

International Journal of Agriculture Extension and Social Development

Volume 9; SP-Issue 2; February 2026; Page No. 90-94

Received: 14-11-2025
Accepted: 18-12-2025

Indexed Journal
Peer Reviewed Journal

Efficacy of mineral mixture and salt supplementation on serum mineral profile in pica affected camels

¹MK Dhaka, ²FC Tuteja, ¹Sunita Choudhary, ¹AP Singh, ¹JP Kachhawa and ³Rajesh Nehra

¹Department of Veterinary Clinical Medicine, Ethics and Jurisprudence, CVAS, Bikaner, Rajasthan, India

²ICAR-National Research Centre on Camel, Jorbeer, Shivbari, Bikaner, Rajasthan, India

³Department of Animal Nutrition, CVAS, Bikaner, Rajasthan, India

DOI: <https://doi.org/10.33545/26180723.2026.v9.i2Sb.3081>

Corresponding Author: MK Dhaka

Abstract

The present study was carried out to measure serum mineral profile status in pica affected camels and its changes after supplementation of mineral mixture with salt in these camels. The proposed study was carried out at an organized camel herd at NRCC, Bikaner. After that 18 severely pica affected camel were selected and divided into 3 groups to evaluate responsiveness of treatment, mineral mixture (group A) and mineral mixture with common salt (group B) and untreated control group (group C) camels. Blood samples were collected each 15 days of interval up to 60 days for mineral profile. The mean value of total P, Zn, Cu, Fe and Mg that was initially low tend to increase in both treatment groups whereas Na was decreased and tend to stabilized at 60th days in both treatment groups. However, salt treated group was shown better in serum minerals values over another treated group. However additional salt supplementation was observed over mineral supplementation found better results.

Keywords: Pica in camels, serum mineral profile, mineral mixture and common salt

Introduction

The global camel population, spread across 47 countries. About 83 percent of the camel population inhabits mainly the Eastern and Northern Africa and the rest are present in the Indian subcontinent and Middle East (FAOSTAT, 2015) [13]. Camel herders in India rear their camels under traditional grazing with zero inputs (Sahani, 2003) [28].

Pica is a depraved or abnormal appetite. Complete mechanism of pica has not been understood yet; it has been known to be associated with parasitism and deficiencies of phosphorus, salt and protein (Smith, 2015) [32]. Minerals like copper, zinc, and cobalt, has been implicated in the aetiology of pica and fleece dietary pattern in sheep (Fahmy *et al.*, 1980) [12]. Camels are not simply tolerant to salt ingestion but they are positively craving this substance actively eating it in any form and even drinking sea water on their own free will when salt supplementation is not available (Dioli, 2018) [7].

According to camel pastoralists salt is reputed to have beneficial effect on the general wellbeing and fertility of camels and on their skin condition and for these reasons camel herds are periodically driven to graze pastures of salty plants: saltbush or halophytes (Gauthier-Pilters and Dagg 1981; Mandaville 2004) [18, 25].

Materials and Methods

The proposed study was carried out at an organised camel herd at, Bikaner. A total of about 44 male camels in the age group of 2-4 years were examined for eating of non-feed

items. Out of these camels 18 were selected for the present study.

Selection of the 18 male camels of 2-4 years age group, which were found for eating non-food items. all the selected 18 male camels were divided into three groups comprising six animals in each group. In this trial six animals of group-A were fed with specially designed mineral mixture daily at the rate of 30 gram per animal per day mixed with fodder for two month, six animals of group-B were fed mineral mixture 30 gram + 20 gram common salt per animal per day mixed with fodder for two month, whereas six animals of group-C were fed with same basal fodder for two months.

The composition of the prepared mineral mixture per 100 kg was as follows

Dicalcium phosphate ($\text{Ca}_2(\text{PO}_4)_3$) = 59.00 Kg

Calcium carbonate (CaCO_3) = 40.50 Kg

Zinc sulphate (ZnSO_4) = 0.230 Kg

Copper Sulphate (CuSO_4) = 0.160 Kg

Manganese Sulphate (MnSO_4) = 0.030 Kg

Cobalt Sulphate (CoSO_4) = 0.050 Kg

Faecal qualitative examination was conducted to record the gastrointestinal parasitic infections in camel population on the basis of presence/absence of eggs/cysts/oocysts in the faeces by using centrifugal floatation and sedimentation techniques (Soulsby, 1982) [34].

