Prepartum DCAD and calcium concentration effects on colostrum quality and blood mineral and gas concentrations of newborn calves

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ABSTRACT

Eighty-two multiparous Holstein cows were fed diets differing in dietary cation-anion difference (DCAD) and Ca concentrations in a randomized block design experiment beginning 4 wk prior to anticipated calving to determine the effects on colostrum yield and quality and acid-base balance of their calves. Treatments were arranged as a 2 X 2 factorial to provide two DCAD (-22 mEq/100 g DM [NEG] or -3 mEq/100 g DM [NEU]) and two Ca concentrations (1.3 or 1.8% of DM). Birth weight and dystocia score were not different among treatments and averaged 42.7 kg and 1.12 kg, respectively. No differences were observed in colostrum yield among treatments, which averaged 8.75 kg. Colostrum quality, as measured using a Brix refractometer, was not affected by prepartum DCAD but was higher (P = 0.0442) for 1.3 compared with 1.8% Ca: 21.58% and 19.87%, respectively. Concentrations of IgG were higher (P = 0.0034) for cows fed NEG compared with NEU and for 1.3 compared with 1.8% Ca. Calves were fed a commercial colostrum replacer to provide 200 g IgG within 4 h of birth and no difference was observed in IgG concentrations after 24 h of birth. No differences were observed in plasma concentrations of Ca, P, K, Cl, anion gap, or whole blood pH, pO_2, pCO_2, or SO_2 of calves due to treatment. Plasma Mg (P = 0.0391) and lactate (P = 0.0591) were higher for calves born to cows fed 1.3% compared with 1.8% Ca. Interactions of DCAD and Ca were observed for plasma Na (P = 0.0232), plasma Cl (P = 0.0619), and whole blood HCO3 (P = 0.0515) due to higher concentrations observed with NEG and 1.3% Ca compared with NEG and 1.8% Ca. Feeding prepartum diets with 1.8% compared with 1.3% Ca concentrations reduced plasma Mg and lactate concentrations in calves immediately after birth and reduced Brix value of colostrum. Results of this trial indicate that feeding a fully acidified diet prepartum supported higher IgG concentrations and did not alter blood mineral or gas concentrations of calves compared with those born to dams fed a neutral DCAD diet. Feeding 1.8% Ca prepartum decreased colostrum quality as measured by Brix and IgG concentrations and altered plasma Mg and lactate concentrations.
KEY WORDS: DCAD, Ca, colostrum, blood minerals

INTRODUCTION

Feeding a negative DCAD prepartum diet has become prevalent within the dairy industry as a means of reducing the incidence of milk fever (Block, 1984; Oetzel, 1993). This dietary manipulation creates a mild metabolic acidosis in order to alter Ca homeostasis mechanisms.

With increased prevalence for feeding acidified diets prepartum, there is also an increased curiosity of possible effects on calves from the industry. There has been limited research regarding the response of calves born to dams fed negative DCAD diets prepartum. Metabolic and respiratory acidosis are key parameters in measuring the metabolic state of calves. Both measures are strongly correlated with increased incidence of calf mortality (Szenci, 1985). Previous research has not shown any difference in plasma mineral concentrations of calves from dams fed negative versus positive DCAD diets (Tucker, 1992). However, others have reported negative effects on IgG absorption in calves whose dams were fed negative DCAD diets (Joyce and Sanchez, 1994; Guy et al., 1996; Quigley and Drewry, 1998). The objectives of this trial were to determine the effects of prepartum DCAD and dietary Ca concentration on colostrum quality, newborn calf blood mineral and gas concentration, and calf health.

MATERIALS AND METHODS

Animals and Calving Management

All methods were reviewed and approved by the University of Georgia Animal Care and Use Committee prior to conducting the trial. Eighty-two multiparous Holstein calves born to cows fed diets differing in DCAD (-3 [NEU] or -22 [NEG] mEq/100 g DM) and Ca (1.3 or 1.8% of DM) were used in the trial. Cows calved in a dry lot or were brought into a dry calving pen when parturition was near. Time of birth, sex, and dystocia score were recorded at calving. Calves were separated within 4-6 h after birth and fed a colostrum replacer to provide 200 g IgG (Bovine IgG, Land O Lakes® Animal Milk Products Co., Shoreview, MN) via bottle or tube if necessary. Calves were individually housed in a calf barn or in individual calf hutches on sand. Calves received vaccinations and an ear tag and were fed a commercial milk replacer (Nuture Processional 26-17, Vigortone Ag Products, Brooksville, OH) at the rate of 0.68 kg solids per day twice daily through 6 wk of age. During wk 7, the amount of milk replacer fed was reduced by 50% and calves were weaned at the beginning of wk 8. Water and calf starter were offered for free choice daily.

