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Hematobiochemical and Mineral Study of Pica in Dromedary Camels in Al-Najaf Desert –Iraq

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Abstract

THIS STUDY investigates the alterations in hematological and biochemical parameters in Dromedary camels exhibiting depraved appetite, a nutritional disorder with ongoing unclear causes. An overall, 53 dromedary camels aged 1-7, were selected and divided into two groups; 33 with pica and 20 healthy ones. Results showed weight loss and health decline in camels exhibiting symptoms like eating wood, paper, and plastic. Camels in the Pica group have significantly less red blood cells, hemoglobin, packed cell volume, mean corpuscular volume, and hemoglobin concentration. Platelet, neutrophil, and eosinophil counts increase significantly. Pica increases BUN, creatinine, ALT, AST, and ALP. Bilirubin, total protein, albumin, and globulin were unchanged. Camels from the Pica group have lesser iron, ferritin, copper, cobalt, zinc, and phosphorus than macro- and micro-minerals. Calcium was steady. Serum iron and ferritin were positively correlated with copper, zinc, and phosphorus. Cobalt and calcium adversely linked with serum iron and ferritin. Iron and erythrograms are positively connected. This study highlights the link between iron deficiency and pica development in camels, highlighting the correlation between low serum iron concentration, ferritin levels, and persistent dietary iron insufficiency.

Keywords: *Camelus dromedarius*; Hemogram enzyme, Macro-minerals, Micro-minerals, Ferritin.

Introduction

There has been an increase in the level of attention given to the propagation and production of camels in several Arab nations. This surge in interest can be attributed to the economic importance of camels and their remarkable resilience in adverse environmental conditions. Iraq is one of the Arab nations characterized by a significant camel population [1]. Pica, a condition commonly referred to as "depraved appetite," involves the ingestion of substances that lack nutritional value. There is a distinction between the act of licking and chewing substances and the act of ingesting them. Pica is commonly linked to mineral deficiencies, which manifest in clinical symptoms such as the act of biting or ingesting wood, sticks, plastic, and paper. Additionally, individuals with pica may exhibit persistent behaviors like licking hair, chewing on walls, floors, and nearby objects. The behavior of chewing on bones (osteophagia), consuming stones (lithophagia), consuming soil or sand (geophagia), chewing and consuming wood (lignophagia), hair (trichophagia), paper (papyrophilia), glass (hyalophagia), faeces (coprophagia), metal (metallophagia), and urine (urophagia) exemplify various forms of this behavior [2]. The etiology of pica in animals remained poorly comprehended, yet several influential factors have been identified. These factors include deficiencies in specific proteins, α-amino acids, trace elements, and vitamins. Additionally, a decrease in the body's alkali reserve, an imbalanced calcium-phosphorus ratio in the diet, and established connection on the association between phosphorus and calcium deficiency contribute significantly to the occurrence of pica [3].

Insufficient levels of soda salts or phosphates in animal diets may potentially contribute to this issue. The occurrence of pica and fleece dietary pattern in

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sheep has been associated with deficiencies in copper, zinc, and cobalt [4]. Globally, there is a prevalence of primary phosphorus deficiency among domesticated animals, manifesting primarily through symptoms such as pica, which is characterized by a reduced appetite [5]. Pica animals exhibited significantly reduced levels of inorganic phosphorous in comparison to their healthy counterparts, namely camels, buffaloes, and cattle. Pica in camels has been associated with significant gastrointestinal worm infestations, including Haemonchus, Strongyloides, Trichostrongylus, Trichuris, Nematodirus, and Oesophagostomum, as well as deficiencies in essential minerals such as calcium and phosphorus [3].

The intestinal and bowel systems are commonly affected by the predominant side effects of pica. Pica can lead to severe complications, such as cannibalism, the ingestion of foreign objects that can cause traumatic reticuloperitonitis by penetrating the gastrointestinal tract, poisonings (particularly from substances like lead or botulism), and the accumulation of materials like wool, fiber, or sediment that can obstruct the gastrointestinal tract (known as fibrolith) [2].

Hence, the objective of this study conducted in Iraq was to provide insight into the occurrence of pica in camels and to examine the haematological and biochemical changes in camels affected by pica. This was achieved by analysing the reference interval values of haematological and biochemical parameters in pica-affected camels.

