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Effects of Mineral Supplementation on Milk Yield of Free-ranging Camels (*Camelus dromedarius*) in Northern Kenya

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ABSTRACT : The effects of different mineral supplementations on the milk yield of free-ranging Somali camels were investigated in two phases in a semi-arid region of northern Kenya during the dry and wet seasons in 2002 and 2003. In phase 1, twelve (12) lactating camels were selected at random to form four (4) groups each consisting of three camels. The first group served as the control and as a result received no mineral supplementation. In addition to the control diet the other groups received oral doses of minerals as follows over a 60-day period: T1 (P), T2 (High Cu low Co) and T3 (Low Cu high Co). The daily milk yield and blood mineral profiles were measured during the wet and dry seasons. The mean daily milk yield increased from 3.4 L/d to 4.3±0.3 L/d and 5.2 L/d in the dry and wet seasons, respectively. Fifteen (15) lactating camels were selected at random to form five groups each consisting of three replicates. The control group did not receive any mineral supplement. The other four groups in addition to the control diet, received the following treatments: T4 (Common Salt), T5 (High Co), T6 (High Co+P) and T7 (Low Co+P). Mineral supplement T6 produced significantly higher milk yield (5.4±0.5 and 6.5±0.7 L/d) during the dry and wet seasons. Both T6 and T7 had significantly higher milk yield than T4 and T5. During both phases, the blood Ca and P level significantly increased in camels receiving T1, 6 and 7. Animals that received only the trace mineral supplements had lower blood P compared to the ones receiving supplementary P and also the control. Supplementation of lactating camels with Co and P significantly ($p<0.05$) increased milk yield). Effect of common salt, commonly given by farmers, on milk yield was insignificant. It was concluded that mineral supplementation to lactating camels was beneficial, and that mineral supplements should include P and Co. Further research is required to establish P and Co requirements of lactating camels. (**Key Words :** Camel, Minerals, Milk Production, Blood)

INTRODUCTION

In semi-arid regions of northern Kenya, livestock rearing is still the best investment despite frequent severe droughts. Pastoralists in northern Kenya keep camels as storage of wealth and for milk and meat production. Camels play a key role in the livelihood, investment and food security, this being especially true for old women and men and children who cannot follow cattle, sheep and goats across boarders in search of pastures. During the long drought (1998-2000), only camels and donkeys remained with the pastoralists' families, while cattle, sheep and goats were taken to Uganda, Ethiopia and other far pastures. Most of the nomadic tribes in northern Kenya depend on camel milk for survival due to the ability of camels to thrive in extremely arid environments. In some ranches in Laikipia and Isiolo, they market the milk in major towns like Nanyuki and Nairobi. This has proved useful and economical. There are now small dairy plants being developed in several regions of northern Kenya to promote commercial camel milk production by the Kenyan Government, aided by the European Union. Utilization of fresh and sour milk is the mainstay of these communities because the amount of milk produced by camels is higher compared to that of zebu cattle (Karue, 1998).

Camels continue to produce milk during very dry periods when cattle and goats are barely surviving. However, milk production and calf growth rates in camels are generally low, which is attributed to an insufficient access to water and/or to the consumption of forages low in protein, energy and minerals. In most parts of northern Kenya, especially Isiolo and Laikipia, pastoralists are sedenterizing and, as a result, areas covered during grazing and browsing are limited, consequently deficiencies of certain minerals like P, Cu and Co are likely. The current demand for milk calls for extra feeding and mineral

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Table 1. Mineral composition (%)of the mineral premixes supplemented to lactating camels

	Phase 1[1]			Phase 2			
	T1[2] (Complete+P)	T2 [3] (High Cu low Co)	T3 (Low Cu high Co)	T4[4] (Common salt)	T5 (High Co-P)	T6 (High Co+P)	T7 (Low Co+P)
Intake (g/d^{-1})	180	10	7	*ad libitum*	*ad libitum*	*ad libitum*	*ad libitum*
Ca	17.1					17.1	17.1
P	7.2					7.2	7.2
NaCl	26.2			100	94.6	70.4	74.3
Mg	2.5						
Mn	0.4						
Zn	0.7				1.4	1.4	1.2
I	0.05						
Cu	0.20	2.0	0.8		3.9	3.8	1.20
Co	0.005	0.5	2.0		0.09	0.09	0.03
Se	0.002	0.2			0.04	0.04	0.01

