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Effect of Mineral Supplement on Plasma Minerals Concentration of Camels (*Camelus dromedarius*) in Kenya

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ABSTRACT

A study was conducted in Ngurunit and Kargi locations of Marsabit district, Kenya to determine the effect of mineral supplementation on plasma minerals concentration of camels. Two mineral supplements were formulated; one comprising of locally collected, ground bones mixed with locally available natural salt and the other consisted of commercial ingredients. Fifty-nine camels in early lactation were recruited in Kargi and 56 in Ngurunit. Of these camels, 22 were randomly assigned commercial supplement in each site while 12 were put on local supplement in Kargi and 11 in Ngurunit. There were 25 control camels in Kargi and 23 in Ngurunit. Each dam was fed 200 g of supplement daily for 190 days, with blood samples being taken once a month for minerals assay. While the concentration of cobalt and copper was relatively stable, potassium, magnesium and iron exhibited a slight increase. Trends for calcium, sodium, zinc and phosphorus were inconsistent. These results suggested interactions, and that plasma minerals concentration is not a good indicator of dietary mineral content.

Key Words: Mineral supplements; Plasma; Camels; Kenya

INTRODUCTION

Tissue minerals concentration must be maintained within narrow limits if growth, health and productivity of livestock are to be maintained (McDowell, 1987; Kasongo *et al*., 1997). Consequently, it is necessary to provide both macro and trace mineral elements that may be deficient in tropical forages as dietary supplements (McDowell, 1997). Physiological concentration of minerals in body tissues depends on dietary concentration, absorption, interaction between the elements, animal species (Underwood, 1977), and homeostatic regulation (McDowell, 1997).

Kuria *et al*. (2004) reported below the recommended levels of copper (Cu) and zinc (Zn) in forages preferred by camels in Marsabit area of Kenya. Between 22 and 50% of the forages were also found to have marginal or low potassium (K) and phosphorus (P) concentrations, suggesting deficiencies. It was on this basis that this study was initiated to test the effectiveness of direct mineral supplementation in bridging the shortfall in mineral supply.

MATERIALS AND METHODS

Study area. Two study sites were identified, Ngurunit (802 m.a.s. l) and Kargi (460 m.a.s. l), both administrative locations in Marsabit district. Ngurunit receives about 500 mm of rainfall annually and the temperature ranges from 22.5 to 27°C in contrast to Kargi, which receives mean annual precipitation of 250 mm with temperature range of 27 to 38°C (Schwartz *et al*., 1991).

Preparation of mineral supplements. This was based on the report of Kuria *et al*. (2004). Estimates of mineral in-take from forages based on observed proportional in-take by camels were compared with recommended dietary levels and the difference assumed to be the deficit for various elements, to be supplied through the supplement. Eight of the nine mineral elements targeted in this study were found to have deficits.

Deficits for the eight minerals totaled 91.65 g. Chemical compounds to supply various elements were identified and amount of each chemical (g) required to supply the required amount of element computed based on molecular weights. Total weight of chemicals to supply the required elements was 185.5 g to which, 14.5 g of Sodium chloride was added to improve palatability, followed by packaging in single dose sachets weighing 200 g.

Local supplement was formulated using livestock bones and natural salt collected from Chalbi desert, both of which are locally available. Chalbi salt was bought from a local market where it is sold as mineral supplement for livestock. Raw bones were charred, crushed and sieved through 1.5 mm wire mesh. Chalbi salt was also sieved to remove large particles. Based on mineral content of raw materials and the estimated deficits, they were thoroughly mixed in the ratio of 2 (ground bones): 3 (Chalbi salt), weighed and packaged in to 200 g sachets.

Un-like commercial supplement, the packaged amount of local supplement did not cover estimated deficit for all minerals due to low levels of some of the target elements in raw materials (Table I). However, the cost of this supplement was low due to local availability of raw materials.

Table I. Estimated deficit and the amount of minerals supplied by commercial and local supplements.

Element	Estimated deficit (g)	Amount (g) supplied by commercial supplement	Amount (g) supplied by local supplement
Ca	20.0	20.0	24.5
P	13.0	13.0	11.3
Mg	3.0	3.0	1.13
Na	-[a]	5.7	34.3
K	55.0	55.0	.64
Fe	.30	.30	.21
Cu	.05	.05	.003
Co	-	0	.003
Zn	.30	.30	.003

[a] (-) in the Table indicate no deficit

Experimental animals. Fifty-six camels were recruited in Ngurunit and 59 in Kargi. The camels whose average stage of lactation at recruitment was 0.9 months were randomly assigned the two mineral supplements and control. Of the supplemented camels, 22 were on commercial supplement in each site while, 11 were on local supplement in Ngurunit and 12 in Kargi. There were 25 and 23 control camels in Kargi and Ngurunit, respectively.

Feeding of supplement. The supplements were packaged in 200 g sachets and offered to each camel daily. The contents were emptied in a plastic container, mixed with water to a semi-solid paste and orally administered to a restrained camel every morning for 190 days with the aid of trained field assistants.

