EFFECT OF DIETARY CATION-ANION BALANCE ON ACID-BASE STATUS IN HORSES

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Story in Brief

Four mature, sedentary geldings were randomly assigned to one of four experimental treatments to evaluate the effects of varying dietary cation-anion balances on urine and blood pH and blood gasses. Dietary cation-anion balance is calculated as meq((Na + K) - Cl)/kg diet dry matter. Diets consisted of a base concentrate (corn, soybean meal and cottonseed hulls), fed with native prairie grass hay in a 60:40 ratio. Diets were formulated to provide cation-anion balances of -50 (L, low), +50 (ML, medium low), +150 (MH, medium high) and +250 (H, high). Urine pH was significantly lower for the low versus the high DCAB diets. Blood pH, pCO_2 and HCO_3^- values were also significantly lower for the low versus the high DCAB diets, in both arterial and venous samples. The results of this trial indicate that horses consuming diets with a cation-anion balance less than +150 meq/kg of DM may experience metabolic acidosis and increased urinary calcium and magnesium loss.

(Key Words: Equine, Nutrition, Acid-Base.)

Introduction

Currently, little research is available regarding dietary cation-anion balance (DCAB) effects in horses. However, this phenomenon has been studied extensively in dairy cattle, swine and poultry. The equation most commonly used to calculate DCAB is (meq (Na + K) - Cl)/kg dry matter. The equation takes into account only the monovalent elements sodium, potassium and chloride, as they are the most readily absorbed and appear to have the greatest metabolic impact. Sodium and chloride are both involved with osmotic fluid regulation, while potassium is involved with the maintenance of acid-base balance and osmotic pressure regulation. Because sodium and potassium are often absorbed from the gastrointestinal tract in

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exchange for a proton, and chloride is absorbed in exchange for a bicarbonate ion, any alteration in the relative amounts of these ions in the diet could be expected to have an effect on the acid-base balance in the animal. Tucker et al. (1988) showed that by increasing the level of DCAB from -10 to +20 meq/100g DM, milk yield in lactating Holsteins was increased by 8.6 percent. Tucker et al. (1988) demonstrated that altering the DCAB of the diet has marked effects on blood acid-base balance. High chloride diets have been shown to depress blood pH, bicarbonate and increase pCO_2 levels. Petito et al. (1984) showed that an increased ingestion of acid in rats increased urinary and fecal excretion of calcium. These rats also had decreased bone weight due to increased calcium mobilization from the bone without vitamin D action. Topliff et al. (1988) showed that there is a significant increase of calcium and chloride in the urine of horses consuming a diet with a DCAB of +6.5 meq/kg DM versus a diet of a DCAB of +150 meq/kg. Furthermore, these horses had higher concentrations of chloride in the urine. If prolonged, this situation could lead to developmental orthopedic disease in young growing horses, or to an osteoporosis weakening the skeleton in mature horses. The objective of this experiment was to study the effects of varying DCAB in mature sedentary horses.

Materials and Methods

Four mature, sedentary geldings were used in a 4x4 Latin square experiment to study the effects of DCAB on the acid-base status on non-exercised horse. Four diets providing -50 (L), +50 (ML), +150 (MH) and +250 (H) meq((Na + K) - Cl)/kg diet dry matter were rotated among the four experimental periods. Each period consisted of a 21 day adjustment period followed by a 72 hour collection period. Diets consisted of a concentrate and hay mixture in a 60:40 ratio, and were fed in amounts to maintain constant body weights. The concentrate was composed of corn, soybean meal and cottonseed hulls. To achieve the required DCAB levels, calcium chloride and ammonium chloride were added to the L and ML diets, while sodium bicarbonate and potassium citrate were added to the H diet. The MH diet (DCAB of +150) served as the basal diet, representative of a typical ration. Horses were exercised for thirty minutes daily on a hot walker, and were given required health care throughout the trial.

Both arterial and venous blood samples were drawn hourly, via indwelling catheters, for 12 hours post-feeding, and analyzed immediately for pH, pCO_2, tCO_2, HCO_3^-, base excess, standard bicarbonate and base excess extracellular fluid by way of a blood gas analyzer. Total urine production was collected every 4 hours post-feeding for 72 hours and samples analyzed immediately for pH. Fecal grab samples were obtained over 72 hours to represent every 2 hours post-feeding. Composited urine and fecal samples were frozen and stored for later mineral analysis. All data were analyzed using a repeated measures model. Least squares means over time were then tested using the pdiff procedure and significance declared at a probability level of .05 (SAS, 1985).

