Interpretive Summary

Effect of Prepartum Anionic Supplementation on Feed Intake, Health and Milk Production. *By DeGroot and French, page 000*. Decreasing the DCAD of the diet during the last three weeks of gestation has been shown to increase the amount of calcium mobilized from the bone. This in turn decreases the number as well as the degree of metabolic disorders that occur around calving and should increase milk production and health in the subsequent lactation.

NUTRITION, FEEDING, AND CALVES

Effect of Prepartum Anionic Supplementation on Periparturient Feed Intake, Health and Milk Production

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ABSTRACT

Our objectives were to determine if dietary cation-anion difference (DCAD) and source of anions influence periparturient feed intake and milk production of dairy cattle during the transition period. Diets differed in DCAD (cationic or anionic) and anionic supplement. The four diets used prepartum were Control (DCAD +20 meq/100 g DM), BioChlor® (DCAD -12 meq/100 g DM), Fermenten® (DCAD -10 meq/100 g DM), and Salts (DCAD -10 meq/100 g DM). Urine pH was lower for cows that consumed an anionic diet prepartum compared to control. Prepartum diet had no effect on prepartum DMI of multiparous or primiparous cows. Postpartum DMI and milk yield for multiparous cows fed anionic diets prepartum was greater compared to control. Postpartum dry matter intake and milk yield of primiparous cows was similar for prepartum diets. Feeding prepartum anionic diets did not affect plasma Ca at or near

calving. Postpartum β-hydroxybutyrate and nonesterified fatty acids were lower for primiparous cows fed prepartum anionic diets compared to control. Prepartum and postpartum plasma glucose concentrations were not affected by prepartum diet for all cows. Plasma cortisol concentrations were similar between parities during the prepartum and postpartum periods. Liver triglyceride differed for parity by day. Parities were similar at 21 d prepartum, but at 0 d and 21 d postpartum, levels were greater for cows. Results indicate that decreasing the DCAD of the diet during the prepartum period can increase postpartum DMI and milk production of multiparous cows without negatively affecting performance of primiparous cows.

(**Key Words:** Periparturient, DCAD, Milk production)

INTRODUCTION

The transition period, as defined by Grummer (1995), is the three weeks before and after parturition. The transition period is considered the most traumatic time of the annual cycle of the dairy cow (Keady et al., 2001); determining the cows health, production and reproduction in the subsequent lactation. At or near calving, most cows experience some degree of hypocalcemia (Horst et al., 1997). Clinical hypocalcemia or milk fever affects up to 9% of dairy cows (Goff et al., 1987). Guard (1996) estimated the average cost per milk fever case to be $334. In addition, cows with milk fever are also susceptible to secondary disorders, such as ketosis, mastitis, retained placenta, and displaced abomasums (Curtis et al., 1983).

Several nutritional strategies have been used in the prevention of hypocalcemia, including Ca restriction during the prepartum period (Goings et al., 1974) and decreasing the dietary cation-anion difference (DCAD; milliequivalents [(Na + K) – (Cl + S)]/100 g

DM) during the last 3 to 4 wk of gestation (Block, 1984; Goff and Horst, 1997b). Due to difficulty in formulating very low Ca diets, recent interest has focused on DCAD (Horst et al., 1997). Although decreasing DCAD through removal of cations is effective in preventing hypocalcemia (Goff and Horst, 1997a), this generally precludes the use of farm-grown forages high in K. The other alternative to lower the DCAD of prepartum diets is to feed anionic salts ($MgSO_4$, $MgCl_2$, NH_4Cl, $(NH_4)_2SO_4$, $CaCl_2$, and $CaSO_4$).

Diets high in cations, especially Na and K cause blood pH to increase, resulting in a state of milk metabolic acidosis (Goff et al., 2004). This in turn reduces the ability of the periparturient cow to maintain Ca homeostasis at or near calving by reducing tissue responsiveness to parathyroid hormone (Goff and Horst, 1997b; Phillippo et al., 1994). Low DCAD diets (≤ -5 meq/100 g diet DM) through addition of anions, increases target tissue responsivness to parathyroid hormone by preventing mild metabolic alkalosis (Horst et al., 1997).

Several studies have shown improved Ca metabolism by decreasing DCAD through feeding anionic salts (Joyce et al., 1997; Moore et al., 2000). However, only one study (Block, 1984) has shown a positive milk yield response (7%) for cows fed anionic salts prepartum. In addition, anionic salts can have a negative effect on prepartum DMI (Joyce et al., 1997; Moore et al., 2000). Reduction in prepartum DMI due to the addition of anions is often attributed to decreased palatability, but may represent a response to metabolic acidosis induced by anionic salts (Vagnoni and Oetzel, 1998). Regardless of the exact mechanism whereby anionic diets elicit their negative effect on prepartum DMI, decreasing DMI may be counterproductive.

The present study was conducted to determine if prepartum DCAD (+20 or -10 meq/100 g DM) and source of anions (feed grade anionic salts or commercial acidified by-products) affect peripartum DMI, Ca homeostasis, and milk production in the subsequent lactation.

MATERIALS AND METHODS

Animals and Diets

The Oregon State University Institutional Animal Care and Use Committee approved all procedures involving animals. Thirty-five multiparous and 19 primiparous Holstein cows were selected from the Oregon State University Dairy Center, blocked by expected calving date and assigned at random to one of four prepartum dietary treatments beginning four weeks prior to expected calving date. The experimental design was a randomized incomplete block with factorial arrangement of treatment. Main effects were parity and prepartum diet. Data was collected beginning 21 d prepartum and ended 21 d postpartum. Cows were group housed in a freestall barn and fed individually using Calan® gates (American Calan, Northwood, NH).

