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MINERALS PROFILE IN PRE-AND POST FED DESERT SHEEP IN THE SUDAN

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ORIGINAL ARTICLE

Abstract: *The objective of this study was to assess the changes in serum minerals profile in desert sheep in Sudan in relation to feed interval; pre feeding (fasting overnight), post feeding (3hrs after feeding). Twenty one yearling unsaturated males of Sudan desert sheep with an average body weight of 31.11kg were used in this study.The serum level of (Cu and Mn) was significantly high (P<0.05) in post feeding than pre feeding, while serum level of (Zn) was high in pre feeding when compared with the post feeding with percentage of changes amounting for (15%). However the serum level of (Na) was significantly (P<0.05) higher during pre feeding than post feeding whereas serum level of (Mg) was higher, while serum level of (K) was lower during pre feeding than post feeding with percentage of changes (8%) and (10%), respectively.*

Key words: *Mineral Profile, Feed Interval, Micro mineral, Macro mineral, Mineral requirements, Desert sheep.*

INTRODUCTION

Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life, minerals are chemical constituents used by the body in many ways, although they yield no energy, they have important roles to play in many activities in the body (Malhotra, 1998; Eruvbetine, 2003). Every form of living matter requires these inorganic elements or minerals for their normal life processes (Hays and Swenson, 1985; Ozcan, 2003). The basic functions performed by the minerals are: they are structural components of body tissues, are involved in the maintenance of acid-base balance and in the regulation of body fluids, in transport of gases and in muscle contractions (Malhotra, 1998; Murray et al., 2000).

Animals of similar age, breed and physiological state in a common environment can show marked differences in their efficiency of mineral utilizations. For example, the fractional absorption of copper can vary from 0.042 to 0.112 (Suttle, 1984). Age can affect requirement through changes in absorption efficiency, for example, pre ruminating lambs have an 80% absorption efficiency for copper, whereas lambs with a functional rumen have only 3-5% (Underwood, 1981). The form of mineral in the diet and the presence or absence of synergistic and antagonistic compounds and elements are of prime importance in determining whether or not the sheep meets its mineral requirements, perhaps the best known interaction is between copper, molybdenum and sulfur as reported by researchers, showed that copper functions in the utilization of iron in an early stage of haemopoiesis. Copper deficiency results in an increase in iron in the liver, whereas an excesss of copper results in a decrease in iron content of the liver, thus reflecting the role of copper in iron utilization. Copper is present in blood plasma as a copper-carrying plasma protein called erythrocuprin. Erythrocuprin provides a link between copper and iron metabolism and mediates the release of iron from ferritin and haemosiderin (Hays and Swenson, 1985). The dietary requirement of copper is affected by the level of some other minerals in the diet, and is increased in ruminants by excessive molybdenum. Treatment of copper poisoning is based on the rationale that excess molybdenum may cause copper deficiency and molybdenum in conjunction with the sulfate ion has been used in treating copper poisoning in ruminants (Pierson and Aenes, 1958). The Cu requirement varies among animal species to some extent but is influenced to a large degree by its relationship with and the intake of other mineral elements such as iron, molybdenum and sulfate.

Animal fluid levels of minerals, in addition to concentrations of particular enzymes, metabolites or organic compounds with which the minerals in question associated functionally, are also important indicators of minerals status (McDowell, 1987; Puls, 1994; Judson and McFarlane, 1998). As minerals form a crucial part in the nutrition of ruminants and are often the limiting factors in their diets, particularly in tropical regions (McDowell, 1976 and McDowell, 1985a). Minerals concentrations of plasma provide an indication of the complete mineral uptake of

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grazing animals, also reflecting water, soil and other non-forge sources, with exception of reserves mobilized from bone. Furthermore, this analysis of mineral concentrations can provide an indication of the sub clinical presence of deficiencies (Underwood, 1981) impacting optimum production. Deviations from these normal limits, which are now well defined for most elements, therefore, constitute useful diagnosis indicators. A further valuable aspect of such fluid composition changes is that they frequently arise prior to the appearance of adverse clinical signs (Underwood, 1979 and McDowell, 1987). Certain plasma minerals are greatly in animals fed a severely deficient diet (Miller and Stake, 1974; Sutherland, 1980; McDowell, 1985a and Minson, 1990). Assessment of mineral status on the bases of plasma of grazing animals has been considered an important strategy to increase animal productivity, especially in those countries are commonly found.

Ideally, animal scientist would like to determine the minerals status of an animal by measuring the minerals content of one tissue that is readily a valuable from a live animal. Although unfortunately, no minerals concentrations of all minerals, the blood plasma is considered very useful tissue fluid as indicate the animal status of most the minerals with low concentrations indicative of dietary deficiency or excess. Plasma minerals after absorption immediately reflect the dietary intake, absorption and availability through gastrointestinal tract. Whole blood or blood plasma or serum is widely used for studies in mineral nutrition. Values significantly and consistently above or below " normal " concentrations or range provide suggestive but no conclusive evidence of dietary excess or deficiency of particular mineral.