Sampling

Colostrum was harvested and a sample collected within 2-8 h of calving. Colostrum analysis via Brix refractomer was conducted immediately after colostrum harvest (MISCO DD-1 Refractometer, MISCO, Solon, OH) to indicate quality and a aliquot frozen for IgG analysis using radial immunodiffusion (Bovine IgG Test Kit, Triple J Farms, Bellingham, WA). Blood samples were collected immediately after birth and prior to colostrum feeding and again at 24 h after birth for analysis of lactate, pH, and blood gases to include pO_2, pCO_2, pSO_2, and $pHCO_3$,Ca, Mg, Na, K, and Cl (Siemens Medical Solutions USA, Inc., Malvern, PA). Body weights were recorded prior to the calf entering individual calf pens on the day of birth. Calf mobility, mortality, and health events were recorded and monitored for the following 8 wk.

Statistical Analysis

PROC MIXED procedures of SAS were used to analyze the data. The model included block, DCAD treatment, Ca treatment, interaction of DCAD and Ca, week, interactions of week and treatments, and sex of calf. Significance was declared when $P < 0.05$ and trends were declared when $P > 0.05$ and ≤ 0.10. When an interaction was detected, the PDIFF option was used for mean separation.

RESULTS

Birth weight and dystocia score were not different among treatments (*P* > 0.10) and averaged 42.7 kg and 1.12, respectively. No differences (*P* > 0.10) were observed in colostrum yield, which averaged 8.75 kg (Table 1). Colostrum quality measured by Brix refractometer was not different among DCAD treatment but was higher (*P*=0.0442) for 1.3% Ca compared to 1.8% Ca: 21.58% and 19.87%, respectively. Concentrations of IgG measured via radial immunodiffusion were different for prepartum DCAD (*P* = 0.0034) and Ca (*P* = 0.0120). Cows fed NEG prepartum had higher IgG concentrations compared to NEU: 9,982.1 mg/dl and 5,395.0 mg/dl, respectively. Colostrum IgG was also higher for cows fed 1.3% Ca compared with 1.8% Ca: 9,558.5 mg/dl and 5,818.4 mg/dl, respectively.

Serum concentrations of Ca, P, K, anion gap, and whole blood pH, and concentrations of pO2, pCO2, or pSO_2 of calves were not difference (*P* > 0.10) among treatments (Table 2). Calves born to cows fed 1.3% Ca prepartum had higher serum concentrations of Mg (*P*=0.0391) and whole blood concentrations of lactate (*P*=0.0591) compared with those born to cows fed 1.8% Ca prepartum. An interaction was observed between DCAD and Ca for plasma Na (*P*= 0.0232), plasma Cl (*P*= 0.0619), and whole blood HCO_3 (*P*= 0.0515), which were higher for NEG and 1.3% Ca compared with NEG and 1.8% Ca. An interaction of DCAD and day was observed for serum CO_2 (*P* = 0.0062) and whole blood HCO_3 (*P* = 0.0237). Serum CO_2 concentrations increased more for calves born to cows fed NEU prepartum from d 0 to d 1 compared with those born to dams fed NEG (Figure 1). Whole blood HCO_3 decreased from d 0 to d 1 (27.42 to 26.88 mmol/L) in calves born to cows fed NEG while it increased (26.60 to 28.29 mmol/L) in calves from cows fed NEU (Figure 2).

DISCUSSION

Research on the effects of prepartum DCAD and Ca on calves and colostrum has been limited. No differences were observed in colostrum yield from cows fed either a NEU or NEG diet prepartum. However, colostrum quality was effected by both DCAD and Ca concentration of prepartum diets. Colostrum quality was initially measured by Brix refractometer immediately after harvesting colostrum. The Brix refractometer has been proven to be a valid on-farm tool to detect colostrum quality (Bartier et al., 2015). Research using the Brix refractometer has reported that a Brix score between 18% and 23% is equivalent to a IgG concentration of 5,500 mg/dL, indicating high quality colostrum (Jones and Heinrichs, 2011). Our Brix measures indicated that quality was reduced for cows fed 1.8% Ca versus 1.3% Ca prepartum. Brix scores averaged 19.87 and 21.58%, respectively. A subsample was frozen and further used to measure IgG content using radial immunodiffusion. These results indicated quality was negatively affected by feeding either NEU or increased Ca (1.8% Ca). These results suggest that cows fed diets that are not acidified to decrease urine pH to a range of 5.5 to 6.0 or fed excess Ca would be more likely to have lower quality colostrum and be subject to greater failure rates of successful passive transfer of IgG.

Concentrations of IgG measured in the serum of calves was not affected by the DCAD status of the diet fed to cows prepartum. Results from our current trial indicate there was no effect on the apparent efficiency of IgG absorption in calves based on the acidification level of prepartum diets fed to the cow. Joyce and Sanchez (1994) and Guy et al. (1996) reported lower IgG concentrations in calves born to cows fed anionic diets prepartum which is in contrast to our results.

