decades, farmers and scientists have been aware of the dangers of calving dairy cows with excess subcutaneous fat, also known as overconditioned cows, on their subsequent performance (Morrow, 1976). Negative consequences of overconditioned cows at calving have included reduced DMI, fatty liver, less milk production, increased metabolic problems, and poor reproductive performance (Drackley, 1999). The presence of overconditioned cows (BCS >3.75) on farms is likely less of a problem today than in the latter part of the 20th century. However, excessive intake of calories by nonlactating cows can lead to accumulation of body fat that is hidden from view (omental, mesenteric, and prerenal fat; Drackley et al., 2014), such that BCS was unchanged, although Drackley et al. (2014) did not

Received June 13, 2017.
Accepted October 26, 2017.
[1]Current address: Department of Animal Nutrition and Production, University of Sao Paulo, 13635-900, Pirassununga, Brazil.
[2]Current address: San Isidro, Perez Zeledón, San José, Costa Rica.
[3]Current address: Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, T6G 2P5, Canada.
[4]Current address: 52 Sunrise Park Rd, Balchem Corp., New Hampton, NY.
[5]Corresponding author: chasstap@ufl.edu

report carcass fat that included subcutaneous fat. This may cause managers to be content that their cows will not experience the negative effects of overconditioning on postpartum performance because BCS is within industry recommendations. Although it remains to be determined whether greater accumulation of visceral fat around parturition may have subsequent negative effects on performance, overconsumption of calories during the entire dry period compared with feeding to maintenance led to increased concentrations of plasma fatty acids (Janovick et al., 2011; Graugnard et al., 2013; Mann et al., 2015) and BHB (Janovick et al., 2011; Mann et al., 2015), and increased concentration of triacylglycerol (**TAG**) in liver (Janovick et al., 2011; Graugnard et al., 2013) without changing yield of milk (Graugnard et al., 2013; Mann et al., 2015). If cows are overfed calories only during the last 3 wk of gestation (close-up period), a common current practice, negative results can occur postpartum, including greater loss of BW (Zhang et al., 2015) and a more rapid increase in hepatic TAG (Ji et al., 2012).

Choline is classified as a quasivitamin because it does not fit the classical definition of a vitamin in that it is not identified as being needed as an enzyme cofactor, it is required in gram rather than in milligram quantities by nonruminants, and, unlike B vitamins, it becomes an integral part of the structural component of tissues [e.g., phosphatidylcholine (**PC**) in cell wall membranes; Zeisel, 1991]. Choline is a major lipotropic compound in mammals in that it promotes the export of fat from the liver as part of very low density lipoproteins. Indeed, lactating dairy cows supplemented with ruminally protected choline (**RPC**) chloride around the time of parturition have experienced a reduction in concentration of hepatic TAG (Santos and Lima, 2009; Zom et al., 2011; Elek et al., 2013). This lipotropic effect of choline has been suggested as the main mechanism to help explain the frequent improvement in yield of milk by cows supplemented with RPC around parturition (Shahsavari et al., 2016).

Overfeeding energy during the entire dry period should increase hepatic concentrations of TAG. Therefore, the aim of the present experiment was to evaluate the effect of supplementation with RPC on performance of multiparous cows that have been fed calories to meet or greatly exceed requirements during the entire dry period. Our hypothesis was supplementation of RPC in the periparturient period would preferentially benefit those multiparous dairy cows that were more prone to develop fatty liver postpartum; that is, those overconsuming calories in the prepartum period. An interaction of prepartum caloric intake by RPC supplementation was expected. A second aim was to evaluate the effect of energy density of the prepartum diet and RPC supplementation to dams in late lactation on the growth rate of their female offspring from birth to yearling age.

MATERIALS AND METHODS

Cows and Dietary Treatments

The experiment was conducted at the University of Florida dairy farm from November 2014 to September 2015. All procedures involving cows in the experiment were carried out according to the University of Florida's Institutional Animal Care and Use Committee.

At 47 ± 6 d before the expected calving date, pregnant, nonlactating Holstein cows with at least 1 previous lactation (n = 109) were enrolled in the experiment. Selection criteria included apparently healthy cows with no history of chronic disease before enrollment and a 305-d mature equivalent milk yield greater than 6,800 kg. For cows that completed the study (n = 93), the mean ± standard deviation for BW and BCS (Elanco Animal Health, 2009) were 735 ± 90 kg and 3.54 ± 0.33, respectively, at the time of enrollment. Cows were assigned randomly to 1 of 4 treatments in a 2 × 2 factorial arrangement. One factor was RPC fed at 0 (**−RPC**) or 17.3 g/d of choline chloride (**+RPC**) per cow from 21 d before expected calving date through 21 d postpartum. The choline chloride was fed as part of 60 g/d of ReaShure (Balchem Corp., New Hampton, NY). The RPC was mixed with ground corn and dried molasses in a 30:56:14 ratio (as-is basis) and top-dressed (200 g/d) onto the TMR fed to individual cows once daily. Cows assigned to the −RPC treatment received 200 g/d of a top-dressing of ground corn and dried molasses in an 80:20 ratio (as-is basis). The second factor was prepartum diets formulated to 1.63 (excess energy; **EXE**) or 1.40 (maintenance energy; **MNE**) Mcal of NE_L/kg of dietary DM fed in ad libitum amounts (Table 1). Therefore, the 4 treatments were EXE intake without or with RPC and MNE intake without or with RPC. Adjusting the proportions of corn silage, triticale silage, and chopped wheat straw in the 2 prepartum diets largely accounted for the differences in NE_L concentration (Table 1). The major difference between the far-off and close-up diets was the inclusion of an acidogenic product (Biochlor; Arm and Hammer Animal Nutrition, Princeton, NJ) in the close-up diets to create diets with negative DCAD values (Table 2).

Feeding Management and Chemical Analyses

After calving, cows were fed the same diet (Tables 1 and 2), apart from RPC supplementation, through 15 wk PP. From dry off to 25 d before expected calv-