[1] Salts were dissolved in 300 ml water.
[2] T1 = *Afya Bora DairyLick*®. [3] T2 = *Unga Farm Care*® dairy premix; DCP®.
[4] T4 = Common salt (*Magadi*®), also used to supply NaCl for T5, T6 and T7; Cu and Co were supplied from carbonate salts (from Kobian®) for T3, T5, T6 and T7.
The control group had no mineral supplementation.

supplementation to promote higher yields.

Specific behavior indicating mineral deficiencies in camels has been observed (Kaufman, 1998) and investigations on the mineral status of camels in research stations and under free-ranging conditions have shown possible P, Cu and Co deficiencies (Onjoro, 2004). However, mineral requirements and status of free-ranging camels are not well documented neither are the effects of varying mineral supply on milk yields of camels. There is need to investigate the effects of supplementing P, Cu and Co at various levels on milk yield and mineral levels in blood and milk of free-ranging lactating camels in northern Kenya. This study was designed to establish the effects of mineral supplementation on milk yields of free-ranging camels. The information generated will be essential in forming mineral supplements for lactating camels in order to alleviate mineral deficiency and hence increase milk production.

MATERIALS AND METHODS

Location and climate

The experiment was carried out at Gudas Field Station of Kenya Agricultural Research Institute (KARI) in the semi-arid lands of Marsabit district of northern Kenya. The field station has an annual rainfall of between 150-350 mm (Bake, 1983). The station has a borehole, which forms a permanent source of water. Camels were watered once every week. The station has a large open grazing field predominated by scattered *Acacia seyal, Acacia gerardii*, *Euclea schimperi, Rhus natalensis, Grewia tembensis, Indigofera spinosa*, *Salvadora persica* and *Setaria sativa, Hyperrhenia spp.* and *Cynadon dactylon* grassland.

The feeding trials were carried out between August 2002 and January 2003. The experimental period covered two short dry seasons and four wet months. During this period, the area received rains at the end of September spreading to October (32 ml rainfall), and the normal short rains starting in December, and spreading to January (37 mm). The dry seasons (August and November) received no rains. Daily temperatures were 25°C-37°C.

Animal management

The camels were managed under the traditional system, adapted from the Rendille, one of the camel pastoral communities. Camels were allowed to go browsing between 6.00 and 9.00 a.m. after the morning milking depending on weather. During the dry season, they left earlier because they had to travel long distances (sometimes over 5 km). Camels then came back between 6.00 and 7.00 p.m. for evening milking and to rest overnight. During the night the animals were kept in a corral, an enclosure made from thorny wood branches, commonly called *boma*. Camels were taken to watering site (bore hole water) on a weekly basis. Hand-milking was done twice every day at 6.00 a.m. and 6.00 p.m. Calves were used to stimulate milk let-down, and thereafter left to suckle their dams for at least 4 h during the night and 1 h in the morning. Calves remained behind when the dams went to browse. They were also let into nearby shrubs to feed.

Experimental procedure

Fifteen healthy-looking breeding camels (≈450 kg) in second parity, being in the second to fourth month of lactation were selected. They were divided into treatment groups of three camels, each selected at random. All animals were drenched with an antihelminthic (Mebendazole) and kept on normal grazing pastures with no additional feeds for the whole experimental period. Animals in the control group were not given mineral supplements,

Table 2. Mean daily milk yields of lactating free-ranging camels supplemented with oral doses of minerals and trace elements (Phase 1)