For serum mineral status examination blood samples from these 18 camels were collected from jugular vein puncture

in sterile vacuutainers having no anticoagulant. These vacuutainers tubes were kept in slanting position for one hour at 37 °C. Blood clots of these slants were broken and tubes were centrifuged at 3000 rpm for 15 min. The serum was harvested in small Pyrex tubes and was stored in the deep freeze at -20 °C till analysis.

Mineral estimation was evaluated of serum calcium, phosphorus, Sodium and Magnesium were estimated to assess mineral profile of camels at various stages of treatment by colorimetric method with kits supplied by AGD Biomedicals Private limited using Smart-Spec Plus Spectrophotometer (Bio Rad). Calculations for these mineral concentrations were made as per manufacturer instructions (AGD Biomedicals).

And serum copper, zinc, cobalt, selenium and iron were estimated by Inductively Coupled Argon Plasma Spectrometer (iCAP 7000Series) model manufactured by Thermo Fisher Scientific Inc. The iCAP 7000 series is a

range of Inductively Coupled Argon Plasma Optical Emission Spectrometer (ICP-OES) which use an Echelle optical design and a Charge Injection Device (CID), solid-state detector to measure trace elemental concentrations in a wide range of samples. Serum samples were digested as per the procedure described by Kolmer *et al.* (1951)^[22].

Results and Discussion

Faecal examination of the 21 pica affected camels revealed that none of the camel was affected with heavy parasitic load. Whereas parasitic infestations were recorded in four camels, these were identified as *Trichuris* (2), *Nematodirus* (1) and *Strongyle* (1) by eggs morphology. Since no heavy parasitic infestation was recorded, therefore no special deworming was under taken.

Mineral profile

Table 1: Comparative mean $\pm$ SE values of mineral profile in healthy control group D with group A, B and C on day 0 and day 60

Parameters	Healthy animal (Group-D)	Treated group (Group-A)		Treated group (Group-B)		Untreated group (Group-C)	
		0 th day	60 th day	0 th day	60 th day	0 th day	60 th day
Minerals profile							
Ca (mg/dl)	10.67 ±0.17	10.56 ±0.36	10.69 ±0.35	10.82 ±0.24	10.68 ±0.24	10.14±0.16	10.35 ±0.26
P (mg/dl)	7.04 ^C ±0.29	4.55 ^D ±0.23	6.61 ^C ±0.3	5.14 ^D ±0.50	7.12 ^C ±0.17	5.42 ^D ±0.33	4.22 ^D ±0.25
Na (mmol/L)	152.08 ^C ±6.19	181.94 ^D ±7.09	142.78 ^C ±4.17	173.26 ^D ±3.04	145.69 ^C ±3.51	194.03 ^D ±5.78	142.5 ^C ±5.43
Zn (µg/dl)	62.92 ^C ±1.98	46.25 ^D ±2.48	57.08 ^C ±1.50	49.17 ^D ±1.24	64.58 ^C ±1.87	37.5 ^D ±2.58	46.67 ^D ±1.54
Cu (µg/dl)	33.75 ^C ±1.91	22.08 ^D ±1.19	29.58 ^C ±0.77	25.42 ^D ±0.42	28.75 ^C ±0.85	20.42 ^D ±1.19	23.33 ^D ±0.53
Fe (µg/dl)	122.92 ^C ±7.29	51.17 ^D ±2.70	95.83 ^C ±12.90	54.58 ^D ±3.44	87.08 ^C ±9.73	58.75 ^D ±2.12	32.92 ^D ±2.53
Se (µg/dl)	30.42 ^C ±1.44	27.08 ^C ±1.19	29.58 ^C ±1.36	28.33 ^C ±0.83	34.58 ^C ±1.36	25.42 ^C ±0.42	20.00 ^D ±1.12
Mg (mg/dl)	3.51 ^C ±0.15	2.28 ^D ±0.15	3.18 ^C ±0.06	2.37 ^D ±0.08	3.75 ^C ±0.17	2.67 ^D ±0.12	2.13 ^D ±0.08

Note: Mean $\pm$ SE bearing different superscript (C, D) between treated and healthy control camels differ significantly ($p < 0.05$).

