DIETARY CATION-ANION BALANCE AND MILK FEVER IN DAIRY COWS

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Story in Brief

Our objective was to evaluate the effectiveness of a low dietary cation-anion balance in preventing milk fever and udder edema in dry cows consuming a high Ca diet, and to evaluate the effect of this diet on calves delivered by these cows. Seventy primiparous or multiparous cows and 50 pregnant heifers were offered alfalfa hay-based diets beginning 4 wk before projected calving date. Diets contained 1.6% Ca and a dietary cation-anion balance of -3 or +9 milliequivalents per 100 grams diet dry matter. Feeding a low vs high dietary cation-anion balance in a high Ca diet for 3 wk prepartum did not reduce the incidence of milk fever. Udder edema appeared to regress more rapidly postpartum for cows that had consumed the low dietary cation-anion balance during the dry period. Test diets fed to prepartum cows did not affect systemic acid-base status of their calves. We conclude that the prophylactic effects on the occurrence of milk fever of feeding a low dietary cation-anion balance during the dry period may be absent when diets contain more than 1.6% Ca and dietary cation-anion balance is -3, or higher.

(Key Words: Calcium Chloride, Milk Fever, Edema, Acid-Base.)

Introduction

The dietary cation-anion balance (DCAB) equation for poultry was defined as meq((Na+K)-Cl)/100 g diet DM by Mongin (1980). However, Tucker et al. (1991) recently demonstrated that the effect of S on systemic acid-base status in lactating dairy cows is similar to the effect of Cl; hence, DCAB for dairy cows could be calculated as meq((Na+K)-(Cl+S))/100 g diet DM. Feeding a low DCAB for several weeks prepartum increases the availability of Ca to the cow.

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The effects of feeding different DCAB to young calves has been evaluated (Beighle et al., 1988); however, the effect of the DCAB consumed by pregnant cows on their offspring has not been investigated. Our objectives were to evaluate the influence of feeding a diet with a low DCAB but a high Ca content during the dry period on systemic acid-base status and the occurrence of milk fever and udder edema, and to evaluate the effects of these diets on the systemic acid-base status of the neonatal calves from these cows.

Materials and Methods

Experimental Design and Treatments

Seventy primiparous or multiparous cows and 50 pregnant heifers were offered sorghum silage and concentrate (PRETRIAL, Table 1) in a total mixed diet, in addition to grazing bermuda grass from the cessation of lactation until 4 wk prepartum. Beginning 4 wk $\pm$ 3 d before their projected calving date, we fed an alfalfa hay-based adaptation diet (HI-BAL, Table 1) for 1 wk. At 3 wk prepartum, animals were assigned to one of two diets in a randomized complete block design. The two test diets (Table 1) contained sorghum silage, alfalfa hay and concentrate in a 10:56:34 DM ratio, and approximately 1.6% Ca on a DM basis. We supplemented one of these diets with limestone (HI-BAL) and the other with $CaCl_2$ (LO-BAL) in order to maintain a constant dietary Ca concentration while lowering the DCAB from +9 to -3. At calving, cows were offered a diet containing alfalfa hay, sorghum silage, whole cottonseed and concentrate (FRESH; Table 1) for 3 wk. All diets were offered for ad libitum consumption twice per day. Intake of individual cows was recorded daily during the prepartum period, whereas lactating cows were group-fed the FRESH diet.

Sample Collection and Analysis

Blood and urine samples were collected 10 h postfeeding once per week at 3, 2, and 1 wk before the expected calving date, within 12 h after parturition, and at 1, 2 and 3 wk postpartum. Blood samples were collected from calves within 12 h after calving, and at 1, 2 and 3 wk postpartum.

Body condition and udder edema were evaluated weekly from 3 wk before the projected calving date until 3 wk postpartum. Body condition was scored on a scale of 1 to 9, where 1 represents extremely thin and 9 represents extremely obese (Aalseth et al., 1983). To evaluate edema, we developed a scale of 0 to 10, where 0 represented no edema and 10 represented severe edema. In both scoring systems, half-point gradations were used to increase

Table 1. Ingredient and nutrient composition of experimental diets (DM Basis).