Materials and methods

Ethical approval

The Before collecting samples, all participants in this investigation were duly informed and provided their consent for the purpose of testing and publication of the obtained results. The study protocol, subject information, and informed consent form underwent a thorough review and received approval from a local ethics committee affiliated with the Faculty of Veterinary Medicine at the University of Kufa.

Animals

The study involved 53 dromedary camels, aged between 1 and 7 years. An extensive research project took place in the Madhloom district of the Al-Najaf Province in Iraq from March 2023 to August 2023, concentrating on the observation and inspection of camels. Every camel that was affected, particularly Camel No. 33, showed signs of pica. The camels in the control group, labeled as No. 20, showed good health.

Hematological and biochemical analysis

Ten ml of venous blood was collected from the jugular vein of each camel. The blood samples were transported to the laboratory of clinical pathology in order to undergo hematological and biochemical analysis. Hematological parameters, such as red blood cells (RBCs), white blood cells (WBCs), hemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and platelets (Plts), were analysed using the fully-automated Vet scan HM5 Hematology Analyzer (ABAXIS Company, Union City, California USA). The analysis was conducted on 3 ml blood samples collected in EDTA tubes.

Blood samples with a volume of 7 ml were placed in plain tubes and subjected to centrifugation for duration of 15 minutes at a speed of 3000 revolutions per minute. This process was carried out in order to isolate clear sera that were not haemolyzed. The resulting sera were then stored at a temperature of -20°C until they could be subjected to biochemical analysis. The serum samples were transported to the laboratory at the Kufa Faculty of Veterinary Medicine for analysis.

Biochemical assays were employed to quantify the concentrations of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP). Cholesterol, creatinine, blood urea nitrogen (BUN) levels, total protein (TP), albumin, globulin, and bilirubin were quantified using spectrophotometric methods. The measurements were conducted using commercially available test kits from Cypress Diagnostics (Belgium), following the instructions provided by the manufacturer. The quantification of iron, copper, cobalt, and zinc was performed using atomic absorption spectrophotometry with the Autoanalyzerbt 35i instrument (RingeLsan Co.) located in Gaziemir-Izmir, Turkey

The concentration of total serum ferritin (μg/l) was measured as part of routine analysis using a commercially available Ferritin reagent provided by Spectrum Company, Sun long Biotech Co.Ltd (China). The equivelar equation for standard curves was employed to perform the calculations.

Statistical analysis

Data were investigated using the Statistical Package for the Social Sciences version 26 (IBM Corp., NY, USA). The descriptive statistics for the results were presented as the mean ± standard error (SE). A t-test for independent samples was employed to conduct a comparative analysis between two distinct groups, namely those consisting of Pica and healthy Camels. The Pearson correlation test was utilized to examine the relationship between specific Camels and their Pica values [8].

Results and Discussion

Clinical findings

Engaging in the ingesting substances that are not typically considered as sustenance, such as hair, soil, and inanimate objects like wood, paper, and plastic, can lead to various negative effects on the body. These effects include a decline in overall physical well-being, a decrease in body weight, a decrease in the size of bodily humps, as well as subsequent loss of appetite and an increased need for hydration.

Pica, also known as "depraved appetite," has been studied in various animal species, prompting the exploration of multiple etiological factors that may contribute to the manifestation of this condition [6]. Pica is often considered a nutritional disorder in livestock, although its underlying causes are subject to debate. The causes of nutritional deficiencies and imbalances have been a subject of debate, as discussed by [7]. In order to effectively diagnose abnormal behavior or diseases that may pose a risk to the performance or survival of camels, it is imperative to possess a comprehensive comprehension of hematologic, biochemical, and mineral variations. This study conducted a comprehensive comparison of the hematobiochemical and mineral profiles between camels exhibiting pica and those without pica.

Hematology

The Pica group exhibits significantly reduced levels of red blood cells (RBC), hemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), and mean corpuscular hemoglobin concentration (MCHC) compared to the control group. Furthermore, a significant elevation in platelet count is observed in the pica group when compared to the control group. The findings from the DLC analysis indicate a significant elevation in neutrophil and eosinophil counts, while lymphocyte and monocyte counts were observed to be significantly reduced in the pica group as compared to the control group (Table 1).

