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EFFECT OF DIETARY CATION-ANION DIFFERENCE ON MINERAL BALANCE IN WEANLING HORSES

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Story in Brief

Sixteen Quarter Horse weanlings were used in a split-plot design experiment to determine the effects of dietary cation-anion difference (DCAD) on mineral metabolism and dry matter digestibility. Experimental diets with a DCAD of +325 (High, H) and -52 (Low, L) were fed for 180 d. Sodium balance was higher in horses consuming Diet H vs Diet L. Horses fed Diet L experienced an increased chloride balance compared with those on Diet H at 240 and 330 d of age. Urinary excretion of calcium was higher and fecal excretion was lower in horses consuming Diet L vs Diet H. Furthermore, calcium balance was significantly higher in horses fed Diet L than those fed Diet H. These results suggest that growing horses are able to compensate for a chronic metabolic acidosis by increasing intestinal absorption of calcium in order to enhance calcium balance.

Key Words: DCAD, Horse, Mineral

Introduction

The effects of dietary cation-anion difference (DCAD) on growth performance, mineral balance and bone formation have been evaluated in horses, swine, poultry and dairy cattle. Research has indicated that horses consuming diets low in DCAD may be in a negative calcium balance due to an increased urinary excretion of calcium (Wall et al., 1992; Baker et al., 1993; 1997). However, a recent study in weanlings has found that horses consuming diets low in DCAD actually had higher calcium balances than those fed diets high in DCAD despite an increased urinary excretion of calcium (Wall et al., 1997). It appears that these horses were able to compensate for the increased urinary excretion by enhancing intestinal calcium absorption. These results suggest that mineral metabolism may not be adversely affected by DCAD. Therefore, the objectives of the present study were to evaluate the long-term effects of DCAD on mineral metabolism in growing horses.

Materials and Methods

Sixteen Quarter Horse weanlings were used in a split-plot design experiment to determine the effects of dietary cation-anion difference (DCAD) on mineral metabolism and dry matter digestibility. Horses were blocked by age and sex, then randomly allotted to the two treatment groups (High or Low) with four fillies and four colts per treatment. The diets consisted of a pelleted concentrate of corn, soybean meal and cottonseed hulls fed in a 70:30 ratio with native prairie grass hay. Experimental diets with a DCAD of +325 (High, H) and -52 (Low, L) were formed by supplementing Diet H with sodium bicarbonate and Diet L with calcium chloride (Table 1). The DCAD of the diets was calculated as meq (Na + K) - (Cl + S)/kg of diet DM. Rations were formulated to contain equivalent amounts of digestible energy (DE=2.9 Mcal/kg DM) across treatments. Diets were analyzed and found to contain approximately equal amounts of CP, calcium, phosphorus, magnesium and sulfur. The 25 wk trial consisted of three 72 h collection periods at 150, 240 and 330 d of age during which a complete urine collection was taken. Multiple fecal grab samples were collected to represent every 2 h post-feeding during each collection period. Fecal mineral analysis was performed using Inductively Coupled Plasma Spectroscopy[1]. Urinary Ca, P and Mg was analyzed using an Ektachem 700 analyzer[2] and read at 680 nm. Urine sodium, potassium and chloride concentration was determined using a Beckman System E4A Electrolyte Analyzer[3]. Data were analyzed by analysis of variance appropriate for a split-block design experiment (SAS, 1985). Least squares means were calculated for each parameter within a period and orthogonal contrasts were then used to test for differences between treatment means.

Results and Discussion

The effects of DCAD on mineral balance at 150, 240 and 330 d of age are shown in Tables 2, 3 and 4. At 150, 240 and 330 d of age, the increase ($P<.05$) in urinary sodium excretion for Diet L compared with Diet H corresponded to higher ($P<.05$) sodium intakes for horses consuming Diet H vs Diet L. No difference in fecal sodium excretion was observed between treatments during any period. Those horses consuming Diet H retained more ($P<.05$) sodium than those consuming Diet L across day of age. In a related study, Wall et al. (1997) found that higher sodium intakes in weanlings consuming diets high in DCAD (+ 353) resulted in increased ($P<.05$) urine and fecal sodium excretion compared with diets low in DCAD (-35).

The intake of potassium was similar across treatments at 150, 240 and 330 d of age. Consequently, no difference in urinary and fecal excretion or potassium balance was detected. This agrees with data in horses (Wall et al., 1997) and dairy cattle (Delaquis and Block, 1995) in which potassium metabolism was not affected by feeding diets high and low in dietary cation-anion difference.