Prepartum diets differed in DCAD (cationic or anionic) and anionic supplement (BioChlor® (Arm and Hammer Animal Nutrition Group; http://www.ahdairy.com/ahdairy/), Fermenten® (Arm and Hammer Animal Nutrition Group; http://www.ahdairy.com/ahdairy/), or fertilizer grade anionic salts), and were Control (DCAD +20 meq/100 g DM; n= 9 cows and n= 4 heifers), BioChlor® (DCAD -10 meq/100 g DM; n= 9 cows and n= 5 heifers), Fermenten® (DCAD -10 meq/100 g DM; n= 8 cows and n= 5 heifers), and Salts (DCAD -10 meq/100 g DM; n= 9 cows and n= 5 heifers. Dietary cation anion difference was calculated using the following equation:

[(% Na in DM/. 023) + (% K in DM/.039)]- [(% Cl in DM/.035) + (% S in DM/.016)]. Due to variability of ingredient mineral composition, average DCAD was +22, -12, -11, and -10 meq/100 g DM for Control, BioChlor®, Fermenten®, and Salts, respectively.

Average number of lactations for multiparous cows was 2.78, 2.89, 3.00, and 3.11 for control, BioChlor®, Fermenten®, and anionic salts diets respectively. Average number of days cows were on prepartum diet were 29, 31, 29, and 30 for all cows on control, BioChlor®, Fermenten®, and anionic salts diets respectively. There were 7 cows that did not finish the trial: 3 on BioChlor® diet (displaced abomasum, stillborn twins, and intestinal blockage); 2 on control diet (displaced abomasum and 18 d overdue); and 2 on Fermenten® diet (under conditioned and lameness). These cows were removed from the trial at or soon after calving. Data from these 7 cows were not included in analysis and animals were replaced with other cows. Cows not on treatment for at least 14 d before parturition were also excluded from the data set and replaced as soon as possible. Four cows had twins (two on control, one on Fermenten®, and one cow on anionic salts), and were included in the data set because these cows responded similarly to the treatments when compared to cows that had a single birth.

Ingredients were sampled weekly, dried to static weight at 55°C in a forced air oven, and ground through a 1-mm screen in a Thomas Wiley Mill (Thomas Scientific, USA). Weekly ingredient samples were composited monthly and analyzed by Cumberland Valley Analytical Services Inc (Maugansville, MD). Nutrient composition of forages, concentrates, and mineral/vitamin premixes are shown in Tables 1, 2 and 3, respectively. Prepartum and postpartum diets were formulated using the CPM Dairy (version 2.0) ration evaluator. Ingredient and nutrient composition of diets is shown in

Tables 4 and 5, respectively. Prepartum diets were formulated to be isonitrogenous and contained approximately 1.60 Mcal NE_L/kg DM. For prepartum diets, forages and concentrates were weighed and blended in a Uebler Mixing Cart (Uebler Manufacturing, Vernon, NY). Anionic supplementation was discontinued at calving. All cows received a common TMR postpartum that was mixed and delivered by the Oregon State University Dairy staff. Postpartum diet was formulated for approximately 17% crude protein and 1.79 Mcal NE_L/kg DM. Cows were fed twice daily, with approximately 67 and 33 % of daily feed allowance offered at 0700 and 1300 h, respectively. Feed offered and refused was recorded daily at the morning feeding.

Plasma Sampling and Analysis

Plasma samples were collected by venipuncture on -21, -14, -11, -9, -7, -5, -3, -2, -1, 0, 1, 7, 14, and 21 d relative to parturition. Samples taken on 0 d were within 2 h of parturition and 1 d samples were taken 24 h after parturition. Blood was collected in tubes (Becton Dickson, Franklin Lanes, NJ) containing K EDTA, Na heparin, or Na heparin plus NaFl and put on ice immediately after collection. Plasma was separated after centrifugation at 1600 x *g* for 15 min at 5°C, and frozen at -80°C until analysis. Sampling time (approximately 1300 h) corresponded to approximately 5 h after morning feeding.

A subsample was used for analysis which included -21, -14, -9, -7, -5, -3, -1, 0, 1, 7, 14, and 21 d relative to parturition for BHBA, NEFA, total calcium, glucose, and phosphorus. A subsample was used for analysis which included -21, -14, -7, -5, -3, -1, 0, 1, 7, 14, and 21 d relative to parturition for cortisol. Plasma collected from K EDTA additive tubes was analyzed for β-hydroxybutyrate (Procedure 2440, Stanbio Laboratory,

Boerne, TX) and nonesterified fatty acids (NEFA-C, WAKO Pure Chemical Industries, Richmond, VA). Plasma from Na heparin plus NaFl tubes was analyzed for glucose (Procedure No. 1070, Stanbio Laboratory, Boerne, TX). Plasma from Na heparin tubes was analyzed for total calcium (Procedure No. 0150, Stanbio Laboratory, Boerne, TX), phosphorus (Procedure No. 0830; Stanbio Laboratory, Boerne, TX), and cortisol (DSL-10-2000; Diagnostic Systems Laboratories, Oxon, UK). All spectrophotometric measurements were conducted using a BIO-TEK (Winooski, VT) EL-309 microplate autoreader.