The metabolic status of calves as measured by the incidence of respiratory and metabolic acidosis. Normal calves with little to no respiratory distress will have a serum pCO_2 of 55 ± 3 mmHg (Szenci, 1985). Our results indicate the average pCO_2 concentrations of calves for treatments were greater than 55 ± 2 mm Hg, which indicated little or no respiratory distress. Serum pH is used in combination with pCO_2 as an indicator for metabolic acidosis. Serum pH was not affected by prepartum DCAD, which is consistent with Tucker (1992) who concluded that feeding negative DCAD diets prepartum has no effect on acid-base status or blood minerals of calves.

CONCLUSION

Results of this trial suggest that feeding a fully acidified diet to cows prepartum does not alter blood mineral or gas concentrations of their calves compared with calves born to dams fed a non-acidified diet. Feeding a NEG diet did result in higher quality colostrum as indicated by IgG concentrations. However, increasing the dietary Ca concentration to 1.8% compared with 1.3% may negatively affect colostrum quality resulting in lower Brix and IgG concentrations, which could negatively affect calf health when fed in the production setting.

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Table 1. Colostrum yield and characteristics of cows fed diets differing in prepartum DCAD and Ca concentrations

DCAD	NEU[1]		NEG				*P*	
Ca	1.3%	1.8%	1.3%	1.8%	SE	DCAD	CA	DCAD X Ca
Yield, kg/d	10.1	7.9	8.4	8.6	1.2	0.6092	0.4567	0.3085
BRIX, %[2]	21.42	19.16	21.74	20.58	0.81	0.2792	0.0442	0.4914
IgG, mg/dL[3]	6135.9	4654.0	12981.0	6982.8	1171.0	0.0034	0.0120	0.1153

[1] NEG= negative DCAD, NEU= neutral DCAD

[2] Measured by Brix Refractometer (MISCO DD-1 Refractometer)

[3] Measured by radial immunodiffusion (Bovine IgG Test Kit)

Table 2. Serum metabolites of calves born to cows fed diets differing in prepartum DCAD and Ca concentrations

DCAD	NEU[1]		NEG			P		
Ca, %	1.3%	1.8%	1.3%	1.8%	SE	DCAD	Ca	DCAD x Ca
Serum								
IgG, mg/dL	1151.9	1018.6	1036.1	1103.7	267.13	0.9547	0.9006	0.7063
Ca, mg/dL	11.05	11.28	11.05	11.23	0.24	0.9095	0.3447	0.9045
P, mg/dL	6.98	6.98	6.89	6.85	0.14	0.4361	0.8940	0.8982
Mg, mg/dL	2.40	2.28	2.41	2.33	0.05	0.5843	0.0391	0.6907
K, mEq/L	6.92	7.14	7.77	6.54	0.49	0.8029	0.3047	0.1517
Na, mEq/L	142.48	139.25	140.60	143.47	1.29	0.3668	0.8845	0.0232
Cl, mEq/L	100.43	98.48	100.04	102.01	1.02	0.1259	0.9948	0.0619
CO_2, mmol/L	27.47	29.20	28.03	28.41	0.61	0.8515	0.0816	0.2773
Anion gap, mmol/L	20.71	18.62	19.45	19.32	0.71	0.6911	0.1131	0.1825
Whole blood								
pH	7.26	7.26	7.24	7.27	0.02	0.7214	0.2102	0.2751
pO_2, mmHg	45.54	39.25	43.21	42.84	4.19	0.8799	0.4119	0.4806
pCO_2, mmHg	60.60	64.03	66.54	58.18	3.24	0.9887	0.4415	0.0770
HCO_3, mmol/L	26.89	28.00	28.01	26.30	0.70	0.6726	0.6613	0.0515
SO_2, mmol/L	62.11	58.17	59.68	61.58	2.93	0.8659	0.7214	0.3311
Lactate, mg/dL	6.74	5.78	6.93	6.13	0.47	0.5698	0.0591	0.8670