The aim of the present study was to assess the changes in minerals profile during pre feeding and post feeding and to evaluate mineral requirements and appraise the concentrations of critical micro minerals and macro minerals in addition to define normal limit of these elements copper, Manganese, Zinc, Sodium, Magnesium and Potassium in the serum of desert sheep in Sudan.

MATERIALS AND METHODS

Experimental animals

Twenty one yearling unsaturated males of Sudan desert sheep with an average body weight of 31.11kg were used in this study. The animals were purchased from the local market; they bear the characteristic of the indigenous desert sheep breed. They have large and flabby ears, long tapering tail, and long -legged. The coat color was brown. The animals were housed in an un-shaded sheep's pen; at Halat Kuku in Khartoum north, Sudan. Prior to commencement of the experiment the animals were dewormed with antihelmintic (Ivermectin 0.5 ml per 25 kg body weight)they were also given long acting Oxtetracycline at a dose rate of 1 ml per 10 kg body weight, the animals were then allowed to adapt for approximately three weeks, the duration of the intervention was one week.

Feeding rations

The animals were fed according to relevant standards for the group. The rations were offered ad libitum through out the experimental period. The ingredients for all diets were mainly grounded Bagasse 35%, Groundnut Hay 20%, molasses 20%, ground nut cakes 10%, wheat bran 10%, sorghum Hay 9% and salt 1%. The chemical composition of ingredients were calculated according to the Nutrient composition of Sudanese animals feeds Bulletin (3), 1999: Dry matter 89.82%, Crude Protein 6.66%, Fiber 28.27, Ash 7.11%, Nitrogen Free Extractive (NFE) 45.23% and Metabolisable Energy (ME) 0.74%. The Minerals contents of ingredients are derived from FAO's Animal Feed Resources Information System (1991-2002) and from Bo Gohl's Tropical Feeds (1976-1982) are shown in table (3).

Blood samples

Daily Blood samples of 5.0 ml were collected from the jugular vein from each animal into plain vacutioners one sample in the morning (pre-feeding samples) the other was collected after 3hour (post- feeding samples) the blood was then allowed to clot, then centrifuged at 3000rpm for five minutes and the serum was removed and stored at – 20 ^{0}C into sealed plastic containers until analyzed.

Biochemical analysis

Determination of serum (Na+) and (K+): Serum sodium and potassium were determined by flame photometer (Jenway PFP, England) as described by Varly (1967).

Determination of serum Mg+2, Cu+2, Mn+2, and Zn+2: These elements were determined using the atomic absorption spectrophotometer model (Unicam-929, England) at the department of biochemistry, central veterinary research laboratories.

Statistical analysis: Data were analyzed with the SPSS 10.0 statistical package program (SPSS Inc, Chicago, Illinois USA). Student test (T-test) was performed for the statistical analysis of biochemical results. Statistical significance was considered when $P<0.05$.

RESULTS

Effects of deficiency and accesses of minerals, their critical or average values in different samples, requirements and tolerance for minerals in dietary components and their concentrations in pre-Feeding and post-feeding taken from the animals are presented in Tables; 1 to 6 and Figures; 1 and 2.

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Serum micro minerals

Table 4 and Figure 1 shows the status of serum micro minerals of (Cu, Mn and Zn) concentrations of the desert sheep the Pre- feeding and post- feeding. Serum (Cu) mean was (1.41 ± 0.05) mg/l and Serum (Mn) mean (0.30 ± 0.04) mg/l however, the level in post feeding were significantly (P<0.05) higher than pre feeding, (0.98 ± 0.04) mg/l, (0.30 ± 0.04) mg/l; for Cu and Mn respectively. Whereas the Serum (Zn) was lower in post feeding (1.32 ± 0.11) mg/l than pre feeding (1.12 ± 0.08) mg/l, the difference between them is amounted for (−15%). However, the mean (±Std) for the overall serum (Zn) was (1.22 ± 0.07) mg/l and (min – median - max) values were (0.6 - 1.2 - 2.2) mg/l, respectively.

Serum macro minerals

The status on serum macro minerals (Na, Mg and K) concentrations of the desert sheep pre feeding and post feeding are shown in table 5 and figure 2. Mineral (Na) decreased significantly (P< 0.05) in post feeding than pre feeding. Mean level of (Mg) in pre feeding was (19.86 ± 2.41) mg/l and in post feeding was (18.23 ± 1.51) mg/l with percentage of change (-8%), while serum (K) increased in post feeding (141.7 ± 7.2) mg/l than pre feeding (128.5 ± 9.3) mg/l with a difference amounting for (10%).