Results and Discussion

The effect of treatment over time on urine pH is shown graphically in Figure 1. Horses consuming diet L had significantly lower urine pH values, ranging from 5.40 on diet L to 8.14 on diet H. The effect of treatment over time on arterial and venous blood pH is shown graphically in Figures 2 and 3. Arterial and venous blood pH values were significantly lower on diet L. Values ranged from 7.32 on diet L to 7.42 on diet H for arterial, and 7.31 on diet L to 7.41 on diet H for venous samples. The effect of treatment over time on blood pCO_2 is shown graphically in Figures 4 and 5. Arterial and venous blood pCO_2 was significantly lower on diet L, with arterial values ranging from 38.92 on diet L to 48.37 on diet H and venous values ranging from 45.36 on diet L to 53.70 mm/Hg on diet H. Treatment over time effects on blood HCO_3^- are shown in Figures 6 & 7. Arterial and venous blood HCO_3^- was significantly lower on diet L, with arterial values ranging from 22.53 on diet L to 29.30 on diet H and venous values ranging from 23.93 on diet L to 31.22 mmol/L on diet H .

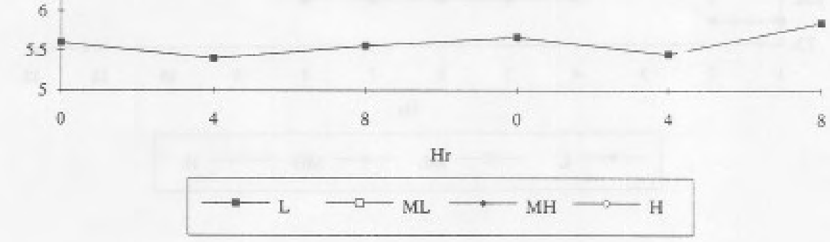

Figure 1. Effect of DCAB on urine pH post feeding.

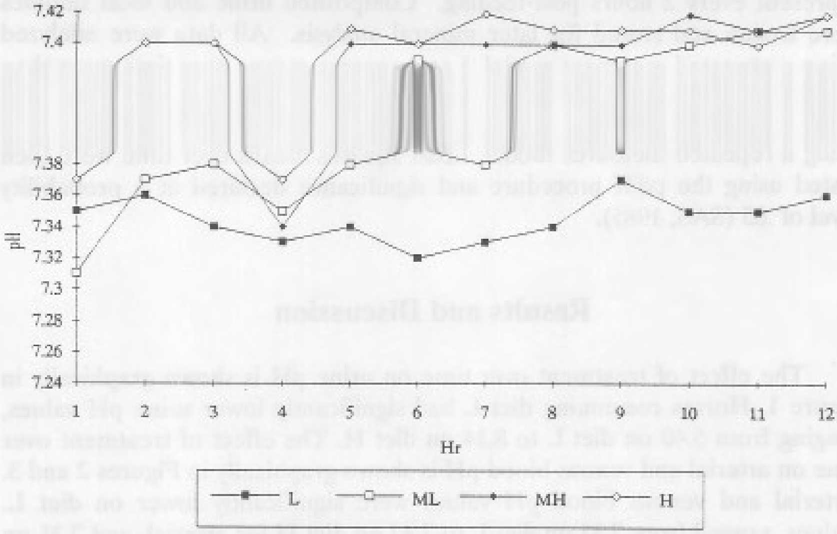

Figure 2. Effect of DCAB on arterial blood pH post feeding.

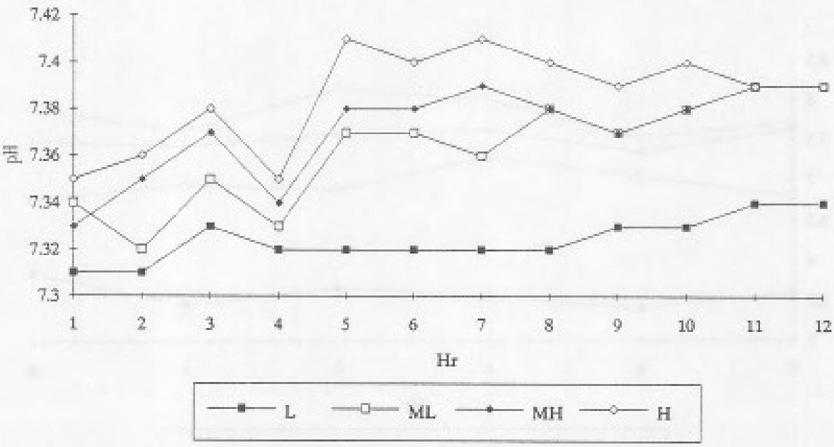

Figure 3. Effect of DCAB on venous blood pH post feeding.

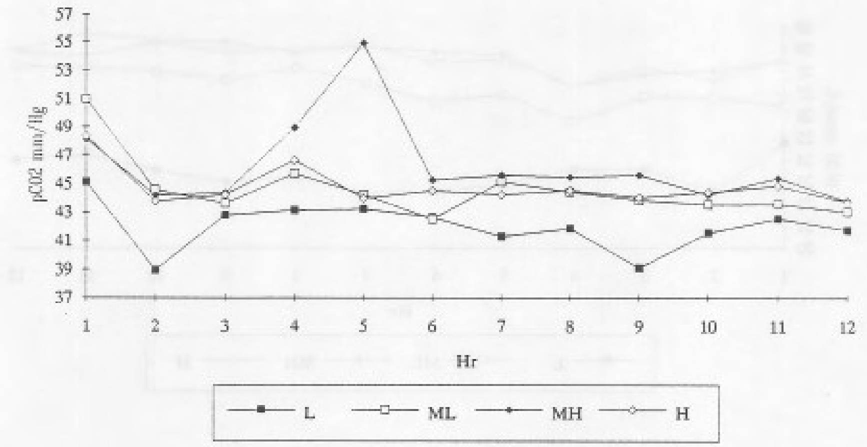

Figure 4. Effect of DCAB on arterial blood pCO_2 post feeding.