Liver samples were obtained by percutaneous trochar biopsy (Veenhuizen et al., 1991) from each cow on -21 d, within 2 d postpartum, and 21 d relative to parturition, immediately frozen, and stored at -80°C until analysis. Liver biopsies were performed at approximately 1330 h. Liver sample size was approximately 3 grams. Based on observations, liver biopsy did not result in decreased milk production or feed intake. Liver triglyceride content was determined using the procedure described by Piepenbrink et al. (2004) and a commercial kit (Procedure No. 2200; Stanbio Laboratory, Boerne, TX).

Body weight and body condition score were measured weekly. Body condition score was assigned using a 5-point scale (1 = thin, 5 = fat; Wildman et al., 1982) by two individuals. Midstream urine samples were obtained at the time of blood sampling by manual stimulation of the vulva and analyzed for pH immediately after collection with a pH meter (Corning model 20 pH meter; Corning Life Sciences, Acton, MA). Energy balance was calculated for all cows using BW and NRC (2001) equations for NE_L requirement. Cows were milked twice daily and milk production was recorded daily.

Milk was analyzed for fat, protein and SCC on two consecutive milkings each week by Willamette Valley DHIA (Salem, OR).

Statistical Analysis

Data were analyzed as repeated measures using the Proc Mixed procedure in SAS (SAS User's Guide, 2001). Cow within block by parity by treatment was defined as the subject. For equally spaced repeated measures, AR(1) covariance structure was used. Akaike's information criteria was used to select the best covariance structure from one of three spatial structures [SP (POW) (spatial power law), SP (GAU) (Gaussian), and SP (SPH) (spherical)] for unequally spaced repeated measures. Prepartum and postpartum data were analyzed separately. For all variables, cows and heifers were analyzed together to test parity and parity by diet interactions (Moore et al., 2000). Model used was $Y_{ijklm} = \mu + B_i + P_j + T_k + PT_{jk} + C_{(ijk)l} + D_m + DP_{jm} + e_{ijklm}$ where μ= overall mean, B_i = ith block (1,2,…9), P_j = jth parity (multiparous or primiparous), T_k = kth treatment (control, BioChlor®, Fermenten®, and salts), $C_{(ijk)l}$ = lth cow within the ith block, the jth parity, and the kth treatment, D_m = mth day or week (repeated measure), and e = residual error. Urine pH, prepartum and postpartum cortisol, and prepartum and postpartum calcium were significant for parity by prepartum diet interactions. All other data was then analyzed separately to view diet effects (Moore et al., 2000). All other results will be shown separately for cows and heifers. Results in tables are reported as least squares means. Preplanned contrast was control versus anionic supplements. Dry matter intake data by day were compared by orthogonal contrasts: linear, quadratic, and cubic. Significance was declared at $P \leq 0.05$ and trends at $0.05 < P \leq 0.10$.

RESULTS AND DISCUSSION

Body Weight, Body Condition Score and Urine pH

Diet and parity means for body weight, BCS, and urine pH are shown in Table 6. Body weight was not different between prepartum diets ($P < 0.71$) during the prepartum period. As expected, prepartum and postpartum BW was greater for multiparous compared to primiparous cows. Body weight from wk 3 prior to parturition to wk 1 prior to parturition increased ($P < 0.08$) from 704 to 711 kg, respectively, for primiparous and multiparous combined. Body weight during the postpartum period was similar ($P < 0.99$) between diets for all cows. Postpartum body weight decreased ($P < 0.01$) from 644 kg wk 1 to 606 kg wk 3 for all cows.

Prepartum BCS was similar for prepartum diets ($P < 0.62$) and was 3.56. Cows were in the suggested range of body condition score, which is 3.50. Body condition score during the postpartum period was similar between prepartum diets ($P < 0.68$) and parity ($P < 0.62$). Body condition score decreased ($P < 0.01$) from 3.44 wk 1 to 3.30 wk3 postpartum.

Parity by diet interaction was significant ($P < 0.01$) for urine pH. Heifers receiving Fermenten® had lower pH (6.24 vs. 6.80; $P < 0.01$) compared to cows fed Fermenten®. Likewise, heifers fed salts tended (6.55 vs. 6.77; $P < 0.08$) to have lower urine pH compared to cows receiving salts. Within either BioChlor® or control diets, parities responded similarly. Anionic diets were effective in reducing urine pH below the 6.5 threshold recommended for Holsteins (Moore et al., 2000). However, urine pH less than 6.0 would indicate excessive anion supplementation (Moore et al., 2000) as seen in the BioChlor® diet.

Dry Matter Intake, Milk Yield and Composition, and Energy Balance

Prepartum diet means for dry matter intake, milk production and composition, and energy balance are shown in Table 7. Prepartum diet did not affect prepartum DMI of cows or heifers. Horst et al. (1994) reported that addition of >300 meq of anions/kg diet may reduce intake. BioChlor®, Fermenten®, and salts diets were supplemented with 275, 312, and 257 meq anions/kg DM, respectively. Therefore, anionic supplementation in the current experiment was near or below the threshold where DMI would be negatively affected. Joyce et al. (1997) reported depressed DMI in multiparous cows supplemented 471 meq anions/kg DM, whereas Moore et al. (2000) showed no decline in DMI for multiparous cows supplemented 329 meq anions/kg DM. However, prepartum DMI was lower for heifers supplemented 329 meq anions/kg DM. Prepartum DMI differed by day ($P < 0.01$) for all cows, decreasing linearly and quadratically from 14.5 to 9.9 kg from -21 d to -1 d relative to parturition, respectively. Parities differed ($P < 0.01$) during the prepartum period with cows consuming 14.2 kg DM/d and heifers consuming 11.9 kg DM/d. Prepartum DMI of heifers is similar to a data set compiled by Hayirli et al. (2002); however cows in that experiment consumed 1.85 kg DM/d less on average than the cows in the current study. Parity by day or prepartum diet by day interactions were not significant for prepartum DMI.