The haematological parameters exhibited a statistically significant difference ($P<0.05$) in the group with pica, as determined through data analysis. These findings align with a previous study conducted on pica camels [9], and are in agreement with another research [10]. Iron, which plays a crucial role in the formation of hematological values, can be attributed to dietary deficiency or failure of intestinal absorption [11].

The occurrence of microcytic hypochromic anaemia can be ascribed to several factors, including the grazing habits of camels on iron-deficient pasture, impaired iron absorption caused by intestinal disturbances, and copper deficiency in the soil of AL-Najaf. These factors collectively affect the availability and utilization of iron in the synthesis of hemoglobin [12].

Biochemical analysis

Based on the biochemical parameters presented in Table 2, it is evident that the concentrations of BUN, creatinine, AST, ALT, ALP, and bilirubin in the pica group have exhibited a statistically significant increase. Within the pica group, there has been a notable reduction in cholesterol levels. Furthermore, there is no significant difference observed in the total serum protein, albumin, and globulin concentrations between the two groups.

The concentrations of micro and macro elements presented in Table 3, demonstrate a notable reduction in serum iron, ferritin, copper, zinc, and cobalt levels within the pica group compared to the control group. Furthermore, it is noteworthy that the phosphorous concentrations observed in the Pica group are significantly lower compared to the control group. There is a lack of statistically significant disparity observed in the serum calcium concentration between the two groups.

The finding displays the interrelationships among serum iron, ferritin, copper, cobalt, zinc, calcium, and phosphorus. There was a strong and statistically significant positive correlation observed between copper, zinc, and phosphorus levels and the concentrations of serum iron and ferritin (Table 4).

A robust positive correlation between the counts of red blood cells (RBC), haemoglobin (Hb), haematocrit (HCT), and platelets with serum iron levels. Conversely, the concentration of ferritin exhibited a negative correlation with the aforementioned red blood cell parameters (Table 5).

Pica can potentially arise due to a deficiency in specific amino acids or proteins [13].The results of the statistical analysis indicated that pica camels exhibited significantly elevated serum levels of AST, ALT, and ALP in comparison to healthy camels. Hence, it is possible that the activity, production, or elimination of these three hepatic enzymes may be altered. The findings presented in this study are consistent with prior research conducted [9].

Based on the biochemical analyses conducted in this study, the serum levels of total protein, albumin, globulin, and bilirubin did not exhibit any statistically significant variations between the two groups, as reported by [14].

The findings of the biochemical analysis conducted in this study revealed a statistically significant elevation in blood urea nitrogen (BUN) and creatinine levels. Consequently, the elevation of blood urea nitrogen (BUN) and creatinine levels, which facilitate the breakdown of muscle protein during the mobilization of significant bodily reserves, aligns with the conclusions of other researchers [6, 13].

The present study aimed to investigated the serum mineral and trace element concentrations in camels, comparing those with and without pica. In light of this observation, it was found that the levels of iron, ferritin, copper, cobalt, and zinc in the serum were notably diminished in camels exhibiting pica, in comparison to a control group. In contrast, the concentrations of macro elements, specifically Calcium, were found to be similar in both groups. However, the levels of phosphorus were significantly lower in the pica group compared to the control group.In the context of Iraq's local setting, the present findings indicate that Iraqi camels of typical health exhibit a median serum iron concentration that aligns with previously documented data on the mean and range of iron levels in Iraqi camels [15].

Consistent with the findings of [7], our study reveals a potential correlation between reduced serum iron levels and diminished serum ferritin levels, indicating a prolonged state of nutritional iron deficiency. This deficiency is believed to be a contributing factor in the manifestation of pica among cattle. A study by [6], found that horses with pica behavior had notably lower levels of iron and copper in their blood compared to healthy horses. [16], determined that iron deficiency was the primary cause of pica symptoms in lambs, as revealed in a separate research investigation. [17], have documented similar results in human participants.