Table 1 - Minerals included in study for sheep, with their functions and effects of deficiency or toxicity

Elements	Function	Deficiency	Toxicity
Copper	Many enzyme system, haemoglobin formation, cartilage/bone formation	Poor or faded hair, reduced growth, lameness	Anorexia, jaundice, abdominal pain, haemolytic crisis
Manganese	Growth, skeleton reproduction	Impaired reproduction, skeletal abnormalities, abortion, reduced growth	Disruption of rumen flora, reduced growth, anaemia
Zinc	Epidermal tissue, skeletal formation wound healing	Poor reproduction, rough skin, poor immune function, reduced intake and growth	Uncommon: anaemia, reduced bone formation, reduced weight gain
Sodium	Electrolyte, nerve impulse transmission	Common in grazing cattle, depressed appetite	Diarrhoea, anorexia thirst, salivation abdominal pain, convulsions, muscular spasms
Magnesium	Energy, fat and protein metabolism	Loss appetite, reduced gain, hyper excitability, "grass tetany" in coordination, convulsions	Reduced intake, diarrhoea
Potassium	Electrolyte, nerve impulse transmission	Rapid decline in feed and water intake, loss of vigour, pica	Unlikely to occur, cardiac problems, oedema

Sources: National Research Council, (1980). Mineral Tolerance of Domestic Animals, Washington, D.C: National Academy of Sciences

Table 2 - Minerals requirements and tolerances for sheep

Mineral mg/Kg DM	Minimum concentrations	Maximum tolerable concentration
Cu^{2+}	5	25
Mn^{2+}	15 – 25	1000
Zn^{2+}	20 – 30	300
Na^{+1}	700 – 900	35000
Mg^{2+}	1200	5000
K^{+1}	5000	30000

Where range is given, the lower value is for maintenance and higher value is for growing animals. (NRC, 1985; Reuter and Robinson, 1997)

Table 3 - Minerals contents of ingredients in study for sheep

Ingredients / Minerals	Cu mg/kg DM	Mn mg/kg DM	Zn mg/kg DM	Na g/kg DM	Mg g/kg DM	K g/kg DM
Wheat bran	14	113	89	0.1	4.6	13.7
Baggasse	12	-	103	0.1	0.8	1.3
Molasses	5	152	36	0.3	2.2	14.1
Sorghum hay	-	-	-	-	2.2	30.6
Groundnut hay	-	-	-	-	-	-
Groundnut cake	6	127	25	0.4	6.1	11.2
Total	37	392	253	0.9	15.9	70.9

The contents of this table are currently derived from FAO's Animal Feed Resources Information System (1991-2002) and from Bo Gohl's Tropical Feeds (1976-1982); Last updated on 24/10/2012; From (http://www.feedipedia.org/content/feeds).

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Table 4 - Pre feeding and post feeding status on serum micro minerals (Cn, Mn and Zn) concentrations of the desert sheep

Elements	Status	N	Mean ± Std	SD	Min	Max	Med.	CV	Change	Average value*
				Statistics						
Cu Mg/L	Pre feeding	21	0.98 ± 0.04^{a}	0.14	0.65	1.17	1.01	15%	44%	>0.65
	Post feeding	21	1.41 ± 0.05^{b}	0.16	1.13	1.67	1.44	11%		
	Overall	42	1.20 ± 0.05	0.26	0.65	1.67	1.15	22%		
Mn Mg/L	Pre feeding	21	0.14 ± 0.02^{a}	0.07	0.06	0.30	0.15	47%	113%	>0.015 – 0.5
	Post feeding	21	0.30 ± 0.04^{b}	0.12	0.17	0.51	0.23	42%		
	Overall	42	0.22 ± 0.03	0.13	0.06	0.51	0.18	58%		
Zn Mg/L	Pre feeding	21	1.32 ± 0.11	0.38	0.60	2.20	1.28	29%	-15%	>0.6
	Post feeding	21	1.12 ± 0.08	0.26	0.75	1.50	1.08	23%		
	Overall	42	1.22 ± 0.07	0.34	0.60	2.20	1.20	28%		

N: number, Std: Standard error mean, SD: Standard deviation, Min: Minimum value, Max: Maximum value, Med.: Median, CV: coefficient of variance and Aver.: Average. $^{a, b}$ Means with different superscripts in the same column are significantly different at (P <0.05). *Minerals concentrations in plasma are higher than the above given values. Pamela et al., 2001).

