Effect of Zinc Supplementation on Plasma Mineral Concentration in Grazing Goats in Sub-Humid Climate of Tanzania

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SUMMARY

Tropical pastures are characterised by fast growth and early maturity during the rain seasons and a fall in nutritive value during the dry seasons. Animals should be supplemented with minerals known to be deficient. The bioavailability of common supplements and their possible undesirable effects are hardly known. This study was conducted to determine the effect of zinc supplementation on plasma zinc, calcium and inorganic phosphate in East African local goats. The goats were randomly divided into two groups of 12 each. One group was supplemented with 24 mg/Kg body weight of Zn every other day for six weeks during the rainy and dry season. The unsupplemented group was the control. Blood samples collected from goats in both groups were analysed for plasma Zn, Ca and Pi using standard methods. The concentration of plasma Zn was significantly higher ($P<0.05$) in Zn supplemented goats than in the control group during rainy and dry seasons. In both groups plasma Zn concentration was above the normal minimum levels of 18 μmol/l, except towards the end of dry seasons. Plasma Ca (1.9 – 3.1 mmol Ca/l) and Pi (1.3 – 1.60 mmol Pi/l) concentrations for Zn-supplemented group were lower during all the sampling days ($P <0.05$) than for the control group (Ca 2.0 – 3.4 mmol/l and P (1.5 - 1.62 mmol/l) in all seasons. It is concluded that, goats in the study area and probably areas with similar ecological conditions should be supplemented with Zn only when there is evidence of Zn deficiency during prolonged dry seasons.

Keywords: East African goats, zinc supplementation, plasma zinc, calcium and inorganic phosphate

INTRODUCTION

Zinc is one of the essential nutrients required in the body for proper functioning of a number of enzymes which are involved in energy and protein metabolism apart from being involved in immune system in animals (McDowell, 1992; Hogan *et al.*, 1996). It is involved in antioxidant systems that maintain the integrity of phagocyte cells and lymphoid tissues (Miller *et al.*, 1996). Impairment of the antioxidant system can result in a higher incidence and more severe clinical signs of diseases (Hogan *et al*., 1996). Zinc is not stored in the animal body therefore it needs to be supplied continuously (McDowell, 1992).

In Tanzania, zinc deficiencies have been demonstrated in forages from different parts of the country including Morogoro region (Chauhan and Deringo, 1997; Pereka and Phiri, 1998; Phiri, 2001). Apart from low levels of Zn in Morogoro there are also low levels of phosphorus and calcium (Mwakatundu, 1977; Phiri, 2001). However, excessive Zn may reduce the

absorption of calcium or phosphorus (Underwood and Suttle, 1999). In Tanzania like most parts of Africa goats play an important household economic role and the daily management involve outdoor grazing on natural pastures. These pastures are characterised by fast growth and early maturity during the rain seasons and fall in nutritive value during the dry seasons (Humphreys, 1980; Das and Sendalo, 1990). The present study aimed at investigating the effect of Zn supplementation to local goats on body balance of zinc, calcium and inorganic phosphate.

MATERIALS AND METHODS

Study area and animals of study

The study was carried out in Morogoro municipality which has semi humid climate in 2001. During the study period the study area was characterized by a dry season which started from June to October and a rainy season from March to May. The study involved 24 female East African local goats, aged six months to one year (9 ± 4 months). The mean body weight of the goats was 10 ± 3 kg. The goats were clinically examined before commencement of the experiment. Only goats which were found to be free from diarrhoea, with normal temperature and without any obvious skin lesion were used for the study. All selected goats were dewormed by using Milsan® (Interchem pharm LTD, Moshi- Tanzania) which contains levamisole 1.5%, and oxyclozanide 3%.

Experimental design

The goats were randomly divided into two groups of 12 goats each. The first group was the control group and was not supplemented with Zn. The second group was the treatment group and was supplemented with Zn at a dose of 24 mg/kg body weight as zinc oxide (ZnO) in drinking water. The supplementation was done every other day and continued for 6 weeks during both the dry and wet seasons. The selection of the dose of zinc to supplement was based on the fact that the normal Zn requirement for goats ranges from 15 to 30 mg /kg body weight per day. To achieve the selected dose 30 mg of Zinc oxide was dissolved in 350 mls of portable water and administered to the animal by using a drenching gun.