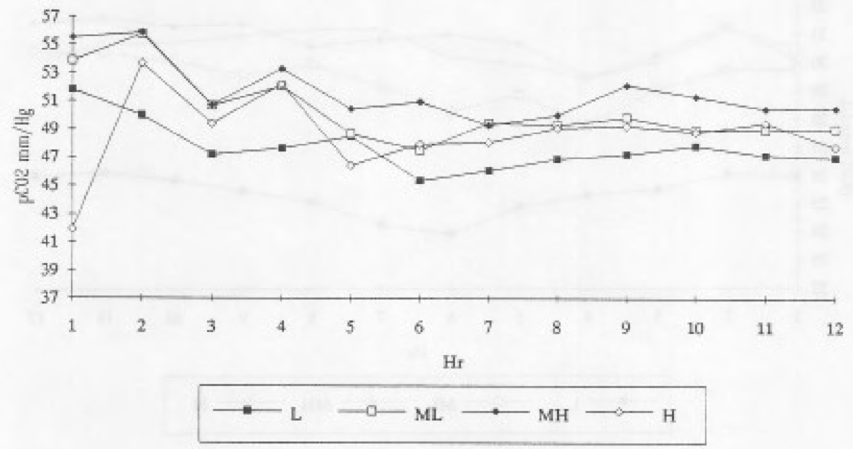

Figure 5. Effect of DCAB on venous blood pCO_2 post feeding.

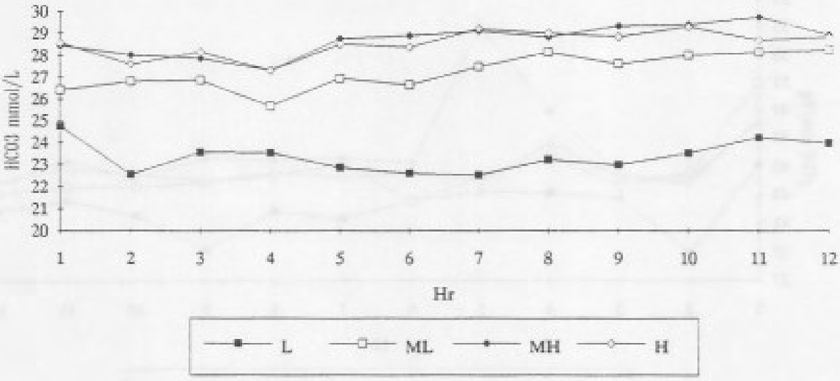

Figure 6. Effect of DCAB on arterial blood HCO_3 post feeding.

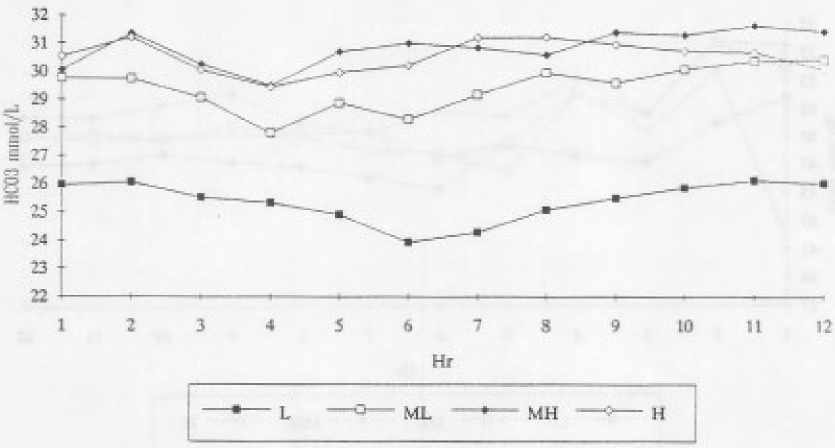

Figure 7. Effect of DCAB on venous blood HCO_3 post feeding.

Blood acid-base status is influenced by absorption of inorganic ions. The absorption of cations such as Na and K will increase the generation of base in the systemic system, and the absorption of anions, such as Cl, will increase acid generation. Data from this experiment agree with that of Tucker et al. (1988) in that diets with a low DCAB (high Cl concentration) decrease blood pH, bicarbonate and pCO_2 levels.

In summary, these data indicate that horses consuming diets providing a DCAB of less than +150 meq/kg of DM may experience a state of nutritionally induced metabolic acidosis. This acidosis may lead to increased urinary calcium excretion. Further research is needed to study the effects of DCAB on skeletal growth and soundness of young horses, as well as the mature performing horse.

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