Ingredient, (%)	Diet Pretrial	Hi-Bal	Lo-Bal	Fresh
Alfalfa hay	....	56.26	56.26	31.51
Sorghum silage	59.25	10.25	10.25	14.84
Whole cottonseed	....	....	....	6.49
Shelled corn, ground	26.56	31.48	31.48	33.22
Sorghum grain, rolled	7.07	....	....	....
Soybean meal	5.17	....	....	11.00
Cane molasses, liquid	1.04	....	....	....
Dried cane molasses	....	....	....	1.50
Dicalcium phosphate	.68	....	....	.62
Trace mineralized salt	.23	.51	.51	.49
Calcium chloride[a]	....	....	1.50	....
Limestone	....	1.50	....	.19
Dynamate[b]	....	....	....	.16
Nutrient, (%)				
DM, as fed	38.90	70.25	72.50	59.6
CP	9.85	19.25	17.80	19.2
NE_L[c] Mcal/kg	1.48	1.44	1.48	1.55
ADF	27.55	29.80	28.70	23.4
NDF	38.20	41.05	37.60	32.2
Ca	.50	1.56	1.62	.73
P	.36	.27	.26	.48
Mg	.28	.36	.35	.29
Na	.11	.29	.30	.23
K	.93	1.37	1.41	1.12
Cl	.32	.65	1.11	.45
S	.15	.32	.34	.32
meq(Na+K)-(Cl+S)/100 g diet DM	10.19	9.35	-3.41	5.99

[a]Anhydrous, 94-97% calcium chloride.
[b]Double sulfate of K and Mg.
[c]Calculated from ADF.

resolution. Clinical milk fever was diagnosed by personnel of the Oklahoma State University School of Veterinary Medicine. After calving, milk samples were collected one day per week during consecutive p.m. and a.m. milkings.

Results and Discussion

Cow Responses

Performance. Prepartum DMI (Table 2) was lower for heifers than mature cows; DMI was approximately 1 kg lower for the LO-BAL than the HI-BAL diet as well. These responses support the observation of Tucker et al. (1988) that reductions in DCAB depress DMI.

Mature cows produced more milk than heifers (Table 2); because milk composition was not affected by age of the cows, milk fat and protein yields also were higher for mature cows than for heifers. Milk fat content was somewhat higher (P = .066) for HI-BAL at 3 wk postpartum, and milk protein content tended to be higher (P = .094) for HI-BAL at 1 wk postpartum. Performance responses were affected more by the age of the test animals than by the test diet consumed.

Acid-Base Status. Blood $[H^+]$ was greater for the LO-BAL than the HI-BAL diet both prepartum and at parturition (Table 3). All cows were switched to the FRESH diet at parturition. At 1 wk postpartum, $[H^+]$ of heifers that had been fed LO-BAL prepartum appeared to rebound in response to the removal of acidogenic agents from the diet so that blood $[H^+]$ was lower than for heifers previously fed HI-BAL. Blood HCO_3^- responses were inversely related to changes in $[H^+]$, reflecting the metabolic nature of the acid challenge presented by LO-BAL. Interpretation of treatment effects for $[H^+]$ were virtually identical to those for pH.

Blood HCO_3^- (Table 3) tended to be lower for heifers than mature cows prepartum; however, this trend was reversed postpartum. Mature cows consumed more DM and produced more milk than heifers; hence, this reversal may be attributed to higher metabolic acid production by mature cows. Blood pCO_2 was correlated closely with blood HCO_3^-, being low prepartum and tending to be high postpartum for animals consuming LO-BAL prepartum. Similarly, pCO_2 was lower for heifers than for cows prepartum, but reversed postpartum.