In feeding trail experiment, significantly low in mean serum concentrations of phosphorus, zinc, copper, iron and magnesium were recorded in the both treated and untreated groups on day 0 (pre-treatment) compared to group-D healthy control camels. Deficiency of P in pica affected camels have been reported by Beniwal and Singh (2007)^[5] and Koted (2019)^[24]. Serum Zn levels become low in pica affected camels (Singh *et al.* 1986; Beniwal and Singh, 2007)^[31, 5]. Decreases in Mg concentrations in the pica affected camels were reported by Singh *et al.* (1986)^[31]. Comparative high Cu levels ($>60 \mu\text{g/dl}$) in healthy camels have been reported (Dongre 2000; Faye *et al.* 2005 and Dixit *et al.* 2008)^[9, 17, 8]. Decreases in serum Cu levels in pica affected camels have been reported by many researchers Singh *et al.* (1986)^[31] and Beniwal and Singh (2007)^[5]. In camels mineral supplementation increased blood Cu level (Faye and Bengoumi, 1997)^[14]. Mohamed (2004)^[26] observed an increase in Cu concentration with age. Cu concentrations were higher in rainy season than dry season.

Whereas, significant high value in mean serum sodium concentration was recorded in the both treated groups (A, B) and untreated (group C) on day 0 (pre-treatment) compared to group-D healthy control camels. Salt supplementation did not reflect positive response on serum Na concentration in

the body. The camel very high requirement of salt in his diet is probably related to these facts and by the camel physiological copying mechanisms of a specialised desert herbivore required to withstand hot temperatures and water deprivation (Shamat *et al* 2009, Babiker *et al* 2014)^[30, 2].

Whereas no significant difference was recorded in mean serum concentrations of calcium and selenium in both the treated groups A and B on day 0 and 60 (pre and post-treatment) compared to group-D healthy control camels. Also, no significant difference was recorded in mean serum concentrations of calcium and selenium in the untreated group C on day 0 (pre-treatment) and significant decrease was recorded in mean serum concentration of selenium in group C on day 60 (post-treatment) compared to group-D healthy control camels. Mean serum Ca levels within this range in healthy Indian camels have been reported by Bhatt and Kohli (1961)^[6] and Koted (2019)^[24] in pica affected camels. Recorded selenium levels in the present study falls within the normal range (Faye and Seboussi, 2009)^[16].

In the feeding treatment trial experiment, no significant difference in the mean serum calcium concentration either within or between the treated and untreated control groups was recorded. Mean serum calcium levels remained almost 10 mg/dl in every group at any stage of treatment, this indicate there was no Ca deficiency in these animals.

Table 2: Comparative mean±SE value of serum mineral in Group A, Group B and Group C at different intervals of treatment