Treatment	Milk yield (L/d)			Difference to initial milk yield (L/d)	
	Initial	Dry season	Wet season	Dry season	Wet season
Control	3.2	3.3±0.1 [b]	3.4±0.2 [c]	0.1±0.1 [b]	0.3±0.3 [b]
T1 (Complete+P)	3.4	3.4±0.1 [b]	4.4±0.4 [b]	0.0±0.1 [b]	0.9±0.3 [a b]
T2 (high Cu, less Co)	3.5	3.4±0.0 [b]	4.0±0.3 [b]	0.0±0.1 [b]	0.5±0.3 [b]
T3 (high Co, less Cu)	4.0	4.6±0.1[a]	5.5±0.4 [a]	0.5±0.1 [a]	1.4±0.4 [a]
Herd mean	3.4*	3.4±0.2 [b]	4.3±0.3 [b]	0.2±0.1 [b]	0.7±0.2 [b]
SEM		0.24	0.17	0.16	0.16

n = 24 (3 animals per treatment for 8 weeks); T1-T3 = Treatments; * Initial herd mean calculated from 1 year's records.
Means with different superscripts in the same column are significantly different ($p<0.05$).

Table 3. Mean daily milk yields, milk gains of lactating free-ranging camels given mineral supplements (Phase 2)

Treatment	Milk yield (L/d)			Difference to initial milk yield (L/d)	
	Initial	Dry season	Wet season	Dry season	Wet season
Control	4.7	4.6±0.1 [ab]	5.6±0.1 [a]	-0.1±0.1	1.0±0.1[b]
T4 (NaCl)	4.5	4.1±0.4 [b]	4.5±0.5[b]	-0.1±0.4	0.3±0.2[b]
T5 (high Co)	4.7	3.5±0.3 [bc]	3.7±0.1[b]	-0.2±0.4	-0.1±0.2[b]
T6 (high Co + P)	5.0	5.4±0.5 [a]	6.5±0.7 [a]	0.5±0.2	1.6±0.2 [a]
T7 (Low Co + P)	3.9	4.5±0.3 [a b]	5.5±0.2 [a]	0.8±0.2 [a]	1.8±0.2 [a]
Herd mean	4.5	4.4±0.2	5.2±0.2	0.2±0.1	0.9±0.2
SEM		0.25	0.36	0.17	0.24

n = 24 (3 animals per treatment for 8 weeks).
Means with different superscripts in the same column are significantly different ($p<0.05$).

while animals in the experimental groups received varying amounts of mineral supplements (Table 1). The experiment comprised two phases of 60 and 120 days, respectively. A two-week preliminary period was allowed before data collection.

In phase 1, four groups of three animals were used: three groups received mineral supplementation (treatment 1 to 3), while one group served as the control. The experiment was carried out from early August 2002 to early October 2002. For T1, T2 and T3, 180, 10 and 7 g of the mineral mixtures, respectively, were dissolved in deionized water (300 ml) and given to the animals individually in glass bottles on a daily basis at 6.00 p.m. The amounts were based on manufactures' recommendation to satisfy a dairy cow yielding 10 kg milk per day. This was done for 60 days that included a totally dry month and one wet month. Daily milk yield was measured (Onjoro, 2004). The difference in mean daily milk yield between the previous week and the initial milk yield was used to estimate the increase in milk yield. Samples of milk and blood were collected at the beginning of this experiment and thereafter every two weeks and analysed for Ca and P (AOAC, 1990). Only samples collected after two weeks and those collected at the end of the experimental period were analysed for minerals.

Phase 2 involved four treatments and one control, each having three camels. For this experiment (Treatment 4 to 7), mineral supplements were prepared with NaCl (common salt) as the base (Table 1). Camels were trained to lick the minerals provided *ad libitum*. The camels that were denied water for six days, were given it in containers that contained minerals. After two days the camels could recognise the minerals in the containers. From that time on, the camels licked the minerals at will. A 10-day training and adaptation period was given prior to the sampling and milk yield records. Data collection was done for four months beginning October 2002 to the end of January 2003. Daily milk yield, blood and milk samples were taken as in phase 1. Milk yield data are presented as means and compared for significant differences. These means were also correlated with the mineral contents of blood and milk.