Urine $[H^+]$ (Table 3) tended to be higher for heifers throughout the study, although the difference was smaller postpartum than prepartum. This matches changes in the concentrations of blood HCO_3^- and pCO_2. The importance of this response is unclear but, because acidosis increases the flow of Ca through the readily-exchangeable Ca pool (Takagi and Block, 1988), it may be an important factor in the superior ability of younger animals to utilize

Table 2. **Least square means for performance responses as affected by parity of test animals and dietary cation-anion balance.**

Week[4]	Parity[1] 1	Parity[1] 2	*P*	Diet[2] HI-BAL	Diet[2] LO-BAL	*P*	Parity 1 HI-BAL	Parity 1 LO-BAL	Parity 2 HI-BAL	Parity 2 LO-BAL	SE[3]
Daily DM intake, kg											
-3	9.9	12.8	<.001	12.1	10.7	<.001	10.7^{b}	9.2^{a}	13.5^{d}	12.1^{c}	.4
-2	10.2	12.9	<.001	12.1	10.9	.004	10.8^{a}	9.6^{a}	13.5^{c}	12.2^{b}	.4
-1	9.9	12.0	<.001	11.4	10.4	.067	10.5^{ab}	9.2^{a}	12.3^{b}	11.6^{b}	.5
Daily milk yield, kg											
+1	17.7	28.7	<.001	23.5	22.9	NS[5]	18.4^{a}	16.9^{a}	28.5^{b}	28.9^{b}	1.1
+2	24.6	38.6	<.001	31.4	31.8	NS	24.7^{a}	24.6^{a}	38.2^{b}	39.0^{b}	1.4
+3	27.2	41.6	<.001	34.1	34.8	NS	27.2^{a}	27.3^{a}	40.9^{b}	42.3^{b}	1.3
Milk fat content, %											
+1	4.24	4.47	NS	4.46	4.25	NS	4.24	4.23	4.67	4.26	.22
+2	3.83	3.76	NS	3.88	3.72	NS	3.89	3.78	3.87	3.66	.15
+3	3.56	3.59	NS	3.71	3.45	.066	3.68	3.45	3.74	3.44	.15
Daily milk fat yield, kg											
+1	.77	1.31	<.001	1.07	1.01	NS	.80^{a}	.74^{a}	1.34^{b}	1.27^{b}	.07
+2	.95	1.46	<.001	1.25	1.17	NS	.98^{a}	.93^{a}	1.51^{b}	1.40^{b}	.06
+3	.97	1.47	<.001	1.26	1.18	NS	1.02^{a}	.93^{a}	1.51^{b}	1.43^{b}	.06
Milk protein content, %											
+1	3.83	3.96	NS	4.02	3.77	.094	4.00^{ab}	3.66^{a}	4.05^{b}	3.88^{ab}	.15
+2	3.55	3.49	NS	3.55	3.49	NS	3.61	3.48	3.49	3.49	.07
+3	3.36	3.33	NS	3.33	3.36	NS	3.33	3.39	3.32	3.34	.06

Table 2. (Continued)

Week[4]	Parity[1] 1	Parity[1] 2	*P*	Diet[2] HI-BAL	Diet[2] LO-BAL	*P*	Parity 1 HI-BAL	Parity 1 LO-BAL	Parity 2 HI-BAL	Parity 2 LO-BAL	SE[3]
Daily milk protein yield, kg											
+1	.68	1.15	<.001	.94	.89	NS	.73[a]	.63[a]	1.15[b]	1.15[b]	.04
+2	.89	1.36	<.001	1.15	1.11	NS	.92[a]	.86[a]	1.37[b]	1.35[b]	.05
+3	.92	1.38	<.001	1.14	1.16	NS	.92[a]	.92[a]	1.36[b]	1.41[b]	.05

[a,b,c,d]Means within a row with different superscripts are different ($P < .05$).

[1]Parity 1 = primiparous; Parity 2 = multiparous.

[2]HI-BAL = dietary cation-anion balance of +12 meq/100 g diet DM; LO-BAL = dietary cation-anion balance of -11 meq/100 g diet DM.

[3]SE of class means are equal to SE of treatment means/1.414.

[4]Week relative to calving; (-) = prepartum, (+) = postpartum.

[5]NS = $P > .10$.

Table 3. Least square means for blood and urine acid-base status as affected by parity of test animals and dietary cation-anion balance.