Dry matter intake during the postpartum period was significantly different for multiparous cows. Multiparous cows fed an anionic prepartum diet had greater DMI postpartum compared to the control diet (19.5 vs. 17.4 kg DM/d; $P < 0.01$). Likewise, postpartum DMI was greater for primiparous cows fed an anionic prepartum diet compared to control (14.2 vs. 12.8 kg DM/d; $P < 0.04$). Feeding an anionic diet

prepartum does not decrease postpartum DMI (Goff and Horst, 1998; Gulay et al., 2004) or has shown to increase postpartum DMI (Joyce et al., 1997). Multiparous cows consumed more dry matter postpartum compared to primiparous cows (17.5 vs. 13.71 kg DM/d; $P < 0.01$). Dry matter intake increased (linear, quadratic, cubic; $P < 0.01$) for all cows from 9.7 kg DM/d on the day of calving to 38.9 kg DM/d. Parity by day or prepartum diet by day interactions were not significant for postpartum DMI.

Milk production was greater for multiparous cows fed anionic prepartum diets versus control (43.1 vs. 36.6 kg/d; $P < 0.01$). This increase was due to the significant increase in DMI during the postpartum period for anionic prepartum diets versus control. Prepartum diet did not affect milk production of primiparous cows (29.4 kg/d; $P < 0.91$). Parity by day interaction was significant ($P < 0.01$) for milk production with multiparous cows increasing at a faster rate compared to primiparous cows (data not shown). Prepartum diet by day interaction was not significant for milk production.

Fat percentage and yield, protein percentage and yield, as well as 3.5% FCM were similar for all diets in multiparous cows and all diets in primiparous cows. Primiparous cows fed anionic diets prepartum tended ($P < 0.06$) to have a lower fat percentage when compared to heifers fed the control diet prepartum. Fat percentage decreased ($P < 0.01$) for all cows by week from 4.95% wk 1 postpartum to 4.20% wk 3. Likewise, protein percentage decreased ($P < 0.01$) by week for all cows from 4.07% wk 1 postpartum to 3.11% wk 3 postpartum. Butterfat yield increased ($P < 0.01$) by week for multiparous cows from 1.83 to 1.98 kg/d from wk 1 to wk 3 postpartum. There was no difference ($P < 0.76$) by week in butterfat yield for primiparous cows. Protein yield did not differ ($P < 0.43$) by week for primiparous or multiparous cows. 3.5 % fat corrected milk increased

($P < 0.01$) by week for multiparous cows from 45.2 wk 1 to 51.2 kg/d wk 3 postpartum. Prepartum diet by day interaction was not significant for 3.5 % FCM, fat and protein yield.

Energy balance was similar for all diets during the pre- and postpartum periods for multiparous cows. Energy balance was also similar for heifers during the prepartum period; however energy balance for the postpartum period tended ($P < 0.09$) to be different for anionic diets versus control. The majority of this difference was from the Fermenten® diet. Parity by week interaction was significant ($P < 0.01$) for prepartum energy balance when cows and heifers were analyzed together (Figure 1). Multiparous cows started the trial in higher energy balance than primiparous cows; however prepartum energy balance was similar by wk 2 prepartum. Parity by week or prepartum diet by week interactions were not significant for prepartum energy balance. However, parity by week interaction was significant ($P < 0.03$) for the postpartum period.

Plasma Metabolites

Prepartum diet means are shown in Table 8 for plasma metabolites measured. Prepartum diet did not affect prepartum or postpartum plasma glucose. Prepartum plasma glucose concentrations were unaffected by prepartum diet, but were affected by day and parity. Plasma glucose concentrations during the prepartum period decreased as parturition approached then increased the day before calving ($P < 0.01$). Glucose concentrations prepartum were higher in heifers versus cows (76.4 vs. 67.4 mg/dL; $P < 0.01$). Prepartum diet by day interaction was not significant for plasma glucose. Postpartum glucose concentrations differed for parity by day ($P < 0.01$). Postpartum glucose concentrations decreased in multiparous cows, but not in primiparous cows.

Prepartum plasma P tended ($P < 0.08$) to be greater for multiparous cows fed an anionic diet prepartum. Prepartum plasma phosphorus concentrations were affected by day with concentrations decreasing from 21 d prepartum to 1 d prior to parturition (6.6 to 5.4 mg/dL; $P < 0.01$). Prepartum and postpartum plasma phosphorus levels were similar between parities. Postpartum phosphorus concentrations were affected by day ($P < 0.01$) with concentrations increasing from the day of calving to 21 d postpartum. Diet had no effect on postpartum phosphorus concentrations. Parity by day or prepartum diet by day interactions were not significant for prepartum and postpartum plasma P concentrations.