Mineral	Treated group-A					Treated group-B					Control group-C				
	0 th day	15 th day	30 th day	45 th day	60 th day	0 th day	15 th day	30 th day	45 th day	60 th day	0 th day	15 th day	30 th day	45 th day	60 th day
Ca (mg/dl)	10.56 ±0.36	10.63 ±0.41	10.44 ±0.43	10.78 ±0.4	10.69 ±0.35	10.82 ±0.24	10.58 ±0.25	10.78 ±0.22	10.66 ±0.27	10.68 ±0.24	10.14 ±0.16	10.21 ±0.36	10.21 ±0.14	10.35 ±0.22	10.35 ±0.26
Range	9.47-11.80	9.44-11.94	9.33-11.86	9.57-12.08	9.75-11.97	10.04-11.80	9.61-11.16	10.07-11.51	9.61-11.36	9.93-11.25	9.47-10.56	9.08-11.58	9.72-10.74	9.46-10.82	9.64-11.43
P (mg/dl)	4.55 ^a ±0.23	5.52 ^{bA} ±0.18	6.1 ^{bB} ±0.16	6.44 ^{bB} ±0.26	6.61 ^{bB} ±0.3	5.14 ^a ±0.50	5.96 ^{bA} ±0.29	6.25 ^{bB} ±0.3	6.48 ^{bB} ±0.24	7.12 ^{bB} ±0.17	5.42 ±0.33	5.18 ^A ±0.34	4.97 ^A ±0.32	4.54 ^A ±0.28	4.22 ^A ±0.25
Range	3.77-5.17	4.77-6.08	5.83-6.89	5.74-7.62	5.68-7.85	3.13-6.60	5.06-7.00	5.13-7.23	5.81-7.49	6.53-7.68	4.42-6.62	4.25-6.42	4.09-6.08	3.42-5.36	3.26-4.98
Na (mmol/L)	181.9 4 ^a ±7.09	168.06 ^a ±9.28	156.6 ^b ±7.77	157.5 ^b ±7.97	142.78 ^b ±4.17	173.2 6 ^a ±3.04	157.08 ^b ±3.67	158.89 ^a ±2.58	151.74 ^b ±3.4	145.6 9 ^b ±3.51	194.0 3 ±5.78	167.5 7 ±6.9	154.38 ±2.36	150 ±6.71	142.5 ±5.43
Range	155.0-204.58	129.58-199.58	133.75-190.00	135.83-185.00	128.33-154.58	166.2-183.75	141.67-167.50	151.67-166.67	139.17-164.17	136.2-158.33	173.3-206.67	149.5-197.92	146.67-162.92	134.5-179.17	127.0-160.42
Zn (µg/dl)	46.25 ^a ±2.48	51.67 ^{bA} ±0.53	52.92 ^{bA} ±0.77	54.17 ^{bB} ±0.83	57.08 ^{bB} ±1.50	49.17 ^a ±1.24	52.08 ^{aA} ±0.77	50.83 ^{aA} ±1.24	57.92 ^{bB} ±1.64	64.58 ^{bB} ±1.87	37.5 ±2.58	50.42 ^A ±2.18	50.83 ^A ±0.83	44.17 ^A ±1.39	46.67 ^A ±1.54
Range	40.00-52.50	50.00-52.50	50.00-55.00	50.00-55.00	50.00-60.00	45.00-52.50	50.00-55.00	47.50-55.00	52.50-62.50	57.50-70.00	30.00-45.00	42.50-55.00	47.50-52.50	40.00-47.50	42.50-52.50
Cu (µg/dl)	22.08 ^a ±1.19	23.75 ^{aA} ±0.56	24.58 ^{bA} ±0.42	27.50 ^{bA} ±0.65	29.58 ^{bB} ±0.77	25.42 ^a ±0.42	24.58 ^{aA} ±0.42	25.42 ^{aA} ±1.00	27.08 ^{aA} ±1.00	28.75 ^{bB} ±0.85	20.42 ±1.19	25.42 ^A ±0.42	24.17 ^A ±0.53	25.83 ^A ±0.83	23.33 ^A ±0.53
Range	17.50-25.00	22.50-25.00	22.50-25.00	25.00-30.00	27.50-32.50	25.00-27.50	22.50-25.00	22.50-30.00	25.00-30.00	25.00-30.00	17.50-25.00	25.00-27.50	22.50-25.00	22.50-27.50	22.50-25.00
Fe (µg/dl)	51.17 ^a ±2.70	57.83 ^{aA} ±4.91	68.33 ^{aB} ±11.10	87.08 ^{bB} ±11.52	95.83 ^{bB} ±12.90	54.58 ^a ±3.44	59.92 ^{aA} ±5.35	67.08 ^{aB} ±8.62	78.33 ^{bB} ±8.53	87.08 ^{bB} ±9.73	58.75 ±2.12	49.17 ^A ±7.06	42.5 ^A ±4.33	31.25 ^A ±2.02	32.92 ^A ±2.53
Range	42.00-62.50	45.00-80.00	47.50-122.50	55.00-140.00	60.00-155.00	40.00-62.50	42.50-80.00	50.00-107.50	55.00-117.50	60.00-130.00	50.00-62.50	27.50-67.50	27.50-57.50	27.50-40.00	27.50-45.00
Se (µg/dl)	27.08 ^a ±1.19	28.75 ^{aA} ±0.85	27.50 ^{aA} ±0.65	27.92 ^{aA} ±0.77	29.58 ^{aB} ±1.36	28.33 ^a ±0.83	28.33 ^{aA} ±1.24	28.75 ^{aA} ±0.85	29.58 ^{aA} ±1.64	34.58 ^{bB} ±1.36	25.42 ±0.42	30.42 ^A ±0.42	29.58 ^A ±0.77	28.33 ^A ±0.53	20.00 ^A ±1.12
Range	25.00-32.50	25.00-30.00	25.00-30.00	25.00-30.00	25.00-35.00	25.00-30.00	22.50-30.00	25.00-30.00	22.50-32.50	30.00-40.00	25.00-27.50	30.00-32.50	27.50-32.50	27.50-30.00	17.50-25.00
Mg (mg/dl)	2.28 ^a ±0.15	2.83 ^{bA} ±0.2	2.93 ^{bB} ±0.15	3.05 ^{bB} ±0.08	3.18 ^{bB} ±0.06	2.37 ^a ±0.08	2.6 ^{bA} ±0.11	2.6 ^{bA} ±0.1	3.32 ^{bB} ±0.24	3.75 ^{bB} ±0.17	2.67 ±0.12	2.57 ^A ±0.13	2.48 ^A ±0.13	2.3 ^A ±0.09	2.13 ^A ±0.08
Range	1.86-2.76	2.02-3.46	2.57-3.54	2.88-3.30	2.93-3.34	2.06-2.60	2.28-3.06	2.34-3.06	2.59-3.96	3.08-4.17	2.26-3.11	2.22-3.01	2.16-2.94	2.01-2.63	1.89-2.49