Blood pH	Parity[1]			Diet[2]			Parity 1	Parity 1	Parity 2	Parity 2	
Week[4]	1	2	*P*	HI-BAL	LO-BAL	*P*	HI-BAL	LO-BAL	HI-BAL	LO-BAL	SE[3]
-3	7.40	7.40		7.41	7.40		7.41	7.40	7.40	7.41	
-2	7.39	7.40		7.41	7.37		7.41	7.36	7.41	7.39	
-1	7.40	7.41		7.41	7.41		7.41	7.39	7.42	7.41	
0	7.41	7.40		7.42	7.40		7.43	7.40	7.41	7.40	
+1	7.40	7.41		7.40	7.41		7.38	7.41	7.41	7.41	
+2	7.40	7.40		7.40	7.40		7.40	7.40	7.40	7.40	
+3	7.40	7.41		7.40	7.40		7.39	7.40	7.41	7.41	
Blood $[H^+]$, neq/L											
-3	39.4	39.4	NS[5]	39.3	39.6	NS	39.1	39.8	39.5	39.4	.5
-2	41.6	40.3	NS	39.4	42.4	.001	39.4[a]	43.7[b]	39.4[a]	41.2[a]	.8
-1	39.8	39.0	.099	38.6	40.2	.009	38.7[ab]	40.9[c]	38.5[a]	39.5[abc]	.6
0	38.7	39.6	NS	38.2	40.2	.001	37.4[a]	40.0[b]	39.0[ab]	40.3[b]	.6
+1	40.4	38.9	.006	40.2	39.1	.068	41.6[b]	39.2[a]	38.8[a]	38.9[a]	.5*
+2	39.9	39.9	NS	39.9	39.9	NS	39.7	40.1	40.1	39.7	.5
+3	40.2	39.1	.053	39.6	39.7	NS	40.3[b]	40.0[ab]	38.8[a]	39.4[ab]	.5
Blood HCO_3^-, meq/L											
-3	28.2	28.3	NS	28.4	28.1	NS	28.0	28.4	28.8	27.8	.8
-2	25.9	28.8	<.001	28.8	25.9	<.001	27.7[b]	24.1[a]	29.9[c]	27.8[b]	.7
-1	25.1	26.9	NS	26.5	25.6	NS	25.4	24.9	27.6	26.2	1.6
0	27.4	28.1	NS	28.9	26.5	.002	29.0[b]	25.9[a]	28.9[b]	27.2[ab]	.7

Table 3. (Continued)

Week	Parity[1] 1	Parity[1] 2	*P*	Diet[2] HI-BAL	Diet[2] LO-BAL	*P*	Parity 1 HI-BAL	Parity 1 LO-BAL	Parity 2 HI-BAL	Parity 2 LO-BAL	SE[3]
+1	29.4	27.9	.098	27.8	29.4	.067	28.8[ab]	30.0[b]	26.9[a]	28.9[ab]	.9
+2	29.7	28.0	.065	28.1	29.5	.054	29.7[b]	29.6[b]	26.5[a]	29.5[b]	.9*
+3	29.7	27.9	.089	28.6	29.0	NS	29.5	29.8	27.6	28.2	1.0
Blood pCO2, mm Hg											
-3	44.5	46.0	.014	44.7	45.8	.066	43.9[a]	45.1[a]	45.5[a]	46.5[b]	.6
-2	43.9	46.5	<.001	45.8	44.6	.058	44.5[ab]	43.4[a]	47.2[c]	45.7[bc]	.7
-1	44.6	45.8	.054	45.9	44.5	.013	45.3[abc]	44.1[a]	46.6[c]	45.0[ab]	.6
0	43.0	44.5	.049	44.0	43.5	NS	43.3	42.8	44.7	44.3	.8
+1	47.5	45.5	.005	46.9	46.1	NS	47.9[c]	47.1[bc]	45.8[ab]	45.1[a]	.7
+2	47.6	46.8	NS	47.1	47.2	NS	47.4	47.7	46.7	46.8	.5
+3	48.1	46.5	.001	47.0	47.6	NS	47.7[bc]	48.4[c]	46.2[a]	46.9[ab]	.5
Urine pH											
-3	8.02	8.26		8.18	8.10		8.09	7.94	8.26	8.26	
-2	7.00	7.64		8.03	6.62		7.74	6.26	8.32	6.97	
-1	7.38	7.63		8.29	6.71		8.19	6.57	8.39	6.86	
0	7.08	7.33		7.86	6.55		7.83	6.34	7.89	6.76	
+1	7.03	7.54		7.32	7.24		7.05	7.01	7.59	7.48	
+2	7.14	7.48		7.37	7.24		7.31	6.96	7.43	7.53	
+3	7.10	7.55		7.31	7.34		7.04	7.17	7.59	7.51	