Prepartum BHBA concentrations were lower in heifers than in cows (5.82 versus 4.84 mg/dL; $P < 0.01$). Prepartum diet did not affect prepartum BHBA concentrations. Prepartum BHBA increased ($P < 0.01$) from 21 d prepartum to 1 d prepartum for all cows. Postpartum BHBA was lower for both multiparous ($P < 0.06$) and primiparous ($P < 0.01$) cows fed anionic diets prepartum compared to control. Postpartum BHBA concentrations were affected by day ($P < 0.01$) for all cows, peaking at d 7 postpartum and decreasing through 21 d postpartum. There was a parity difference in postpartum BHBA with cows having concentrations of 8.58 mg/dL and heifers 5.39 mg/dL ($P < 0.02$). Parity by day or prepartum diet by day interactions were not significant for prepartum and postpartum plasma BHBA concentrations.

Prepartum NEFA concentrations were different between parity (268 and 73 µmol/L for cows and heifers respectively; $P < 0.01$). Prepartum NEFA levels increased ($P < 0.01$) from 80 µmol/L to 340 µmol/L, from 21 d to 1 d prepartum, respectively. Prepartum diet had no affect on prepartum NEFA concentrations for cows and heifers. There was a decrease in postpartum NEFA concentration for primiparous cows fed an

anionic diet prepartum versus control ($P < 0.01$). Dry matter intake and NEFA concentrations have been shown to be inversely related during the postpartum period (Overton and Waldron, 2004) and this would explain the increase in postpartum DMI of primiparous cows fed anionic diets prepartum. Parity also affected postpartum NEFA levels with multiparous cows having greater ($P < 0.01$) concentrations (638 μmol/L) than primiparous cows (360 μmol/L) throughout the postpartum period. Postpartum NEFA levels decreased from the day of parturition to 21 d postpartum ($P < 0.01$). Other studies have shown that NEFA concentrations begin increasing approximately 5 d before calving, peak at or around calving and begin to decrease 3 to 5 d postpartum (Goff et al., 1996; Grummer, 1993). Results of the current research are in agreement with these recent studies. Parity by day or prepartum diet by day interactions were not significant for prepartum and postpartum plasma NEFA concentrations.

Liver triglyceride (% wet weight) differed for parity by day ($P < 0.03$). Parities were similar at 21 d prepartum, but liver TAG was greater for multiparous cows the day of parturition (5.92 vs. 2.95 % wet weight for multiparous and primiparous cows, respectively) and 21 d postpartum (7.94 vs. 3.58 % wet weight for multiparous and primiparous cows, respectively). Liver TAG concentrations have been correlated with circulating NEFA concentrations (Grummer, 1993). For multiparous cows, greater plasma NEFA during both the prepartum and postpartum periods compared to primiparous cows lead to differences in liver TAG. Prepartum diet had no affect on liver TAG during the transition period. Prepartum diet by day interaction was not significant for the transition period.

Plasma Ca concentrations for the prepartum (11.0 vs. 9.2 mg/dL for primiparous and multiparous, respectively) and postpartum (11.3 vs. 8.7 mg/dL for primiparous and multiparous, respectively) periods were greater for primiparous cows versus multiparous cows ($P < 0.01$). Dietary treatment had no effect on prepartum plasma Ca concentration for cows or heifers. However, parity did not respond similarly to prepartum diet (parity by diet interaction; $P < 0.01$). Prepartum plasma Ca was not different by day for cows or heifers. Parity or diet by day interactions was not significant.

An interaction ($P < 0.01$) between parity and prepartum diet was also shown during the postpartum period for plamsa Ca concentrations. Concentrations of postpartum plasma Ca for primiparous cows were similar across prepartum diet. This interaction was due to the magnitude of the difference between primiparous and multiparous cows. Parity by day interaction was significant due to multiparous cows not acting similarly to primiparous cows during the postpartum period ($P < 0.01$). Plasma Ca concentrations for primiparous cows increased until 21 d postpartum where levels decreased. However, multiparous cows postpartum plasma Ca concentrations increased from the day of parturition through 21 d postpartum. Prepartum diet by day interaction was not significant. The use of anionic salts during the prepartum period has repeatedly been shown to prevent hypocalcemia in multiparous cows at or near calving (Block, 1984; Horst et al., 1997; Joyce et al., 1997). Our results are similar to those of Moore et al. (2000), which showed no improvement in postpartum Ca metabolism of primiparous cows when supplemented with an anionic diet prepartum. Plasma Ca concentrations were similar on 0 d and 1 d postpartum between multiparous cows fed the control or anionic diets prepartum. One reason for this could be the amount of calcium found in the

prepartum diets and the time that these cows spent on those diets prepartum. There were only 2 cows (1 cow on Control and one cow on Fermenten® diet prepartum) showing signs of clinical hypocalcemia around calving.

Prepartum plasma cortisol concentrations were different for parity by treatment ($P < 0.05$). Heifers fed the Fermenten® diet during the prepartum period had lower ($P < 0.05$) concentrations than cows fed the same diet. Likewise, heifers fed salts diet during the prepartum period had decreased ($P < 0.09$) plasma cortisol concentrations compared to cows fed the same diet. Parity had no effect for all cows on BioChlor® and Control whereas cows on the Fermenten® and Salts diet had greater concentrations of prepartum cortisol compared to primiparous cows on the same diets. There was a trend for a parity by day interaction for prepartum cortisol concentration ($P < 0.09$). Prepartum cortisol concentrations increased as parturition approached. Diet by day interaction was not significant.