RESULTS

Milk yield

In phase 1 of the experiment, mean milk yield of all animals increased from 3.4 L/d to 4.3±0.3 L/d in the dry and wet seasons (Table 2). Camels tended to produce more milk in the wet season compared to the dry season. Mineral supplementation to dairy camels did affect milk production. In Phase 1 it was observed that animals receiving high doses of Co produced significantly higher milk than the other animals. Although these animals already had the highest yield at the beginning of the experiment, addition of Co improved milk yield in the dry season by 15%. In the wet season, this effect was then intensified. The addition of other mineral supplements had no significant effect.

In phase 2 of the feeding trial, the initial means of milk yield were calculated from the proceeding month, which was a wet season, and consequently the mean was higher than in phase 1 (Table 3). Camels in treatment 6 (T6, high

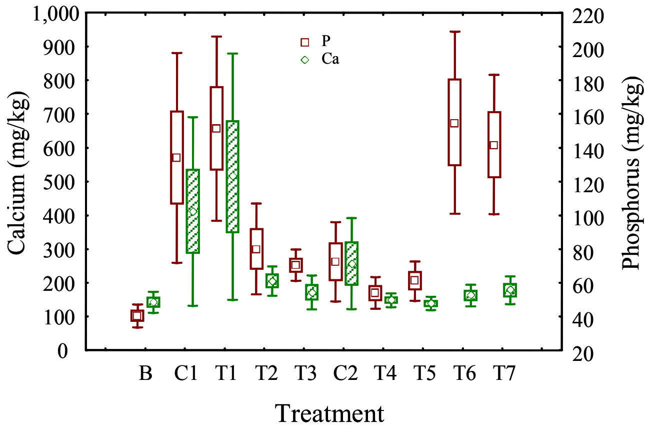

Figure 1. Mineral concentrations in blood serum of experimental camels in phase 1and 2. B = Mineral content at the start; C1 and C2 = Controls in Phase 1 and 2, respectively; T1-T7 = Treatments (see Table 1).

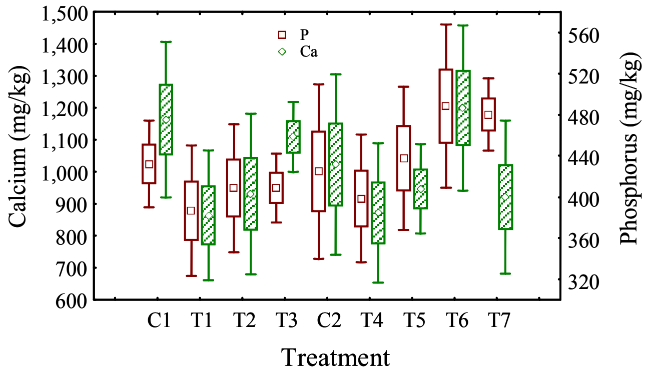

Figure 2. Mineral concentrations in milk of experimental camels in phase 1 and 2. C1 and C2 = Controls in Phase 1 and 2, respectively; T1-T7 = Treatments (see Table 1).

Co+P) produced significantly higher milk yield (5.4±0.5 and 6.5±0.7 L/d) throughout the whole experimental period. The fact that camels in treatment 7 (T7, low trace minerals +P) had higher milk gain (0.8±0.2 and 1.8±0.2) in the drier months of this study is due to the lower initial performance of this group. In the wet season both treatments 6 and 7 had significantly higher milk yield than treatments 4 and 5. They also had larger differences for initial milk yield in both the dry and wet seasons (Table 3). During the dry season the mean milk yield of all experimental animals remained the same, but tended to increase from 4.3 to 5.2 L/d in the wet season.

Contrary to supplementation of P and Co, inclusions of NaCl did not improved milk yield. Supplementation of low levels of Co induced better performance over the whole experimental period. Supplementation with Co also improved milk yield recovery at the end of the dry season and also moderated milk yield loss when the conditions deteriorated.