Table 3. (Continued)

Week	Parity[1] 1	Diet[2] 2	P	HI-BAL	LO-BAL	P	Parity 1 HI-BAL	Parity 1 LO-BAL	Parity 2 HI-BAL	Parity 2 LO-BAL	SE[3]
Urine [H$^+$], neq/L											
-3	69	26	NS	49	47	NS	80	59	18	34	37
-2	741	235	<.001	107	869	<.001	196[ab]	1286[c]	18[a]	452[b]	129*
-1	396	335	NS	6	724	<.001	8[a]	784[b]	4[a]	665[b]	130
0	664	265	.016	64	865	<.001	62[a]	1266[c]	67[a]	463[b]	139*
+1	232	133	.068	181	184	NS	241	223	120	146	53
+2	240	129	.070	156	213	NS	177[a]	304[b]	135[a]	123[a]	64
+3	235	125	.041	178	182	NS	250	221	106	144	53

[a,b,c]Means within a row with different superscripts are different ($P < .05$).

[1]Parity 1 = primiparous; Parity 2 = multiparous.

[2]HI-BAL = dietary cation-anion balance of +12 meq/100 g diet DM; LO-BAL = dietary cation-anion balance of -11 meq/100 g diet DM.

[3]SE of class means = SE of treatment means/1.414.

[4]Week relative to calving; (-) = prepartum, (+) = postpartum.

[5]NS = $P > .10$.

*Parity by diet interaction, $P < .028$.

endogenous Ca. Urine [H^+] was increased sharply by LO-BAL, although this response was more marked for heifers than mature cows; the influence of the LO-BAL diet disappeared within 1 wk of feeding the FRESH diet.

Milk Fever, Retained Placenta and Uterine Infection. Table 4 presents the incidence of metabolic disorders throughout the study. Heifers did not exhibit clinical symptoms of milk fever, and frequency of milk fever cases for mature cows appeared to be similar between test diets. Because heifers produce less milk and are more efficient in absorbing Ca than are mature cows (Horst, 1986), they typically have less problem with milk fever than aged animals. Feeding a low DCAB during the dry period has either prevented or reduced the occurrence of milk fever (Block, 1984); this response has been evaluated most thoroughly with dietary Ca concentrations below 1%, but it has also been demonstrated with dietary Ca as high as 1.81% (Beede et al., 1991). Our LO-BAL diet had a DCAB of -3. The absence of a prophylactic effect of LO-BAL on milk fever in the present study contrasts with the complete elimination of milk fever observed by Block (1984) for a diet with a DCAB slightly below 0; the primary differences between these two studies is that our dietary Ca concentrations were much higher and the differential between our high and low DCAB was much smaller. In our study, the occurrence of retained placenta and uterine infection was not affected by age of the animals or by the test diets consumed.

Udder Edema and Body Condition Scores. Previous research (Beede et al., 1991) has failed to identify any correlation between DCAB and udder edema. However, Beede et al. (1991) evaluated edema only during the dry

Table 4. Incidence of metabolic disorders and infections as affected by age an dietary treatment.

Disorder	Heifers	Mature Cows	HI-BAL[a]	LO-BAL
Clinical milk fever	0/50	9/70	5/60	4/60
Retained placenta	5/50	5/70	6/60	4/60
Uterine infection	7/50	9/70	8/60	8/60

[a]HI-BAL = dietary cation-anion balance of +12 meq/100 g diet DM; LO-BAL = dietary cation-anion balance of -11 meq/100 g diet DM.

Table 5. Least square means for udder edema and body condition score as affected by age and diet.