Parity by diet interaction ($P < 0.05$) was shown for postpartum cortisol concentration. There was a trend for BioChlor® ($P < 0.06$) and Salts ($P < 0.07$) diets to have an effect on postpartum plasma cortisol concentrations. Primiparous cows on BioChlor® (2.32 μg/dL) and control (2.40 μg/dL) diets had greater concentrations of cortisol postpartum compared to cows fed the same diets (1.60 and 2.18 μg/dL for multiparous cows on BioChlor® and control diets respectively). In contrast, primiparous cows on Fermenten® (1.89 μg/dL) and salts (1.96 μg/dL) diets had lower postpartum concentrations of cortisol compared to the cows fed the same diets (2.18 and 2.65 μg/dL for multiparous cows fed Fermenten® and salts respectively). Parity or diet by day was not significant for postpartum cortisol concentrations.

CONCLUSIONS

Anionic supplements were effective in acidifying prepartum diets based on urine pH, which is an indicator of acid-base status. Prepartum anionic diets were not detrimental to prepartum dry matter intake and did not decrease postpartum performance of primiparous cows. Feeding anionic diets prepartum increased postpartum DMI of both primiparous and multiparous cows and increased milk yield of multiparous cows. However, prepartum anionic diets did not increase plasma Ca of multiparous cows at calving. Based on the current research, cows and heifers can be grouped together during the prepartum period of the transition period and fed an anionic diet without negatively affecting prepartum DMI and postpartum performance.

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Table 1. Chemical composition of forages (DM basis).

Item	Corn Silage	Alfalfa Hay	Oat Hay	Grass Silage
CP, %	8.54	21.5	6.79	9.76
ADICP[1], %	0.96	1.20	0.93	1.02
NDICP[2], %	1.52	2.12	1.61	1.70
Soluble Protein, %	4.35	8.72	1.95	5.70
NE_L, Mcal/kg[3]	1.58	1.33	1.30	1.36
NDF, %	43.6	34.2	57.7	54.7
ADF, %	27.2	27.8	37.5	35.9
NFC, %	39.6	30.2	25.5	23.9
Crude Fat, %	3.28	2.22	2.20	3.13
Lignin,	3.13	5.8	4.44	3.94
Ca, %	0.23	1.43	0.28	0.37
P, %	0.20	0.29	0.19	0.29
Mg, %	0.19	0.38	0.12	0.17
K, %	1.06	3.23	1.86	2.43
Na, %	0.02	0.20	0.11	0.08
S, %	0.13	0.32	0.13	0.18
Cl, %	0.31	0.64	0.50	0.59
Fe, ppm	321	626	143	825
Zn, ppm	36.5	18.4	25.7	37.9
Cu, ppm	6.27	9.08	4.27	9.67
Mn, ppm	49.8	53.0	67.2	149
	11.2	53.4	30.2	37.8

[1]Acid detergent insoluble crude protein.
[2]Neutral detergent insoluble crude protein.
[3]Calculated using the equation of Weiss et al. (1992).
[4]DCAD = (Na + K) – (Cl +S).

Table 2. Chemical composition of concentrates (DM basis).

Item	Corn/Barley[1]	SBM/DDG[1]	DDG[2]	WCS[3]	BioChlor	Fer
CP, %	10.3	41.2	30.1	24.6	49.1	5
ADICP[4], %	1.06	4.29	4.65	1.75	0.63	
NDICP[5], %	1.60	5.80	8.10	2.25	2.48	
Soluble Protein, %	1.47	6.63	4.74	5.73	38.3	3
NE_L, Mcal/kg[6]	2.07	1.91	2.00	2.09	1.70	
NDF, %	15.6	25.5	42.8	47.1	22.6	1
ADF, %	6.71	14.5	19.9	36.7	7.88	
NFC, %	69.8	25.0	13.8	4.61	19.6	2
Crude Fat, %	3.60	7.46	13.9	21.1	2.77	
Lignin, %	1.36	3.54	4.74	11.5	2.33	
Ca, %	0.04	0.32	0.57	0.16	0.17	
P, %	0.30	0.80	0.86	0.76	0.73	
Mg, %	0.12	0.37	0.41	0.43	0.30	
K, %	0.43	1.75	1.10	1.23	1.11	
Na, %	0.02	0.52	0.61	0.05	1.15	
S, %	0.14	0.16	0.73	0.28	2.49	
Cl, %	0.12	0.19	0.58	0.10	8.57	
Fe, ppm	49.8	155	132	95.5	101	9
Zn, ppm	28.3	70.0	241	45.8	62.6	5
Cu, ppm	3.91	12.8	25.4	10.6	6.58	
Mn, ppm	12.2	41.3	73.9	20.1	79.1	9
DCAD[7], meq/100 g	-0.24	52.1	-7.21	13.4	-319	-4

[1]Rolled corn/barley and soybean meal/dried distillers grain, 1:1 ratio on an as-fed basis.
[2]Dried distillers grain.
[3]Whole cotton seed.
[4]Acid detergent insoluble crude protein.
[5]Neutral detergent insoluble crude protein.
[6]Calculated using the equation of Weiss et al. (1992).
[7]DCAD = (Na + K) – (Cl +S).

Table 3. Chemical composition of vitamin and mineral mixes (DM basis).