Blood sampling and preparation. Blood samples were collected once per month, between 1800 h and 2030 h, before camels were released for grazing throughout the 190 days supplementation period. Bleeding was done via jugular vein puncture (Fick *et al*., 1979) using 20 gauge vacutainer® needles and 10 mL vacutainer® tubes with EDTA sodium as anticoagulant. To ensure thorough mix with anticoagulant, the tubes were gently inverted several times. After collection, blood samples were centrifuged at 17,600 g for 10 min (HMSO, 1979) to separate the plasma. Using disposable plastic pipettes, the plasma was aspirated, expelled in to cryovials and temporarily stored in a cool box in the field. The samples were later transferred to laboratory and stored at -4°C awaiting mineral analysis.

Laboratory analysis. The plasma was assayed for mineral elements sodium (Na), K, calcium (Ca), P, magnesium (Mg), Zn, Cu, iron (Fe) and cobalt (Co) using Bellanger and Lamand method (1975) with Atomic Absorption Spectrophotometer (Model CTA - 2000). Phosphorus was analysed using colorimetric method described by Sigma Chemicals (1991).

Data analysis. The data were entered and analyzed using Windows based Statistical Package for Social Scientists (SPSS) (Norman *et al*., 1975). Multiple regression analyses were performed on data to test whether plasma mineral concentration was influenced by independent variables of site, type of supplement and time. The model used was as follows;

$PMC = \mu_1 + \beta_2$ site $+ \beta_3$ supplement $+ \beta_4$ time $+ \varepsilon$ where;

PMC = plasma mineral concentration, μ_1 = population mean, β_2 site = effect of site,

β_3 supplement = effect of supplement type, β_4 time = effect of time, ε = random error.

Correlation analysis was done to test for interactions between elements. Means were tabulated while charts were drawn using Windows based Excel (Maria, 1999).

RESULTS AND DISCUSSION

Factors affecting plasma minerals concentration. Regression analysis indicated that plasma minerals concentration was influenced by supplementation and month of sampling/time ($P < 0.05$). Supplementation appeared to influence plasma concentration of macro more than trace elements. As no significant differences were observed in minerals concentration between commercial and local supplements and between sites, the data was combined for subsequent analysis.

Correlation analysis. This revealed significant positive correlations between Ca and Zn ($P = 0.025$; $r = 0.82$) and, Ca and Na ($P = 0.025$; $r = 0.82$) but showed a significant negative correlation between Ca and P ($P = 0.04$; $r = -0.78$).

Supplementation and time of sampling. Effect of supplementation and time of sampling on plasma concentration of trace and macro minerals is shown in Fig. 1 and 2, respectively.

Sodium and K are mainly involved in maintenance of osmotic pressure and acid base balance in the body (McDowell, 1997). These elements are not stored in the body and must be supplied daily in feed. Control mean plasma concentration of Na was above the reported range. The concentration increased with supplementation attaining maximum level during the second month, then declined to reported range by end of fourth month. Control plasma concentration of K was above the reported range and increased with supplementation with the mean level being maintained above reported range. The observed rise in plasma concentration of Na and K despite homeostatic control may suggest higher concentration of both minerals in these particular camels or interaction with other minerals.

Calcium may have influenced the initial rise in plasma concentration of Na as a consequence of significant positive interaction between Ca and Na observed in this study. There is however no biochemical explanation for this interaction and may require further investigation. Camels are reported to show elevation of Ca, Na and K in the plasma as a result of dehydration (Ayoub & Saleh, 1998). The peak plasma concentration of these minerals in this study coincided with height of a dry season. High plasma concentration of Na during this time may be necessary as it is involved in water re-absorption in the kidneys (Ben Goumi *et al*., 1993).

Fig. 1. Effect of mineral supplementation on plasma concentration of trace elements.

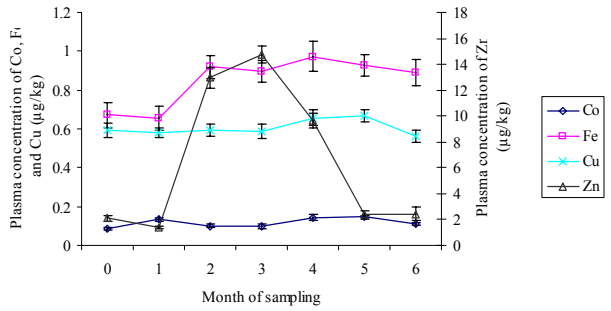
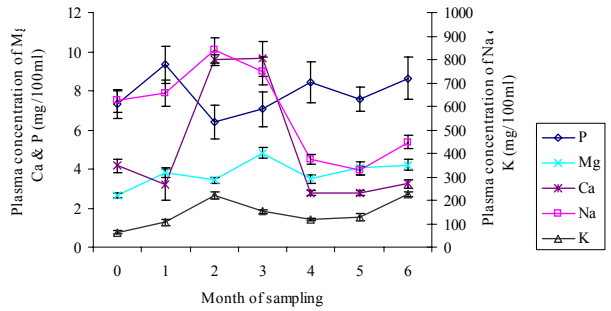


Fig. 2. Effect of mineral supplementation on plasma concentration of macro elements.