Week[4]	Parity[1] 1	Parity[1] 2	*P*	Diet[2] HI-BAL	Diet[2] LO-BAL	*P*	Parity 1 HI-BAL	Parity 1 LO-BAL	Parity 2 HI-BAL	Parity 2 LO-BAL	SE[3]
Udder edema score, (scale = 1 to 10)											
-3	2.1	1.2	<.001	1.5	1.7	NS[5]	1.9^{b}	2.2^{b}	1.1^{a}	1.2^{a}	.2
-2	2.4	1.6	<.001	2.0	1.9	NS	2.4^{b}	2.3^{b}	1.6^{a}	1.5^{a}	.2
-1	3.7	2.6	<.001	3.3	3.1	NS	3.8^{b}	3.7^{b}	2.7^{a}	2.5^{a}	.3
0	4.6	3.5	<.001	4.1	4.0	NS	4.5^{bc}	4.7^{c}	3.7^{ab}	3.2^{a}	.3
+1	4.2	3.9	NS	4.2	4.0	NS	4.3	4.2	4.1	3.8	.3
+2	2.7	2.9	NS	3.0	2.6	.036	2.9^{ab}	2.5^{a}	3.1^{b}	2.7^{ab}	.2
+3	1.7	2.3	.014	2.1	2.0	NS	1.9^{ab}	1.6^{a}	2.2^{b}	2.4^{b}	.2
Body condition score (scale = 1 to 9)											
-3	5.67	6.17	.001	6.10	5.75	.013	5.83^{ab}	5.51^{a}	6.37^{c}	5.98^{b}	.14
-2	5.93	6.09	.043	6.00	6.01	NS	5.96^{ab}	5.90^{a}	6.05^{ab}	6.13^{bc}	.08
-1	5.83	6.21	.001	6.04	6.01	NS	5.87^{a}	5.80^{a}	6.21^{b}	6.22^{b}	.10
0	5.52	5.83	.012	5.59	5.76	NS	5.47^{a}	5.58^{a}	5.71^{ab}	5.94^{b}	.12
+1	5.32	5.63	.012	5.49	5.46	NS	5.35^{ab}	5.30^{a}	5.62^{ab}	5.63^{b}	.11
+2	5.24	5.24	NS	5.28	5.19	NS	5.29	5.19	5.28	5.20	.14
+3	5.15	4.98	NS	5.00	5.13	NS	5.09	5.22	4.92	5.04	.13

[a,b,c]Means within a row with different superscripts are different ($P < .05$).

[1]Parity 1 = primiparous; Parity 2 = multiparous.

[2]HI-BAL = dietary cation-anion balance (DCAB) of +12 meq/100 g diet DM; LO-BAL = DCAB of -11.

[3]SE of class means = SE of treatment means/1.414.

[4]Week relative to calving; (-) = prepartum, (+) = postpartum.

[5]NS = $P > .10$.

Table 6. Least square means for blood acid-base status of calves as affected by age and diet of the dam.

Blood $[H^+]$, neq/L	Parity[1]			Diet[2]			Parity 1	Parity 1	Parity 2	Parity 2	
Week[4]	1	2	*P*	HI-BAL	LO-BAL	*P*	HI-BAL	LO-BAL	HI-BAL	LO-BAL	SE[3]
0	50.5	45.5	.012	49.8	46.2	.069	52.3^{b}	48.7^{ab}	47.3^{ab}	43.8^{a}	1.9
1	41.3	42.2	NS[5]	42.7	40.8	NS	42.1	40.5	43.2	41.2	1.5
2	46.3	43.2	.066	45.3	44.2	NS	47.6^{b}	45.0^{ab}	43.0^{a}	43.5^{ab}	1.5
3	41.3	41.3	NS	42.1	40.5	.038	42.2	40.4	41.9	40.6	.7
Blood pCO_2, mm Hg											
0	55.3	55.9	NS	56.7	54.5	NS	57.1	53.6	56.4	55.5	1.6
1	52.3	50.9	NS	52.3	50.9	NS	53.2^{b}	51.3^{ab}	51.3^{ab}	50.5^{a}	.9
2	49.9	51.6	NS	50.4	51.2	NS	49.4	50.5	51.4	51.8	1.0
3	52.3	52.1	NS	53.3	51.1	.051	54.1^{b}	50.6^{a}	52.5^{ab}	51.7^{ab}	.9
Blood pO_2, mm Hg											
0	34.8	30.9	NS	37.1	28.6	NS	42.3	27.2	31.8	30.0	5.0
1	42.1	37.9	NS	43.5	36.5	NS	48.8	35.5	38.2	37.6	6.0
2	38.7	37.8	NS	41.8	34.7	.024	41.1^{ab}	36.4^{ab}	42.6^{b}	33.0^{a}	3.7
3	33.9	42.5	NS	42.6	33.8	NS	37.3	30.5	47.9	37.2	7.9