[1] NEG= negative DCAD, NEU= neutral DCAD

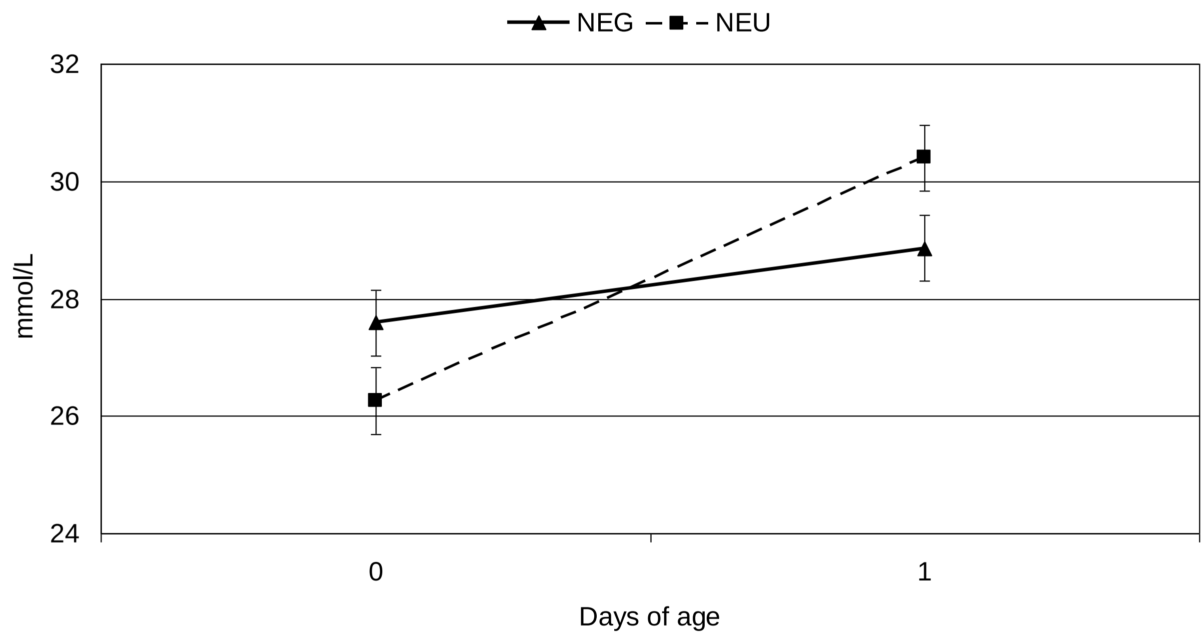

Figure 1. Serum CO_2 concentrations on 0 and 1 day of age of calves born to cows fed prepartum diets with -21 (NEG) or -2 mEq/100g DM (NEU) DCAD (DCAD, X days of age, *P* = 0.0062).

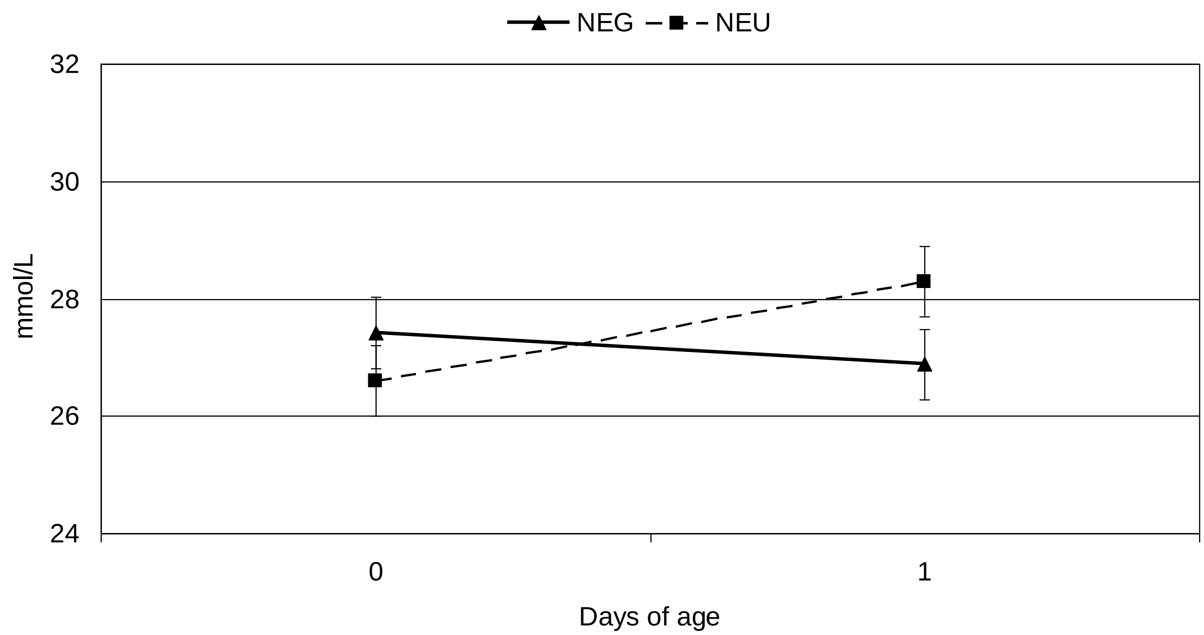

Figure 2. Whole blood HCO_3 concentrations on 0 and 1 day of age of calves born to cows fed prepartum diets with -21 (NEG) or -2 mEq/100g DM (NEU) DCAD (DCAD X days of age, *P* = 0.0237).