Due to the addition of chloride to the low DCAD diet, increased ($P<.05$) intakes of chloride were noted in horses consuming Diet L vs Diet H across all sampling periods. Despite this increased chloride intake, no differences in fecal chloride excretion were detected at any day of age. At 150 d of age, urinary chloride excretion was higher ($P<.05$) in weanlings fed Diet L than those on Diet H. It appears that this increased chloride excretion did atone for the increase in intake as chloride balance was not different ($P>.05$) between treatments H and L. At 240 and 330 d of age, the higher intakes also resulted in an increase ($P<.05$) in urinary chloride excretion for Diet L vs Diet H, however this increase in renal excretion did not counter the higher intake for there was a significant increase in chloride balance on Diet L compared with Diet H. These data agree with others (Baker et al., 1993; Wall et al., 1993, 1997) who have reported significant increases in urinary chloride excretion in response to increased intakes of chloride on low DCAD diets.

At 150, 240 and 330 d of age, no difference in magnesium intake was observed for Diets H and L. Also intestinal absorption was not altered as fecal magnesium excretion was similar ($P>.05$) between treatments at all ages. At 150, 240 and 330 d of age, urinary magnesium excretion was higher ($P<.05$) in horses consuming Diet L than those on Diet H. This increase in excretion resulted in a lower ($P<.05$) magnesium balance for Diet L compared with Diet H across day of age. These data correspond with results in dairy calves (Jackson et al., 1992) where urinary magnesium excretion decreased linearly with increasing DCAD. The increase in urinary excretion of magnesium in the present study may have been a secondary result to the elevated urinary calcium excretion observed across all periods.

Phosphorus intake did not differ significantly between Diets H and L across day of age. At 150 d of age, urinary and fecal phosphorus excretion and balance were not different ($P>.05$) between treatments. In contrast, urinary phosphorus excretion at 240 and 330 d of age was higher ($P<.05$) in horses consuming Diet H as opposed to those on Diet L. Despite this finding, no difference in phosphorus balance was observed between Diets H and L during either period.

Calcium intakes were similar between diets across all periods. At 150 d of age, horses consuming Diet L excreted more ($P<.05$) calcium in the urine than those fed Diet H. These horses also had a lower ($P<.05$) fecal calcium excretion compared with Diet H. Due to this decrease in excretion of fecal calcium, horses on Diet L were able to compensate for the increased urinary calcium excretion as no difference ($P>.05$) in calcium retention was detected between Diets L and H. At 240 and 330 d of age, urinary calcium excretion was higher ($P<.05$) for Diet L than for Diet H. Fecal calcium excretion was also lower ($P<.05$) for horses on Diet L vs those on Diet H. This significant decrease in fecal calcium excretion resulted in an increased ($P<.05$) calcium balance for horses consuming Diet L compared with those on Diet H at 240 and 330 d of age.

Despite the increased urinary calcium excretion observed in the horses consuming the low DCAD diet, calcium balance was increased over those on the high diet due to the enhanced intestinal absorption of calcium. This finding agrees with data from Wall et al. (1997) in which a decreased fecal calcium excretion resulted in increased calcium balance in weanlings consuming a low DCAD diet. Thus, it appears from the present study that growing horses can respond to chronic metabolic acidosis by increasing intestinal calcium absorption in order to compensate for the increased urinary calcium excretion.

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Table 1. Composition of treatment diets (as fed basis).

	Treatment	
Ingredient (%)	High	Low
Ground corn	40.00	40.20
Soybean meal	16.55	17.05
Cottonseed hulls	10.00	10.70
TM salt	.50	.50
Limestone	.80	--

Dicalcium Phosphate	.50	.30
Sodium Bicarbonate	1.50	--
Calcium Chloride	--	1.10
Chromic Oxide[a]	.15	.15
Prairie grass hay	30.00	30.00
DCAD	+325.00	-52.00
[a]Chromic Oxide was added as an indigestible marker.		

Table 2. Effect of DCAD on mineral balance at 150 d of age[a].