Mineral concentration in blood and milk

During phase 1, the blood Ca and P level significantly increased in camels of treatment 1, which received a mineral pre-mix containing P and Ca (Figure 1). This did not have a significant impact on milk P over this period (Figure 2). During phase 2, P and Ca also significantly increased in the blood of animals that received the P supplement (treatment 6 and 7). In both phases 1 and 2 the animals that received only the trace mineral supplement had lower blood P than the control, and that the control had surprisingly high value of P.

DISCUSSION

The number of camels used per treatment was only three because it was very difficult to find a station or a ranch that had a higher number of lactating camels. This is acceptable number for statistical analysis, however it is too small to cover animal influence on milk yields.

The recorded mean daily milk yield of un-supplemented KARI camels in Gudas is about 3.2 L/d. This is comparable to the mean for the research camels of 3.4±0.2 L/d at the beginning of this experiment. Recorded milk yields were also similar to those recently reported for Somali camels in Ethiopia (Bekele et al., 2002). Seasonal effects on milk yield were observed with the rainy season having more milk yield than in the dry season.

The results, once again, appear to have been influenced by nutritional status of the forages, when the rains came in. The fact that some camels received 300 ml water during the oral dosing of minerals may also have put them at an advantage. Generally, mineral supplementation seemed to increase milk yield and serum mineral parameters unlike earlier suggestion by Vittorio et al. (2001). Increase in milk yield in this study for lactating free-ranging camels which received mineral supplements that contained P and Co is in agreement with the findings obtained from dairy cattle studies (Shamra et al., 2002). They reported increases in milk yield, and other blood parameters when they fed mineral supplements that contain Ca, P and Mg. The same has been reported for Cu (Han et al., 2000) and Co (Brzoska, 2001) with subsequent increases in serum and milk Cu and Co. It also resulted in increased milk yield in cattle. Several reproductive parameters including fertility were reported to improve. In the study of Han et al. (2000) Cu was supplemented to cattle at 3.2 mg/kg, among other trace minerals including Se and I and resulted in improved milk yields. Results similar to these have been reported for P (Wu et al., 2000). In an experiment by Argunov et al. (1991), P supplementation increased milk yield by more than 1.9 L/d in cattle with also an increase in blood concentrations of P and Ca.

The positive response in milk yield after supplementation of P, Cu and Co, led to the conclusion that the elements were deficient. Mineral supplementation has been shown to be very successful for Ca and P (Schonewille et al., 1994: Yamagishi and Naito, 1997). Increases in dietary P was reported to linearly increase serum concentrations of inorganic P, while decreasing serum Ca and Mg (Knowlton and Herbein, 2002). Copper supplementation to camels has also been reported to increase serum Cu (Essamadi et al., 1998). Mineral supplementation improves growth rates (Hammadi, 1995) and reduces the interval between successful parturition. Copper supplementation in cows improves calving interval, calf serum levels and weaning parameters. In a trial, 32 young camels (less than 2 years old) were supplemented with copper in four groups of eight each receiving mangrove basal diet *ad libitum* (Faye et al., 1992) and/or a concentrate rich in protein and energy. Food intake of mangrove was slightly improved with mineral supplementation. Copper supplementation resulted in increased growth performance of the calves. Cobalt has not been studied in camels.

The results from this feeding trial indicate that milk production of camels can be improved by dietary supplementation of P and Co. Copper supplementation has also been reported to increase milk production. In a study by Sviatko et al. (1991), milk production significantly increased when dairy cows were supplemented with trace elements including Cu, Mn and Zn. Faye et al. (1992) supplemented Cu and Zn in drinking water, against a basal diet of mangrove *Avicennia marina* which is poor in some trace elements such as Cu, Zn and Mn. Supplementation increased plasma Cu concentration up to normal levels (<70 μg 100 ml). In the current experiment Ca and P levels were also improved during the supplementation period. A high interaction between mineral absorption and quality of the diet was observed.

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