Iron, copper, cobalt, and zinc are crucial micronutrients required for the optimal development, growth, and overall well-being of juvenile and rapidly-growing organisms. Deficiencies of these trace elements can be diagnosed by assessing their concentrations in serum or plasma [18]. Iron deficiency has been recognized as a significant etiological factor for pica in various animal species. Ferritin serves as the primary protein responsible for the storage of iron within the body. When an excess amount of iron is present, ferritin effectively binds to the surplus iron and subsequently stores it within a range of cells, with a particular emphasis on hepatocytes and macrophages [19, 20].

The studies conducted by [7, 10], both concluded that a decrease in serum iron levels, coupled with a decrease in serum ferritin levels, can be associated with chronic iron deficiency. This deficiency has been identified as a significant contributing factor to the occurrence of pica in sheep and cattle.

According to other studies, copper plays a vital role in facilitating the transportation of iron across cellular membranes [21, 22]. A significant portion of copper present in the plasma is bound to a glycoprotein called ceruloplasmin. This glycoprotein exhibits ferroxidase activity and plays a crucial role in facilitating the transport of iron in the bloodstream. Consequently, a deficiency in copper may lead to reduced iron levels [23]. Furthermore, it is plausible that the insufficient intake of these minerals through feed consumption directly contributes to the occurrence of trace element deficiencies in individuals with pica. In a study conducted by [24], it was observed that there was a statistically significant decrease in the concentrations of copper and iron in the serum of cattle exhibiting pica.

According to [11], cobalt is an essential element for the synthesis of vitamin B12 in the rumen. Vitamin B12 serves as a cofactor for the enzymes methylmalonyl-CoA mutase and methionine synthetase, which are involved in the processes of gluconeogenesis and methionine synthesis, respectively. Insufficient dietary intake of Cobalt can lead to a deficiency in vitamin B12, which manifests as a reduction in plasma concentration of B12 and an increase in levels of methylmalonic acid (MMA) and methionine [25].

Zinc (Zn) plays a vital role in maintaining a balanced redox state in animals, facilitating the optimal functioning of the immune system, and promoting the growth and development of organisms. The activity of Zn-dependent enzymes, such as Cu/Zn-dependent superoxide dismutase SOD, is also essential [26]. The presence of zinc deficiency in animals is commonly linked to anorexia and decreased food consumption. This is believed to occur due to the suppression of neuropeptide Y release, which is essential for receptor activation. Zinc plays a crucial role in the perception of taste as it is involved in the functioning of a salivary polypeptide called gustin, which is necessary for taste sensation. Consequently, when the levels of zinc in saliva are low, it consistently leads to a loss of taste, resulting in a notable decrease in appetite and subsequent emaciation [27].

Furthermore, it is noteworthy that the pica group exhibits a substantial decline in Phosphorous concentrations, in alignment with the findings of [12]. This decline can be attributed to a reduction in the intake of dietary phosphates. As per the findings of [2], an insufficiency in phosphorus is identified as the primary etiological factor that underlies the occurrence of anorexia. As stated by [3], there was a significant decrease in circulating inorganic phosphorous levels observed in camels, cattle, and buffaloes exhibiting pica compared to their healthy counterparts. According to the research conducted by [28], there was no statistically significant disparity observed in the serum calcium levels between the two groups.

The results of the correlation analysis indicate a significant positive correlation between serum iron levels and RBC, Hb, PCV, and platelet counts. [29], identified the presence of anemia in camels with iron deficiency based on the observation of below-normal levels of RBC, PCV, and Hb. The presentation discussed the association between iron and platelet count, highlighting the correlation between thrombopoietin and iron state. [30], state that thrombopoietin is crucial for regulating thrombocyte production. Limited research has been conducted on the correlation between hematological parameters and iron levels in camels, as evidenced by the study conducted by [31].

Conclusions

The etiology of pica, a pathological condition characterized by the consumption of non-nutritive substances, is believed to be multifactorial. However, the present study has identified alterations in hemato-biochemical parameters and mineral levels that could potentially serve as valuable indicators for assessing the underlying causes of abnormal appetite or behavior in camels. The presence of a potential phosphorous insufficiency in the serum, coupled with deficiencies in iron, ferritin, and copper, may have played a substantial role in the manifestation of pica in the examined camels.

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Conflicts of interest

There are no conflicts to declare.

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Data availability

All data included within the manuscript.