Blood Sampling and Laboratory Analysis

Blood samples were collected from the jugular vein from each goat on the initial day of mineral supplementation and then subsequently at an interval of every two weeks for a period of six weeks during the rainy season (from 17th march to 5th May 2001) and six weeks during the dry season (from 2nd September to 14th October 2001). Blood samples were collected between 04.00 - 06.00 GMT using heparinised vacutainer tubes (Becton Dickinson, UK) and centrifuged at 5000 x G for 10 minutes to obtain blood plasma. Plasma for determination of plasma Ca, Zn and Pi was harvested into tubes washed in 6N nitric acid to prevent exogenous mineral contamination. The plasma samples were stored at -15^{o}C pending analysis.

Total plasma Ca analysis was done according to modified methods of Gitelman (1967), and Kessler and Wolfman (1964) using a Cecil 2000 spectrophotometer (CE 2041). In this method plasma was added to the acidic medium and incubated for a period of four minutes to ensure the release of protein bound calcium. Thereafter, the acidic medium was made alkaline and then cresolphthalein was added forming a coloured complex with calcium ions and

the absorption of the complex was measured at 574 nm. Intra and inter assay precision were 1% and 2%, respectively. To assure further precision and accuracy of the analysis one control sample with a known concentration of Ca (2.50 mmol Ca/l) was analyzed together with test samples.

Plasma Pi was assayed by measurement of vanado- phospho- molybdate complex formed in acid as described by Fiske and Subarrow (1925). Absorbance of this complex is read at 420 nm. Absorbance data are converted into concentration values using a standard curve. Intra and inter assay precision were 1% and 2%, respectively. To assure further precision and accuracy of the analysis at least one control sample (2.0 mmol Pi/ l) was analyzed together with test samples.

Plasma Zn and Cu concentration were determined by Atomic Absorption Spectrophotometer (AAS) as described by Milner and Whiteside (1984). In this method Zn was liberated from protein by using trichloroacetic acid after centrifugation at 3000G for 10 minutes. Zinc from the supernatant was then determined by AAS using prepared standards. The Intra assay and inter assay coefficients of variation was 2% and 3%, respectively.

Data Analysis

Blood plasma parameter data were analysed using the GLM procedures of the SAS statistical package (SAS, 1990). According to the following model.

$Y_{ij} = \mu + \alpha_i + \beta j + e_{ij}$

Whereby Y_{ij} = General response of the j^{th} goat to i^{th} dietary treatment,

μ = Overall mean

α_i = fixed effect of the ith treatment (Zn supplementation)

βj = Fixed effect of the j^{th} goat

eij = random error variation other than that caused by the j^{th} goat or i^{th} diet

RESULTS

The results of the concentration of Zn in plasma for the Zn supplemented goats and those in the control group are presented in Table 1.

DISCUSSION

The results indicate that there was no significant different ($P < 0.05$) in plasma Zn concentration between Zn supplemented and control goats at the beginning of the study. However, after two weeks of Zn supplementation until the end of the study the levels of plasma Zn were significantly higher ($P < 0.001$) in goats which were supplemented with Zn. The increase in plasma Zn in the supplemented group can probably be due to additional Zn which was given to the animals. The present results are similar to the results observed by Phiri, (2001) who reported an increase in plasma Zn concentration in cows supplemented with Zn in the form of Zinc oxide.

In addition, results in Table 1 indicate that the Plasma Zn concentration was observed to be low at the beginning of the wet season (Day 0), but the levels were found to be high during the subsequent sampling days. The presented results show further that the levels of plasma Zn were decreasing in subsequent sampling periods during the dry season. These findings imply that the nutritive value of natural pastures in the study area tends to be high

during the rainy season and decreases as the dry season intensifies. Similar observation were made by Humphreys, (1980) and Das and Sendalo, (1990). The minimum accepted plasma Zn concentration in goats is reported to be 18 μmol/l (McDowell, 1992). In the present study plasma Zn was observed to be near or above 18μmol/l during the rainy season and on the beginning of the dry season in both groups of goats (Table 1) but, tended to fall below the minimum value towards the end of the dry season for goats in the control group. This observation implies that goats in the study area should only be supplemented with Zn during prolonged dry seasons. Because it is during such periods the quality and quantity of pastures fall drastically and fail to meet the required amount of Zn in the diet.

