

Calcium and Phosphorus Supplementation in Grazing, Lactating Zebu Cows, in Iringa District, Tanzania

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Abstract

The effects of dietary supplementation with dicalcium phosphate containing 10 g calcium and 8 g phosphorus, on plasma total calcium, inorganic phosphate, body condition score and milk yield were studied for 42 days, during the dry season of 1997 in forty grazing, lactating Zebu cows, in Iringa region, Tanzania. The animals were allocated to two groups, one control group (T1) comprising of fifteen cows and a supplementation group (T2) comprising of twenty five cows. Dicalcium phosphate supplementation was done twice per week. Blood samples were collected before supplementation and at the end of experimental period. Total milk yield and body condition of the animals were also recorded. Supplemented cows had higher ($P < 0.001$) mean plasma calcium and inorganic phosphate (1.30 mmol/Ca and 2.08 mmol P/l) than the control cows (1.08 mmol/Ca and 1.58 mmol P/l). Supplemented cows, had a better ($P < 0.0001$) body condition score and produced more milk (3.10 BCS and 181 kg) than control cows (2.63 BCS and 149 kg) and total 42 days milk yield (149 vs. 181 kg). It is concluded that low plasma calcium and inorganic phosphate may be a problem to Zebu cows and that dicalcium phosphate can provide a boost to plasma Ca and Pi during the dry season.

Keywords: Calcium, phosphorus, body condition, milk yield, Zebu cows

Introduction

Livestock production in most parts of Tanzania relies mainly on natural pasture during the rain season and stubble grazing with occasional supplementation with crop residues and by products during the dry season. It is known that most tropical forages are poor in quality in terms of metabolisable energy (ME) and rumen degradable

proteins (RDP). They are also frequently low in minerals, especially phosphorus (P) and sulphur (S), which are needed for optimum microbial fermentation and rumen protein synthesis (Van Houtert, 1993). Supplementation with energy, protein and minerals to animals given low quality tropical grasses should enhance fermentation and hence productive efficiency.

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Calcium and phosphorus are marginally to deficient in soil, pasture and animal tissues in some areas of Tanzania (Sendalo *et al.*, 1988; Phiri *et al.*, 1997; Phiri 2001). The situation may contribute to poor livestock health and low productivity (Kasongo *et al.*, 1997). A study of mineral contents in forages at ASAS Dairy Farm in Iringa region, Tanzania by Pereka and Phiri (1998) revealed that forage Ca contents (0.38%) was marginal to minimal (< 0.30%). Similarly forage P level (0.18%) was below normal levels (> 0.25%) during the dry season. Phiri *et al.* (1997) working with mixed cross bred Zebu at the same location reported low concentration of plasma calcium (Ca) and inorganic phosphate (Pi) in pregnant heifers (2.14 and 1.23 mmol/l), in dry pregnant cows (2.14 and 1.28 mmol/l), in lactating cows (2.20 and 0.94 mmol/l) and in steers (1.90 and 1.80 mmol/l), respectively towards the end of rainy season. These levels were below the recommended levels of Ca (> 2.20 mmol/l) and Pi (> 1.80 mmol/l) in dairy cattle. There is limited information on mineral nutrition particularly in supplementation trials in lactating Zebu cattle. This study was therefore undertaken to determine Ca and P status of lactating Zebu cows under extensive husbandry conditions with or without dry season dicalcium phosphate (DICAP) supplementation.

Materials and Methods

Experimental site

The experiment was carried out at Kilimanihewa and Igingilanyi villages near Iringa airport, 12 to 17 km from Iringa town which is located at 7° 48' S and 35° 43' E. The climate of the area is characterised by dry (June – mid November) and rainy (Mid November – May) seasons. The present study covered 42 days, from August to September 1997. Day temperatures during the study ranged between 10–15°C.

Experimental design and treatments

The study involved 40 lactating Zebu cows in their second to fourth lactation. These cows calved between end of March and July 1997. Fifteen cows were selected from one herd at Kilimanihewa (Herd 1). Twenty five cows were

selected from two herds at Igingilanyi that, 10 cows from one herd (Herd 2) and 15 cows from the second herd (Herd 3). The animals were allocated to two groups, one control group (T1) comprising of fifteen cows, five from each herd and a supplementation group (T2) comprising of twenty five cows, ten cows from herd (Herd 1) at Kilimanihewa, five (Herd 2) and ten (Herd 3) cows from the two herds at Igingilanyi. Dicalcium phosphate supplementation started immediately after first blood samples were taken. Each cow in the supplementation group received 43 g of DICAP ($\text{Ca}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$) every Tuesday and Friday morning (9.00 to 10.00 a.m) an amount to cover maintenance and replace minerals lost in milk. This specification was based on the fact that cows were producing an average 3 to 6 kg of milk per day during the experimental period and approximately 1 g of Ca and 0.8 g of P is retained in 1 kg of milk (NAS, 1988). The mineral compound was mixed with 350 ml of water and administered through the mouth using a long necked bottle.