Sodium is actively re-absorbed, increasing the salt concentration in kidney tissues, which triggers diffusion of water from gromerular filtrate in to the surrounding tissues down in the loop of henle.

Calcium, P and Mg are structural components, mainly stored in bones and teeth (McDowell, 1997). Plasma concentration of Ca declined during the first month, increased to reported range during the second and third months of supplementation, then declined and remained below reported range (Fig. 2). The initial plasma concentration of P was above the reported range. This increased marginally with supplementation attaining maximum level during the first month, declined to reported range in the second month, then continued rising gradually up to the end of supplementation period. The control plasma concentration of Mg was within reported range and increased with supplementation to a level above the reported range.

The trend for P was inverse to that of Ca (Fig. 2) and was reflected in a negative correlation between Ca and P. Due to the roles of Ca and P in formation of bones during which the optimal 2 (Ca): 1 (P) ratio (McDowell, 1992) must be maintained, there is mutual inhibition of absorption of which-ever element may be in excess from intestinal tract (Georgievskii, 1982). This inhibition occurs by way of a chemical reaction between the two minerals forming an insoluble complex. Vittorio *et al*. (1999) observed that Ca is one of the mineral elements that are controlled by homeostasis and is not expected to fluctuate much with diet. Cunha (1973), McDowell (1997) and Lukhele and Van Ryssen (2003) also reported significant negative interaction between Ca and P. These authors observed that excess of either P or Ca in the diet interferes with absorption of the other leading to lower plasma concentration. In this study, for reasons that are not clear, Ca/ P ratio was lower than the optimum throughout the supplementation period, P being in excess of Ca. The gradual increase in plasma concentration of Mg is attributed to supplementation in agreement with Ingraham *et al*. (1987).

Zinc is a major component of metalloenzymes, both as part of molecules and activator (McDowell, 1997). Although plasma Zn concentration was above the reported range at the start of experiment, it increased with supplementation attaining a maximum level of 14.7 ppm in the fourth month, then declined to a low level of 2.4 ppm by the end of supplementation period. This element was regulated above reported range throughout the supplementation period. The observed trend for Zn is attributed to increased supply in harmony with Asif *et al*. (1996) and McDowell (1997). Asif *et al*. (1996) observed that normal concentration of trace elements in different tissues mainly depends on the dietary concentration, absorption and homeostatic control mechanisms of the body. McDowell (1997) observed that though Zn is stored in the liver, this is only in small amounts and it should be supplied regularly in feed to enable the body maintain required level in the blood.

The high levels and rapid increase in plasma concentration of Zn between second and fourth months of supplementation is attributed to positive Ca/Zn interaction observed in this study. Asif *et al*. (1996) reported positive correlation between these mineral elements. In non-ruminant animals, Ca interacts with Zn in a negative way owing to formation of phytate complexes (Georgievskii, 1982; Larsen & Sandstrom, 1992). However, microbial organisms in ruminants (camels inclusive) produce phytase enzyme, which degrade phytate complexes (Spears, 2003). Thus, as supplementation continued, Zn absorption in small intestines continued un-abated resulting to high plasma concentration.

Copper is an essential component of metallo-enzymes and is involved in bone formation and proper cardiac function while, Co is required by rumen micro-organisms for vitamin B_{12} synthesis (McDowell, 1997). These minerals are stored in the liver. Iron plays a vital role in cellular respiration and is a component of haemoglobin and myoglobin (McDowell, 1997). The plasma concentration of Cu, Co and Fe was within reported range at beginning of the experiment. There were minor fluctuations but the concentrations were maintained within this range during supplementation through homeostatic mechanisms (Doyle *et al*., 1990). Vittorio *et al*. (1999) similarly reported a non-significant increase in plasma concentration of Fe with supplementation of camels. Lack of plasma response following oral mineral supplementation has been linked to

efficient specific elemental homeostasis (Doyle *et al.,* 1990). The observed trends suggest that the reported range was reflective of body requirement of these minerals.

The plasma Co and P concentration displayed a seasonal trend, with their concentrations declining during dry season. In wet season when the forage situation improved, plasma concentration of these minerals increased. This observation was in agreement with Faye *et al*. (1991) who observed that there is a high interaction between mineral absorption and quality of diet with well balanced diet, in terms of energy and protein, being crucial in avoiding deficient mineral status.

Implications. There is no direct relationship between diet and plasma minerals concentration apart from for some minerals, which, are reportedly sensitive to dietary change. Other factors, which may include but not limited to homeostasis and interaction, appear to play a more significant role in determining minerals status in the blood.

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