	Treatment		
Item	High	Low	S.E.M.
Sodium			
Intake g/d	28.63[b]	9.61[c]	.66
Urine g/d	17.87[b]	10.26[c]	1.52
Fecal g/d	3.24	1.86	1.02
Balance g/d	7.52[b]	-2.52[c]	1.53
Potassium			
Intake g/d	41.51	39.66	1.39
Urine g/d	19.06	17.66	1.26
Fecal g/d	18.49	19.44	1.45
Balance g/d	3.97	2.56	2.68
Chloride			
Intake g/d	19.08[b]	45.67[c]	1.19
Urine g/d	12.66[b]	34.65[c]	2.08
Fecal g/d	2.23	1.98	.41
Balance g/d	4.17	9.02	1.90
Magnesium			
Intake g/d	7.97	7.61	.27
Urine g/d	1.14[b]	2.16[c]	.27
Fecal g/d	6.50	7.04	.32
Balance g/d	.35[b]	-1.59[c]	.40
Phosphorus			
Intake g/d	17.61	16.82	.59
Urine g/d	.92	.63	.19
Fecal g/d	10.27	9.73	1.04
Balance g/d	6.43	6.47	1.15
Calcium			
Intake g/d	31.45	30.05	1.06

Urine g/d	1.31[b]	5.00[c]	.51
Fecal g/d	17.35[b]	12.52[c]	1.38
Balance g/d	12.78	12.53	1.65

[a]Values are least squares means.

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

Table 3. Effect of DCAD on mineral balance at 240 d of age[a].

	Treatment		
Item	High	Low	S.E.M.
Sodium			
Intake g/d	44.13[b]	14.30[c]	.66
Urine g/d	22.61[b]	9.54[c]	1.52
Fecal g/d	10.12	10.69	1.02
Balance g/d	11.39[b]	-5.92[c]	1.53
Potassium			
Intake g/d	61.16	59.04	1.39
Urine g/d	23.70	27.01	1.26
Fecal g/d	23.51	23.71	1.45
Balance g/d	13.95	8.33	2.68
Chloride			
Intake g/d	29.42[b]	67.99[c]	1.19
Urine g/d	18.25[b]	48.91[c]	2.08
Fecal g/d	4.55	3.97	.41
Balance g/d	6.61[b]	15.12[c]	1.90
Magnesium			
Intake g/d	11.74	11.33	.27
Urine g/d	2.05[b]	3.50[c]	.27
Fecal g/d	10.15	10.02	.32
Balance g/d	-.47[b]	-2.18[c]	.40

Phosphorus			
Intake g/d	25.95	25.05	.59
Urine g/d	.84[b]	.18[c]	.19
Fecal g/d	21.47	19.61	1.04
Balance g/d	3.64	5.27	1.15
Calcium			
Intake g/d	46.33	44.73	1.06
Urine g/d	2.99[b]	9.80[c]	.51
Fecal g/d	36.21[b]	21.25[c]	1.38
Balance g/d	7.15[b]	13.66[c]	1.65

[a]Values are least squares means.

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

Table 4. Effect of DCAD on mineral balance at 330 d of age[a].

	Treatment		
Item	High	Low	S.E.M.
Sodium			
Intake g/d	45.76[b]	15.45[c]	.74
Urine g/d	24.84[b]	10.70[c]	1.69
Fecal g/d	11.17	11.36	1.15
Balance g/d	9.78[b]	-6.62[c]	1.70
Potassium			
Intake g/d	62.59	63.75	1.55
Urine g/d	23.69	27.76	1.41
Fecal g/d	26.51	28.76	1.62
Balance g/d	12.39	7.22	2.98
Chloride			
Intake g/d	30.51[b]	73.41[c]	1.33
Urine g/d	21.61[b]	53.03[c]	2.32
Fecal g/d	4.29	4.51	.46
Balance g/d	4.60[b]	15.87[c]	2.11

Magnesium			
Intake g/d	12.01	12.24	.30
Urine g/d	1.71[b]	3.27[c]	.31
Fecal g/d	9.83	10.43	.36
Balance g/d	.48[b]	-1.48[c]	.44
Phosphorus			
Intake g/d	26.55	27.05	.66
Urine g/d	1.13[b]	.34[c]	.21
Fecal g/d	23.92	22.46	1.16
Balance g/d	1.50	4.24	1.28
Calcium			
Intake g/d	47.41	48.29	1.18
Urine g/d	2.73[b]	10.59[c]	.57
Fecal g/d	39.12[b]	22.02[c]	1.54
Balance g/d	5.57[b]	15.68[c]	1.84

[a]Values are least squares means.

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

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