Experimental animals management

All animals were on grazed natural pastures and crop residues (maize stoves) for the first two weeks. Cows in Herd 2 and Herd 3 were sometimes grazed together. These cows were grazed on pastures from 9.00 a.m. to 6.00 p.m. with a rest of 1-2 hours (around 1.00 to 3.00 p.m) and watered once a day. The average grazing orbit was 10 km/day and at night the animals were kept in corrals. Regular visit and inspections by ward veterinarian for the period of the study was provided, particularly during mineral drenching and dipping. Dipping was done once a week and no measures were taken to control internal parasites.

Blood sampling

Blood samples were collected via the jugular vein from each animal on the first and last day of the experiment into heparinised vacutainer tubes. The whole blood samples were centrifuged within two hours after collection at 2000 x G. for 10 minutes to obtain plasma for total Ca and Pi determinations. All tubes used for collection of plasma were washed in a dilute nitric acid solution to prevent exogenous mineral contamination. The plasma samples were stored at tem-

perature between 15°C and 20°C pending analysis.

Body condition score and milk yield

Body condition was scored as described by Wilderman et al. (1982) with slight modification using a scale from 1 (very poor) to 5 (grossly fat), with half point intervals determined by assessment of the degree of fatness at the tail head and loin. Milk yield from the first day of experiment to the last day of experiment was recorded daily.

Laboratory analyses

Plasma total Ca was assayed using hydroxyquinoline cresolphthalein complexone method as described by Kessler and Wolfman (1964) and Gitelman (1967). Plasma Pi was assayed using measurement of the vanadophospho-molybdate complex formed in acid as described by Fiske and Subarow (1925). Intra assay precision was 1% (CV) for Ca and Pi, respectively. Inter assay precision was within 2% (CV) for both determinations. A standard control sample (2.5 mmol Ca/l) was analysed together with each test sample batch to assure further precision of analytical level and accuracy of the measurements.

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Statistical Analysis

Data were handled statistically using general linear model of SAS (SAS 1990). The design was a case control study and differences between the means were estimated by the least significant difference test (LSD) as described by Box et al. (1978).

Results and Discussions

Data on plasma total Ca and Pi before and at the end of the experiment are presented in Table 1, whereas the results of body condition score and total milk yield for 42 days are presented in Table 2. Cows receiving dicalcium phosphate had higher ($P < 0.05$) overall plasma total Ca (1.30 vs. 1.03 mmol Ca/l), plasma inorganic phosphate (2.08 vs. 1.58 mmol P/l), BCS (3.10 vs. 2.63) and total milk yield (181 vs. 149 kg).

It is well known that homeostatic mechanisms maintain blood Ca concentration within a range of 2.25 to 2.70 mmol/l (Kaneko, 1989).

Table 1: Mean \pm SD of plasma total calcium (Ca) and inorganic phosphate (Pi) as affected by mineral supplementation

Herd	Group	N	Plasma calcium (mmol/l)		Plasma inorganic phosphate (mmol/l)	
			Before	After	Before	After
Herd 1 Kilimahewa	T1	5	1.20 \pm 0.10 ^a	1.06 \pm 0.10 ^a	1.87 \pm 0.10 ^a	1.77 \pm 0.21 ^b
	T2	10	1.20 \pm 0.11 ^a	1.31 \pm 0.25 ^a	1.75 \pm 0.15 ^a	2.19 \pm 0.12 ^a
	Pr > F		0.9958 NS	0.0235	0.8652 NS	0.0001
Herd 2 Igingilanyi	T1	5	1.04 \pm 0.09 ^a	0.96 \pm 0.07 ^b	1.64 \pm 0.05 ^a	1.44 \pm 0.06 ^b
	T2	5	1.11 \pm 0.12 ^a	1.32 \pm 0.18 ^a	1.63 \pm 0.13 ^a	2.07 \pm 0.17 ^a
	Pr > F		0.8569 NS	0.0012	0.9987 NS	0.0001
Herd 3 Igingilanyi	T1	5	1.13 \pm 0.19 ^a	1.03 \pm 0.10 ^b	1.68 \pm 0.12 ^a	1.51 \pm 0.16 ^b
	T2	10	1.15 \pm 0.14 ^a	1.30 \pm 0.20 ^a	1.67 \pm 0.11 ^a	1.89 \pm 0.20 ^a
	Pr > F		0.8964 NS	0.0005	0.9876 NS	0.001
Overall mean	T1	15	1.13 \pm 0.19 ^a	1.03 \pm 0.10 ^b	1.73 \pm 0.14 ^a	1.58 \pm 0.21 ^b
	T2	25	1.15 \pm 0.14 ^a	1.30 \pm 0.20 ^a	1.69 \pm 0.14 ^a	2.08 \pm 0.19 ^a
	Pr > F		0.8964 NS	0.0008	0.8915 NS	0.0001

Means within the same column and herd, with the same superscript letter are not significantly different at ($P < 0.05$), NS=Non Significant