Table 6. (continued)

Week[4]	Parity[1] 1	Parity[1] 2	*P*	Diet[2] HI-BAL	Diet[2] LO-BAL	*P*	Parity 1 HI-BAL	Parity 1 LO-BAL	Parity 2 HI-BAL	Parity 2 LO-BAL	SE[3]
Blood HCO_3^-, meq/L											
0	28.2	30.8	.002	29.2	29.8	NS	28.4[a]	28.0[a]	30.1[ab]	31.6[b]	.8
1	32.0	30.7	NS	31.4	31.4	NS	32.2	31.8	30.5	30.9	.8
2	27.9	29.9	.026	28.6	29.2	NS	27.4	28.4	29.9	29.9	.9
3	31.8	31.5	NS	31.6	31.6	NS	32.0	31.5	31.2	31.7	.6
Blood Total CO_2, mM											
0	29.9	32.7	.001	31.0	31.6	NS	30.1[a]	29.7[a]	31.8[ab]	33.6[b]	.8
1	33.6	32.3	NS	33.0	32.9	NS	33.8	33.3	32.1	32.5	.8
2	29.4	31.6	.022	30.3	30.7	NS	28.9[a]	30.0[ab]	31.7[b]	31.5[ab]	.9
3	33.0	33.1	NS	32.9	33.2	NS	32.9	33.0	32.8	33.4	.6

[a,b,c]Means within a row with different superscripts are different ($P < .05$).

[1]Parity 1 = primiparous; Parity 2 = multiparous.

[2]HI-BAL = dietary cation-anion balance of +12 meq/100 g diet DM; LO-BAL = dietary cation-anion balance of -11 meq/100 g diet DM.

[3]SE of class means = SE of treatment means/1.414.

[4]Week postpartum; 0 = birth.

[5]NS = $P > .10$.

period. In the present study, udder edema was not reduced by LO-BAL during the dry period, but it appeared to regress more rapidly postpartum for animals previously fed LO-BAL than for those fed HI-BAL (Table 5); this response was most evident at 2 wk postpartum.

Udder edema scores were consistently higher for heifers than for mature cows prepartum (Table 5) but edema appeared to regress more rapidly for heifers than for mature cows. Moreover, the final edema score (wk +3) was lower for heifers.

Body condition scores (Table 5) were not affected by diet, but were higher for mature cows than for heifers through wk +1. By wk +2, body condition scores were similar for these groups; hence, mature cows lost more condition than heifers during the first 3 wk postpartum.

Calf Responses

Table 6 presents the effects of age of the dam and diet consumed by the dam prepartum on acid-base status of the calf. Blood $[H^+]$ was somewhat lower throughout the study for calves from cows consuming LO-BAL. This contrasts with the higher blood $[H^+]$ for cows consuming LO-BAL, and is difficult to explain. The low $[H^+]$ for LO-BAL calves was accompanied by slightly lower blood pCO_2, whereas blood HCO_3^- and total CO_2 did not appear to be affected by diet of the dam.

In summary, within the range of balances evaluated in this study, cation-anion balance of the diet fed to dry cows did not appear to affect systemic acid-base status of their neonatal calves. To prevent the occurrence of milk fever when high Ca diets are fed to dry cows, dietary cation-anion balance apparently must be reduced below -3 meq/100 g diet DM.

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