	Prepartum				
Item	Control	BioChlor	Fermenten	Salts	Postpartum
Ca, %	19.8	19.8	20.0	18.3	9.93
P, %	4.00	2.75	4.00	3.61	1.99
Mg, %	0.49	0.16	0.50	0.45	1.99
K, %	1.75	0.23	1.60	1.56	1.54
S, %	0.24	0.23	0.34	5.90	0.99
Na, %	3.75	0.02	2.75	3.50	9.12
Cl, %	---	---	---	19.3	0
Co, ppm	1.65	3.30	1.65	1.65	3.97
Cu, ppm	393	720	730	645	397
Fe, ppm	3044	2625	3039	2800	0
Mn, ppm	180	300	180	201	1589
Zn, ppm	695	702	745	636	1589
Se, ppm	6.00	7.00	6.80	5.60	11.9
Vitamin A, KIU/kg	185	185	185	170	127
Vitamin D, KIU/kg	55.1	55.0	55.1	50.0	39.4
Vitamin E, IU/kg	2475	2479	2480	2255	876
DCAD[1], meq/100 g	193	-7.59	139	-720	374

[1]DCAD = (Na + K) – (Cl +S).

Table 4. Ingredient composition of diets (DM basis).

	Prepartum				
Ingredient	Control	BioChlor	Fermenten	Salts	Postpartum
Corn Silage, %	33.8	34.1	33.8	33.5	17.7
Grass Silage, %	---	---	---	---	17.0
Alfalfa Hay, %	14.3	14.4	14.3	14.2	18.5
Oat Hay, %	14.7	14.8	14.7	14.6	---
Rolled Corn/Barley[1], %	22.8	23.1	22.9	22.6	27.4
SBM/DDG[1], %	2.0	1.6	2.0	2.3	7.7
Dried Distillers Grain, %	0.6	---	0.6	0.8	---
Whole Cottonseed, %	---	---	---	---	9.2
BioChlor, %	---	8.7	---	---	---
Fermenten, %	---	---	7.5	---	---
Protein Mix[2], %	8.6	---	1.0	8.5	---
BioChlor Min/Vit, %	---	3.3	---	---	---
Control Min/Vit, %	3.2	---	---	---	---
Fermenten Min/Vit, %	---	---	3.2	---	---
Salts Min/Vit, %	---	---	---	3.5	---
Lactating Min/Vit, %	---	---	---	---	2.5

[1]Rolled corn/barley and soybean meal/dried distillers grain, 1:1 ratio on an as-fed basis.
[2]Contains 9.3% ground corn, 54.7% wheat middlings, 21.5% dried distillers grain, 4.8% SBM, and 9.7% urea on a DM basis.

Table 5. Chemical composition of diets (DM basis).

	Prepartum				
Item	Control	BioChlor	Fermenten	Salts	Postpartum
CP %	14.7	14.7	14.9	14.7	15.5
Soluble Protein, %	43.3	46.5	46.0	43.1	31.0
NE_L, Mcal/kg[1]	1.61	1.59	1.59	1.59	1.59
NDF, %	35.7	35.0	34.6	35.6	34.0
NFC, %	39.7	40.3	39.8	39.5	38.3
Crude Fat, %	3.45	3.12	3.18	3.49	5.10
Ca, %	0.99	1.00	1.00	1.00	0.66
P, %	0.42	0.37	0.42	0.42	0.40
Mg, %	0.22	0.20	0.21	0.22	0.28
K, %	1.38	1.34	1.37	1.37	1.60
Na, %	0.19	0.16	0.18	0.19	0.30
S, %	0.20	0.38	0.71	0.40	0.25
Cl, %	0.32	1.05	0.35	1.00	0.33
Fe, ppm	341	329	341	341	347
Zn, ppm	57.8	54.9	57.0	58.1	73.4
Cu, ppm	19.0	29.3	29.5	29.1	17.4
Mn, ppm	50.5	54.7	52.2	51.7	92.1
DCAD[2], meq/100 g	22.1	-12.1	-11.3	-9.82	29.1

[1]Calculated using the equation of Weiss et al. (1992).

[2]DCAD = (Na + K) – (Cl +S).

Table 6. Effect of prepartum diet and parity on body weight, body condition score and urine pH.

	Prepartum Diet						Parity Treatment			
Item	Control	BioChlor	Fermenten	Salts	SEM	*P* <	Multiparous	Primiparous	SEM	*P* <
Body weight prepartum, kg	727	714	690	695	25.8	0.71	793	620	18.8	0.01
Body weight postpartum, kg	625	629	622	622	23.2	0.99	697	551	16.6	0.01
BCS prepartum	3.59	3.64	3.52	3.51	0.08	0.62	3.59	3.54	0.06	0.52
BCS postpartum	3.34	3.43	3.37	3.35	0.07	0.68	3.35	3.39	0.05	0.62
Urine pH, prepartum	8.03	5.93	6.52	6.66	0.06	‡	6.89	6.68	0.04	‡

‡Parity by treatment interaction ($P < 0.01$)

Table 7. Effect of prepartum diet and parity on dry matter intake, milk yield and composition, and energy balance[1].