Authors' contribution

The authors mentioned have significantly and directly contributed to the research and have provided their consent for its publication.

TABLE 1. Hematological parameters and DLC for Pica-affected and Control dromedary camels; Mean ± SE

Parameter	Control group No. 20	Pica group No. 33	Significance
RBC ($\times 10^6/\mu$ L)	10204±236.7*	7145±110.7	0.000
Hb (g/dL)	11.6±0.28*	6.5±0.09	0.000
PCV (%)	29.6±0.48*	21.4±0.21	0.000
MCV (fL)	28.6±0.55*	23.3±0.42	0.000
MCHC (g/dL)	39.0±0.53*	30.3±0.39	0.000
Platelets ($\times 10^3/\mu$ L)	174.5±9.80	292.2±6.61*	0.000
WBC /µ L	10322±99.50	10205±126.8	0.528
Neutrophils /µ L %	45.0±0.80	52.2±0.74*	0.000
Lymphocyte /µ L %	41.3±0.72*	33.6±0.63	0.000
Monocyte /µ L %	8.3±0.53*	6.17±0.27	0.000
Eosinophil /µ L %	5.3±0.49	7.9±0.35*	0.000

* Correlation is significant at the 0.05 level (2-tailed)

TABLE 2. Biochemical parameters for Pica-affected and Control dromedary camels; Mean± SE

Parameter	Control group No. 20	Pica group No. 33	Significance
BUN (mg/dl)	30.33±1.56	60.53±1.08*	0.000
Creatinine (mg/dl)	1.56±0.11	2.61±0.04*	0.000
Total protein (g/dl)	7.35±0.21	7.40±0.14	0.843
Albumin (g/dl)	3.43±0.10	3.55±0.06	0.290
Globulin (g/dl)	3.55±0.18	3.64±0.12	0.669
Bilirubin (mg/dl)	0.41±0.04	0.54±0.02	0.012
Cholesterol (mg/dl)	158.10±5.41*	95.85±1.69	0.000
AST (IU/L)	53.05±2.77	80.00±2.11*	0.000
ALT (IU/L)	16.10±1.38	41.60±0.79*	0.000
ALP (IU/L)	31.45±1.39	39.45±1.26*	0.000

* Correlation is significant at the 0.05 level (2-tailed)

TABLE 3. Micro and macro element levels forPica-affected and Control dromedary camels; Mean ± SE

Parameter	Control group No. 20	Pica group No. 33	Significance
Iron(µmol/L)	13.19 ± 0.66*	8.20 ±0.35	0.000
Ferritin (µg/L)	349.00±3.98*	239.01±5.88	0.000
Copper (µmol/L)	10.99±0.57*	6.92±0.30	0.000
Cobalt (µmol/L)	2.42±0.32*	2.06±0.20	0.330
Zinc (mg/dl)	59.9±0.78*	44.9±0.62	0.000
Calcium(mg/dl)	10.00±0.19	10.10±0.13	0.657
Phosphorus (mg/dl)	4.31±0.26*	1.91±0.14	0.000

* Correlation is significant at the 0.05 level (2-tailed)

TABLE 4. Correlation of serum iron, ferritin, copper, cobalt, zinc, calcium and phosphorus levels in camels with pica

		Iron	Ferritin	Copper	Cobalt	Zinc	Calcium	Phosphorus
Iron	Pearson Correlation	1	0.576**	0.439**	-0.011	0.646**	-0.006	0.568**
	Sig. (2-tailed)		0.000	0.001	0.939	0.000	0.968	0.000
Ferritin	Pearson Correlation	0.576**	1	0.577**	0.175	0.801**	0.155	0.827**
	Sig. (2-tailed)	0.000		0.000	0.205	0.000	0.262	0.000
Copper	Pearson Correlation	0.439**	0.577**	1	-0.077	0.509**	0.081	0.490**
	Sig. (2-tailed)	0.000	0.000		0.580	0.000	0.563	0.000
Cobalt	Pearson Correlation	-0.011-	0.175	-0.077	1	0.142	-0.096	0.247
	Sig. (2-tailed)	0.939	0.205	0.580		0.304	0.490	0.072
Zinc	Pearson Correlation	0.646**	0.801**	0.509**	0.142	1	-0.007	0.649**
	Sig. (2-tailed)	0.000	0.000	0.000	0.304		0.959	0.000
Calcium	Pearson Correlation	-0.006	0.827**	0.081	-0.096	-0.007	1	0.212
	Sig. (2-tailed)	0.968	0.000	0.563	0.180	0.959		0.124
Phosphorus	Pearson Correlation	0.568**	0.827**	0.490**	0.247	0.649**	0.212	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.072	0.000	0.124	