Note: -1. Mean± SE bearing different superscript (A, B) between treated and control group differ significantly ($p < 0.05$)

2. Mean± SE bearing different superscript (a, b) within treated group differ significantly ($p < 0.05$)

In feeding treatment trail experiment, significant increase in mean serum P, Zn, Cu, Fe, Mg and Se concentration was recorded in both the treated group-A and B on various stages of 15 days interval evaluation ($p < 0.05$) post treatment compared to group-C control camels and within group comparison to pre-treatment. Whereas, significant decrease in the mean serum Sodium concentration was recorded in the treated group-A and B on various stages of 15 days interval evaluation ($p < 0.05$) post treatment compared to group-C untreated control camels and within group comparison to pre-treatment. Results of the present study shows Na was retained in normal levels to maintain electrolyte balance and absorption of Mg was inversely correlated to Na retention. Calcium levels were also within the normal ranges. The best possible reasons for this appear to be the drinking water resource of these camels was with high total dissolved solutes, ranging from 750-1820ppm. This water was found to contain calcium (60ppm) and chloride (490ppm), as per available water analysis report. High level of hardness has many ill effects on health such as

excess of calcium may affect Fe and Zn absorption from intestine Solanki, (2013) [33].

Soil phosphorus concentration is reported to have significant effect on phosphorus concentration in pasture plants and blood of grazing cattle (Gizachew *et al.*, 2002) [19]. Ca:P ratios may affect intestinal absorption of minerals (Koshihara *et al.*, 2004) [23] and exhibit depraved appetites (Sawal *et al.*, 2015) [29]. Joffe (1949) [21] mentioned that in semi desert soils potassium and P are fixed on surface layer, with irrigation some of K is released and P remains unavailable because of the excess of calcium in the soil. This might explain the possibility of P deficiency in animal in area where P content of soil was normal. This experiment was conducted during June, 2019 to August, 2019.

During this period temperature variations at the experimental station were from 47°C to 31°C. Temperature variations of the desert causing dehydration in the camel overcome the salt supplementation. Since camel homeostasis retains sodium to retain water during high temperature to overcome dehydration. This differing

response of Na retention emphasises the effect of environmental conditions (Achaaban *et al.*, 2000)^[1]. Further more sodium concentrations recorded during each and every stage of the experiment were in the normal range. In India concentration of Na in the camel serum ranged from 85.4 to 204 mEq/L (Temesgen *et al.*, 2012)^[35].

According to Haili *et al.* (2014)^[20] and Onmaz *et al.* (2018)^[27] critical diminishing of some antioxidants like glutathione peroxidase and superoxide dismutase levels in cattle was noticed with pica than normal ones and deficiency of trace elements (Ca, P, Cu, Fe, Se, Co and I) was also recorded. Which were adjusted to normal ones and beneficial in preventing deviated appetite and in strengthening the antioxidant defence system after treatment of pica with prophylactic use of these minerals.

Some studies concerning trace elements such as Cu, Zn, Fe and Mg in camel have shown specific responses to mineral supplementation or deficiencies. In general, the camel metabolism seems to anticipate mineral under-nutrition periods of its life with different mechanisms: like increase of the absorption capacity for Cu and Zn in scarcity periods (Faye *et al.*, 1999)^[15], higher storage capacity for Cu (Faye and Bengoumi, 1997)^[14], tolerance for minerals and electrolytes like Ca, P and Na in excess (El Khasmi *et al.*, 2001; Bengoumi and Faye, 2002)^[10, 3], maintenance of enzymatic activity for caeruloplasmin, superoxide-dismutase in deficient period (Bengoumi *et al.*, 1998; Essamadi *et al.*, 1998)^[4, 11]. There appears to strong supplementation deficiency of these minerals in camels to the extent that deficiency dominates the camel adoptive mechanism and this deficiency is rectified after supplementation.