	Dietary Treatment					
Item	Control	BioChlor	Fermenten	Salts	SEM	P[2]<
Cows						
Prepartum DMI, kg/d	14.4	14.4	14.3	14.2	0.60	0.91
Postpartum DMI, kg/d	17.4	19.4	20.1	19.1	0.52	0.01
Milk, kg/d	36.6	44.0	43.5	42.0	2.11	0.01
Fat, %	4.74	4.58	4.58	4.59	0.23	0.58
Fat, kg/d	1.78	1.98	1.96	1.90	0.12	0.27
3.5% FCM[3], kg/d	45.6	51.1	50.4	49.1	2.60	0.15
Protein, %	3.67	3.38	3.58	3.69	0.16	0.54
Protein, kg/d	1.39	1.46	1.52	1.51	0.08	0.29
Energy Balance Prepartum Mcal/d	4.04	3.80	2.58	3.87	1.40	0.70
Energy Balance Postpartum Mcal/d	-11.1	-11.3	-11.2	-11.3	2.22	0.96
Heifers						
Prepartum DMI, kg/d	11.8	11.3	11.9	12.5	0.37	0.79
Postpartum DMI, kg/d	12.8	13.3	14.7	14.7	0.40	0.04
Milk, kg/d	29.6	28.3	28.2	31.6	1.92	0.91
Fat, %	4.76	4.58	4.09	4.00	0.19	0.05
Fat, kg/d	1.41	1.29	1.14	1.28	0.09	0.15
3.5% FCM[3], kg/d	35.8	33.2	30.7	34.4	2.25	0.30
Protein, %	3.50	3.39	3.56	3.54	0.11	0.99
Protein, kg/d	1.04	0.94	0.99	1.08	0.06	0.62
Energy Balance Prepartum Mcal/d	0.97	1.34	2.77	2.98	0.82	0.20
Energy Balance Postpartum Mcal/d	-10.1	-7.81	-4.32	-7.57	1.57	0.09

[1]Results shown are least square means from separate analyses for cows and heifers. In an analysis of both cows and heifers, cows were different ($P < 0.01$) from heifers for all variables except fat and protein percent, and prepartum energy balance.
[2]Control versus anionic treatments (BioChlor®, Fermenten®, Salts).
[3]3.5% FCM = Fat-corrected milk = 0.4324*(kg milk) + 16.2162*(kg fat).

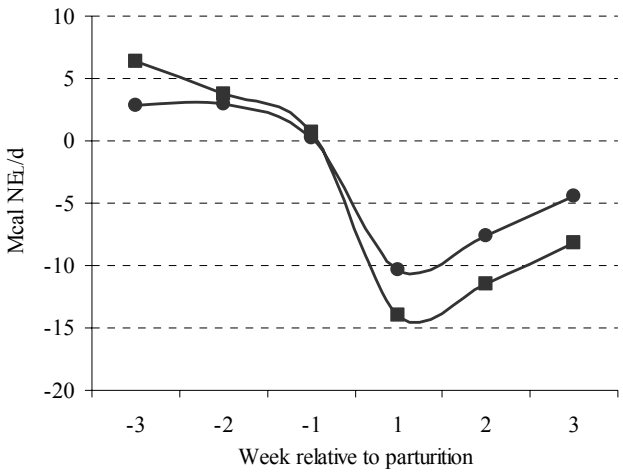

Figure 1. Energy balance of cows (-■-) and heifers (-●-) during the transition period. Prepartum and postpartum data were analyzed separately. Parity by week interaction significant ($P < 0.01$) for prepartum period.

Table 8. Effect of prepartum diet on pre-and postpartum glucose, phosphorus, BHBA, NEFA and Liver triglyceride[1].

	Dietary Treatment					
Item	Control	BioChlor	Fermenten	Salts	SEM	P[2]<
Cows						
Prepartum glucose, mg/dL	67.6	70.6	65.3	66.3	1.6	0.92
Postpartum glucose, mg/dL	69.4	72.2	67.3	66.0	2.2	0.72
Prepartum phosphorus, mg/dL	5.87	6.19	6.81	6.09	0.23	0.08
Postpartum phosphorus, mg/dL	4.05	4.00	4.50	3.96	0.20	0.65
Prepartum BHBA, mg/dL	6.42	5.30	5.91	5.61	0.41	0.10
Postpartum BHBA, mg/dL	11.3	8.98	6.07	8.00	1.5	0.06
Prepartum NEFA, µmol/L	369	238	280	186	72	0.12
Postpartum NEFA, µmol /L	697	597	625	632	59	0.25
Liver TAG, % wet weight	5.58	5.11	4.52	6.70	0.74	0.87
Heifers						
Prepartum glucose, mg/dL	75.5	74.5	72.2	71.0	1.9	0.22
Postpartum glucose, mg/dL	71.4	72.2	69.1	72.2	2.5	0.96
Prepartum phosphorus, mg/dL	5.56	5.85	5.97	5.47	0.33	0.62
Postpartum phosphorus, mg/dL	4.11	3.66	4.02	4.39	0.24	0.77
Prepartum BHBA, mg/dL	5.49	5.05	5.20	5.51	0.30	0.53
Postpartum BHBA, mg/dL	7.92	6.20	4.40	5.66	0.58	0.01
Prepartum NEFA, µmol/L	204	157	121	118	32	0.09
Postpartum NEFA, µmol /L	635	460	377	383	60	0.01
Liver TAG, % wet weight	3.78	3.77	3.66	2.97	0.62	0.68

[1]Results shown are least square means from separate analyses for cows and heifers. In an analysis of both cows and heifers, cows were different from heifers for all variables ($P < 0.01$) except prepartum and postpartum phosphorus and liver TAG.
[2]Control versus anionic treatments (BioChlor, Fermenten, Salts)