Table 1. Concentration of plasma zinc (μmol/l), calcium and inorganic phosphate (mmol/l) in Zn supplemented (Suppl.) and non- supplemented (Cont.) goats

Sampling days	Plasma Zn		Calcium		Inorganic Pi	
	Suppl.	Cont.	Suppl.	Cont.	Suppl.	Cont.
Wet season						
0	22 0 ± 1.56 [a]	21.5 ± 1.32 [a]	2.9 ± 0.53[a]	2.9 ± 0.51[a]	1.49 ± 0.03[a]	1.51 ± 0.04[a]
	(20 – 23.5)	(19.5 – 24.3)	(2.30 – 3.1)	(2.29 – 3.2)	(1.12 – 1.72)	(1.10 – 1.86)
14	38.0 ± 3.09 [a]	31.7 ± 3.69 [b]	2.9 ± 0.42[b]	3.1 ± 0.48[a]	1.47 ± 0.03[b]	1.50 ± 0.08[a]
	(33.0 – 40.2)	(29.2 – 36.3)	(2.49 – 3.2)	(2.75 – 3.35)	(1.24 – 1.82)	(1.22 – 1.82)
28	37.1 ± 2.48 [a]	32.6 ± 2.7 [b]	3.1 ± 0.31[b]	3.3 ± 0.29[a]	1.51 ± 0.05[b]	1.60 ± 0.09[a]
	(35.0 – 43.9)	(28.9 – 34.6)	(2.56 – 3.28)	(2.93 – 3.48)	(1.35 – 1.62)	(1.40 – 1.80)
42	36.1 ± 3.79 [a]	31.4 ± 2.67 [b]	3.1 ± 0.24[b]	3.4 ± 0.29[a]	1.52 ± 0.24[b]	1.62 ± 0.05[a]
	(35.4 – 42.9)	(27.9 – 33.6)	(2.93 – 3.31)	(2.91 – 3.58)	(1.32 – 1.92)	(1.50 – 1.75)
Dry season						
0	32 6 ± 2.56 [a]	31.5 ± 2.32 [a]	1.9 ± 0.63[a]	2.0 ± 0.59[a]	1.60 ± 0.09[a]	1.58 ± 0.08[a]
	(29.5 – 34.5)	(28.5 – 32.3)	(1.45 – 2.4)	(1.59 – 2.2)	(1.50 – 1.76)	(1.52 – 1.86)
14	28.0 ± 4.09 [a]	24.8 ± 3.85 [b]	2.4 ± 0.42[b]	2.7 ± 0.23[a]	1.40 ± 0.06[b]	1.60 ± 0.08[a]
	(23.0 – 30.2)	(22.2 – 28.3)	(2.09 – 2.98)	(2.35 – 3.15)	(1.34 – 1.72)	(1.52 – 1.85)
28	22.5 ± 2.3 [a]	19.9 ± 2.7 [b]	2.3 ± 0.31[b]	2.7 ± 0.39[a]	1.30 ± 0.04[b]	1.60 ± 0.07[a]
	(18.5 – 26.9)	(15.9 – 22.2)	(2.06 – 2.85)	(2.53 – 3.08)	(1.25 – 1.62)	(1.50 – 1.80)
42	18.9 ± 3.70 [a]	16.1 ± 1.60 [b]	2.3 ± 0.24[b]	2.7 ± 0.22[a]	1.4 ± 0.04[b]	1.5 ± 0.08[a]
	(16.4 – 22.9)	(14.8 – 18.8)	(2.03 – 2.71)	(2.51 – 3.08)	(1.30 – 1.66)	(1.45 – 1.75)

Number with the same superscript within the same parameter and row are not significantly different (P> 0.05)

Normal plasma Ca levels in goats range from 2.23 to 2.93 mmol/l (Kaneko, 1989) and Pi levels range from 1.29 to 1.89 mmol/l (McDowell, 1992). Plasma Ca and Pi were within the normal range in both groups of goats (Table 1). However, plasma total Ca and Pi were high ($P < 0.05$) in the control group when compared to Zn supplemented goats in both seasons. It is possible that Zn supplementation had an influence on plasma Ca and Pi levels. This may be due to element interactions, which is said to occur between Zn, Ca, and P. A high level of Ca or P or Zn reduces the efficiency of absorption or utilization of the other element (McDowell, 1992). The addition of Zn to an otherwise adequate diet had been reported to decrease plasma Ca (NRC, 1980) which might be the case in this study. It has been demonstrated that large intake of Zn interferes with the absorption of phosphorus by forming insoluble phosphates hence reducing the amount of plasma Pi (Bondi, 1987). In conclusion, Zn supplementation should be given with cautions to goats which receive

adequate Zn in the pastures and other areas with similar problems when low Ca and P are suspected.

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