Efficacy of treatment for pica in camels

Significant difference was recorded with the mineral mixture supplementation and salt supplementation before and after the treatment trail in the present study. For achieving 100 per cent efficacy with mineral mixture supplementation either period of supplementation may be prolonged or the daily dose of supplementation may be increased. The pica affected camels were feeding with specially designed mineral mixture at the rate of 50 gm per day per animal for two months was found satisfactory in improving serum mineral profiles in camels. This was also found satisfactory in terms of relieving the camels from symptoms of pica. Koted (2019)^[24] also reported satisfactory result in haemato-biochemical and serum mineral profile at the similar mineral mixture feeding in pica camels.

Conclusion

There was decrease in phosphorus, zinc, copper, iron and magnesium seen in the pica affected camels whereas, high value in mean serum concentration of sodium was recorded in the pica affected camels compared to healthy control camels. This became normal by supplementation mineral mixture and salt. Based on mineral profiles results, effect of additional salt supplementation with mineral supplementation in the pica affected camels was found better.

Acknowledgement

The authors wish in their deep sense of gratitude and all praise to the Almighty and sincerely thanks to HOD, Clinical Veterinary Medicine, Director, ICAR-National Research Centre on Camel, Bikaner and Dean, CVAS Bikaner who helped by providing support in completing this work.

References

1. Achaaban MR, Schroter RC, Forsling ML, Ouhsine A. Salt balance in camels subjected to heat stress and water deprivation under two different environmental conditions. *Journal of Camel Practice and Research*. 2000;7(1):57-62.
2. Babiker IA, Shamat AM, Mukhtar AMS, Ahmed FA. The effect of feeding natron (ATRON) as a mineral and buffering agent on the general health and production of camels (*Camelus dromedarius*). *Journal of Camel Practice and Research*. 2014;21(1):1-4.
3. Bengoumi M, Faye B. Adaptation du dromadaire à la déshydratation. *Sécheresse*. 2002;13:121-129.
4. Bengoumi M, Essamadi AK, Chacornac JP, Tressol JC, Faye B. Comparative relationship between copper-zinc plasma concentration and superoxide dismutase activity in camels and cow. *Veterinary Research*. 1998;29:557-565.
5. Beniwal BS, Singh RP. Haemato-biochemical changes in camels suffering from pica. *Annals of Agri Bio Research*. 2007;12:83-86.
6. Bhatt PL, Kohli RN. A study on the normal serum calcium level of the camel. *Indian Veterinary Journal*. 1961;38:246-249.
7. Dioli M. How much, how often and in which form should salt (NaCl) be given to a camel? In: *Proceedings of the 5th Conference of the International Society of Camelid Research and Development*; 2018 Nov 12-15; Laayounee, Morocco. 2018.
8. Dixit SK, Singh AP, Dadhich H, Sharma T, Rathod A. Biochemical and histopathological studies of sarcocytosis in camel (*Camelus dromedarius*). *Indian Journal of Veterinary Pathology*. 2008;32:59-61.
9. Dongre RA. Haemato-biochemical studies in relation to trace mineral status in camel (*Camelus dromedarius*). Bikaner: Rajasthan Agricultural University; 2000.
10. El Khasmi M, Riad F, Safwate A, Farh M, Faye B, El Abbadi N, Lalaoui Kh, *et al.* Influence de la 1, 25-dihydroxyvitamine D3 sur l'excrétion mammaire du calcium et du phosphore chez la chamelle allaitante. *Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux*. 2001;54:277-280.
11. Essamadi K, Bengoumi M, Tressol JC, Chacornac JP, Faye B. Comparative relationship of plasma copper concentration and caeruloplasmin activity of camel and cow. *Trends in Comparative Biochemistry and Physiology*. 1998;5:211-220.
12. Fahmy F, Amer AA, Abd-el-Aziz H, Abd-el-Roaf M. Wool as an effective tool of some deficiency diseases. *Assiut Veterinary Medical Journal*. 1980;7(13-14):262-270.