Table 2. Mean \pm SD of body condition score total milk yield for 42 days as affected by mineral supplementation

Herd	Group	N	Body condition Score		Total milk yield For 42 days (L)
			Before	After	
Herd 1 Kilimanihewa	T1	5	2.70 \pm 0.27 ^a	2.70 \pm 0.27 ^b	152 \pm 26 ^b
	T2	10	2.80 \pm 0.26 ^a	3.05 \pm 0.37 ^a	182 \pm 31 ^a
	Pr > F		0.6974 NS	0.0124	0.0013
Herd 2 Igingilanyi	T1	5	2.90 \pm 0.22 ^a	2.70 \pm 0.27 ^b	159 \pm 22 ^b
	T2	5	2.75 \pm 0.26 ^a	3.10 \pm 0.21 ^a	192 \pm 17 ^a
	Pr > F		0.6485	0.0235	0.0001
Herd 3 Igingilanyi	T1	5	2.70 \pm 0.27 ^a	2.50 \pm 0.35 ^b	137 \pm 29 ^b
	T2	10	2.80 \pm 0.27 ^a	3.20 \pm 0.27 ^a	171 \pm 16 ^a
	Pr > F		0.8973	0.0015	0.0001
Overall mean	T1	15	2.80 \pm 0.25 ^a	2.63 \pm 0.30 ^b	149 \pm 29 ^b
	T2	25	2.78 \pm 0.25 ^a	3.10 \pm 0.29 ^a	181 \pm 29 ^a
	Pr > F		0.9432	0.0001	0.0001

Means within the same column and herd, with the same superscript letter are not significantly different at ($P < 0.05$).

The present study, however, demonstrates that the initial plasma Ca was below this level i.e. 1.14 mmol Ca/l. At the end of the experimental period the level of blood Ca was even lower (1.03 mmol Ca/l) in the unsupplemented cows. The observed plasma Ca levels in the present study are low as compared to 1.36 – 2.17 mmol Ca/l observed by Phiri *et al.* (1997) in July 1997 in crossbred Zebu cattle. However, animals in the latter study were receiving 4 kg of maize bran/sunflower seedcake, approximately 2 kg of hay and 2 kg of green cut fodder per day in addition to grazing. Similar low levels of plasma Ca have been observed in non-paretic postparturient Holstein cows in Canada (Bigras-Poulin and Tremblay, 1998).

There is no obvious explanation for the present extremely low levels in plasma Ca during this dry period. It is possible that at the beginning of the dry season, plants and plant parts of high nutritive value are preferably ingested. When the dry season intensifies animals ingest leaves from trees and shrubs, which are, lower in nutrients and may contain antinutritive factors. The present extremely low plasma Ca levels did not affect the clinical condition of the cows more than the observed loss of body condition and reduced milk yield.

In the present study the initial Pi levels were marginal to deficiency since levels between 1.80 to 2.90 mmol Pi/l (Kaneko, 1989) are considered normal. However, the present levels of plasma Pi are similar to the findings of Phiri *et al.* (1997) in crossbred Zebu cows and cross bred-Zebu steers receiving concentrate mixture. Furthermore, the initial Pi levels are comparable to findings in countries such as Venezuela (1.74 – 2.10), Chile (1.5 – 1.7) and Thailand (1.7 – 1.8 mmol Pi/l), where cross bred Zebu are common (Whitaker *et al.*, 1999). Increase in plasma Pi levels following P supplementation have formally been reported in Zebu cattle grazing fertilized pastures in Kenya (Lumpkin *et al.*, 1961) and in cattle grazing pasture grown on calcareous soils in South Africa (McDowell, 1992), in agreement with present study.

In the present study supplemented animals increased daily milk production between 0.25 l to 1.5 l as compared to unsupplemented which reduced 0.5 to 1.0 l milk per day at the end of the study indicating the importance of Ca and P supplementation. Similarly Bisschop (1964) reported a response in milk yield in cows as a result of P and Ca supplementation in the form of bone meal at Armoedslakte South Africa.

Furthermore, Sheehy *et al.*, (1948), as quoted by Hemingway (1967), provided a phosphorus supplement to cows grazing P deficient grasses 3 months after calving. They observed a clear increase in milk yield per day.

Although energy and protein are usually considered to be the main limiting factors of low intake and poor performance, the present study indicates that, mineral deficiencies can also limit production and health status. The present study revealed that feeding of dicalcium phosphate had a significant effect on plasma total Ca and Pi, body condition and milk yield. The supplemented cows gained more body condition and produced more milk, whereas their contemporaries lost condition, produced less milk and their plasma Ca and Pi were lowered.

Conclusion

Supplementation with calcium and phosphorus may be necessary in certain regions of Tanzania to improve milk yield. There is little knowledge concerning mineral status of animals under both semi-extensive and extensive management systems practised by traditional herdsmen and small dairy farmers in Tanzania. There is therefore need to carry out further research of mineral status of animals in these areas.

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