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

TABLE 5. Correlation of serum iron, ferritin, copper, cobalt, zinc and phosphorus levels with hematological values in camels with pica

		RBC	Hb	PCV	MCV	MCHC	Platelets
Iron	Pearson Correlation	0.283**	0.291**	0.221**	-0.011	0.006-	0.646**
	Sig. (2-tailed)	0.001	0.001	0.001	0.939	0.968	0.001
Ferritin	Pearson Correlation	-0.078	-0.076	-0.102	-0.097	0.018	-0.001-
	Sig. (2-tailed)	0.665	0.675	0.573	0.591	0.921	0.997
Copper	Pearson Correlation	-0.215	-0.255	-0.034	-0.131	-0.237	0.358*
	Sig. (2-tailed)	0.228	0.152	0.850	0.466	0.185	0.041
Cobalt	Pearson Correlation	0.130	0.079	0.105	0.345*	0.015	-0.101
	Sig. (2-tailed)	0.471	0.661	0.562	0.049	0.934	0.577
Zinc	Pearson Correlation	-0.102	0.066	0.026	-0.193	0.026	-0.296
	Sig. (2-tailed)	0.573	0.716	0.884	0.283	0.884	0.094
Phosphorus	Pearson Correlation	-0.023	-0.079	-0.065	0.054	0.013	-0.127
	Sig. (2-tailed)	0.897	0.660	0.717	0.763	0.944	0.482

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

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دراسة دموية ومعدنية لانحراف الشهية في الجمال العربية في صحراء النجف – العراق

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المستخلص

تبحث هذه الدراسة التغيرات في المعايير الدموية والكيموحيوية للجمال العربية التي تظهر عليها انحراف الشهية، وهو اضطراب غذائي له أسباب مثيرة للجدل. تضمنت الدراسة 53 جملا عربيا تراوحت اعمارها من 1-7 سنوات، وتم تقسيمهم إلى مجموعتين: 33 منحرفة الشهية و20سليمة. وأظهرت النتائج فقدان الوزن وتدهور الحالة الصحية لدى الجمال التي تظهر عليها أعراض مثل تناول الخشب والورق والبلاستيك .تحتوي مجموعة الجمال منحرفة الشهية على عدد أقل بكثير من خلايا الدم الحمراء والهيموجلوبين وحجم الخلايا المرصوص ومتوسط حجم الكريات وتركيز الهيموجلوبين. يزداد عدد الصفائح الدموية والعدلات والحمضات بشكل ملحوظ . لوحظ في مجموعة الجمال المنحرفة الشهية زيادة نسبة اليوريا والكرياتينين و ALTو AST وALP ، لم يتغير البيليروبين والبروتين الكلي والألبومين والغلوبيولين . تحتوي مجموعة الجمال منحرفة الشهية على كمية أقل من الحديد والفريتين والنحاس والكوبالت والزنك والفوسفور مقارنة بالمعادن الكبيرة والصغيرة. كان الكالسيوم ثابتا. ارتبط الحديد والفريتين في الدم بشكل إيجابي بالنحاس والزنك والفوسفور. يرتبط الكوبالت والكالسيوم سلبا بالحديد في الدم والفريتين. يرتبط الحديد والصورة الدمويةبشكل إيجابي. تسلط هذه الدراسة الضوء على العلاقة بين نقص الحديد وتطور انحراف الشهية في الجمال، وتسلط الضوء على العلاقة بين انخفاض تركيز الحديد في الدم، ومستويات الفريتين، ونقص الحديد الغذائي المستمر.

الكلمات الدالة :*Camelus dromedarius* ، إنزيمات الدم ، المعادن الكبيرة ، المعادن الدقيقة ، الحديد.