13. FAOSTAT. Animal production yearbook. Rome: Food and Agriculture Organization; 2015.
14. Faye B, Bengoumi M. Comparative trace-element status in camel and cow. *Journal of Camel Research and Practice*. 1997;4:213-215.
15. Faye B, Bengoumi M, Tressol JC. Comparative trace-element excretion in camel and cow. *Journal of Camel Research and Practice*. 1999;6:19-25.
16. Faye B, Seboussi R. Selenium in camel: A review. *Nutrients*. 2009;1:30-49.
17. Faye B, Seboussi R, Askar M. Trace element and heavy metals in healthy camel blood of United Arab Emirates. *Journal of Camel Practice and Research*. 2005;12(1):1-6.
18. Gauthier-Pilters H, Dagg AI. The camel: Its evolution, ecology, behavior, and relationship to man. Chicago: University of Chicago Press; 1981.
19. Gizachew L, Hirpha A, Jalafa F, Smit GN. Mineral element status of soils, native pastures and cattle blood serum in the mid-altitude of western Ethiopia. *African Journal of Range and Forage Science*. 2002;19:147-155.
20. Li H, Wang K, Lang L, Lan Y, Hou Z, Yang Q, *et al*. Study the use of urea molasses multinutrient block on pica symptom of cattle. *Journal of Animal and Plant Sciences*. 2014;21:3303-3312.
21. Joffe JS. Serozem and red semidesert soil. In: *The ABC of soil*. 1st ed. New Brunswick: Pedology Publication; 1949. p. 123.
22. Kolmer JA, Spaulding EH, Robinson HW. *Approved laboratory techniques*. 5th ed. New York: Appleton Century Crofts; 1951. p. 1090-1091.
23. Koshihara M, Masuyama R, Uehara M, Suzuki K. Effect of calcium: phosphorus ratio on bone mineralization and intestinal calcium absorption in ovariectomized rats. *BioFactors*. 2004;22:39-42.
24. Koted R. Clinico-haemato-biochemical and therapeutic studies on pica in camels (*Camelus dromedarius*). Bikaner: Rajasthan University of Veterinary and Animal Sciences; 2019.
25. Mandaville JP. *Bedouin ethnobotany: Plant concepts and plant use in a desert pastoral world*. Arizona, USA: University of Arizona; 2004.
26. Mohamed HF. The zinc and copper content of plasma of Sudanese camels (*Camelus dromedarius*). *Veterinary Research Communications*. 2004;28(5):359-363.
27. Onmaz AC, Gunes V, Çınar M, Cıtil M, Kele I. Hematobiochemical profiles, mineral concentrations and oxidative stress indicators in beef cattle with pica. *Italian Journal of Animal Science*. 2018;17:1055-1062.
28. Sahani MS, Vyas S, Deen A. Improvement in reproductive efficiency in farm camels under hot arid region. *Indian Journal of Animal Reproduction*. 2003;24(2):93-98.
29. Sawal RK, Ranjan R, Kumar S, Narnaware S, Kashinath, Dahiya SS, *et al*. Biochemical and mineral profile of dromedary camels raised under different pasture conditions of Rajasthan. *Indian Journal of Veterinary Medicine*. 2015;35(1):65-66.
30. Shamat AM, Babiker IA, Mukhtar AMS, Ahmed FA. Seasonal and regional variations in mineral content of some important plant species selected by camels (*Camelus dromedarius*) in arid and semi-arid lands of Sudan. *Journal of Applied Sciences Research*. 2009;5(10):1676-1684.
31. Singh KP, Malik KS, Sarup S. Haemato-biochemical studies in camel suffering from pica. *Indian Journal of Veterinary Medicine*. 1986;6:79-81.
32. Smith BP. *Large animal internal medicine*. 5th ed. St. Louis: Mosby Elsevier; 2015. p. 152.
33. Solanki AS. Study of various water quality parameters with reference to human health: A case study of Bikaner city of Rajasthan. *Rasayan Journal of Chemistry*. 2013;6(1):44-46.
34. Soulsby EJJ. *Helminths, arthropods and protozoa of domesticated animals*. 7th ed. London: Bailliere and Tindall; 1982.
35. Temesgen D, Mohammed YK, Beneberu S. Critical macro and micro minerals concentration in the blood serum of camel (*Camelus dromedarius*) in Jijiga district, Eastern Ethiopia. *Livestock Research for Rural Development*. 2012;24:Article 60.