Table 5: Pre feeding and post feeding status on serum macro minerals (Na, Mg and K) concentrations of the desert sheep

Elements	Status	N	Mean ± Std	SD	Min	Max	Med.	CV	Change	Aver. value*
				Statistics						
Na Mg/L	Pre feeding	21	1069.3 ± 129.6^{a}	448.9	535	1860	930	42%	-47%	>3000
	Post feeding	21	571.3 ± 15.9^{b}	55.1	470	680	555	10%		
	Overall	42	820.3 ± 82.3	403.2	470	1860	625	49%		
Mg Mg/L	Pre feeding	21	19.86 ± 2.41	8.29	8.51	36.46	18.84	42%	-8%	>20
	Post feeding	21	18.23 ± 1.51	5.18	9.72	25.52	18.84	28%		
	Overall	41	19.03 ± 1.39	6.81	8.51	36.46	18.84	36%		
K Mg/L	Pre feeding	21	128.5 ± 9.3	32.1	80	190	133	25%	10%	>200
	Post feeding	21	141.7 ± 7.2	24.8	105	190	137.5	18%		
	Overall	42	135.1 ± 5.9	28.8	80	190	135.5	21%		

N: number, Std: Standard error mean, SD: Standard deviation, Min: Minimum value, Max: Maximum value, Med.: Median, CV: coefficient of variance and Aver.: Average. $^{a, b}$ Means with different superscripts in the same column are significantly different at (P <0.05). *Minerals concentrations in plasma are higher than the above given values (Pamela et al., 2001).

Table 6 - Minerals contents of ingredients and mineral requirements of desert sheep in current study

Ingredients \ Minerals	Cu	Mn	Zn	Na	Mg	K
Wheat bran	↓	↓	↓	↓	↓	↓
Baggasse	↓	-	↓	↓	↓	↓
Molasses	↓	↓	↓	↓	↓	↓
Sorghum hay	-	-	-	-	↓	↑
Groundnut cake	↓	↓	↓	↓	↑	↓
Total	↑	↓	↓	↓	↑	↑

↓: lower than requirements.
↑: maximum than requirements.

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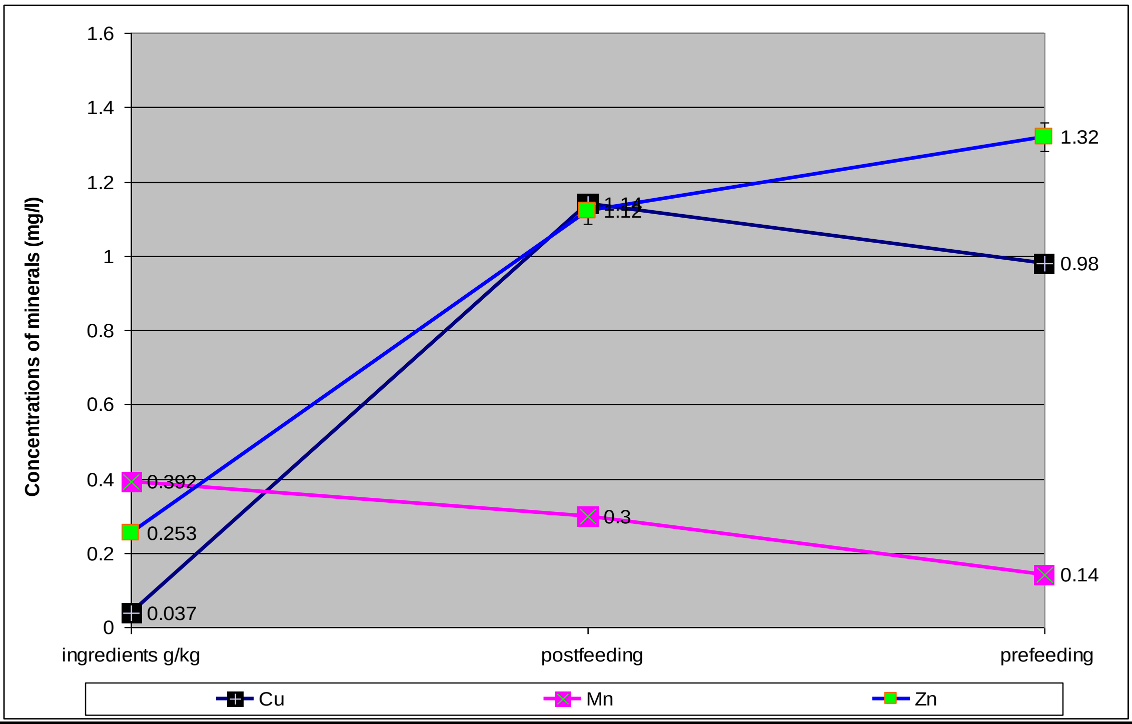

Figure 1 - Mean micro minerals (Cu, Mn and Zn) concentrations in ingredients, post feeding and pre feeding of desert sheep

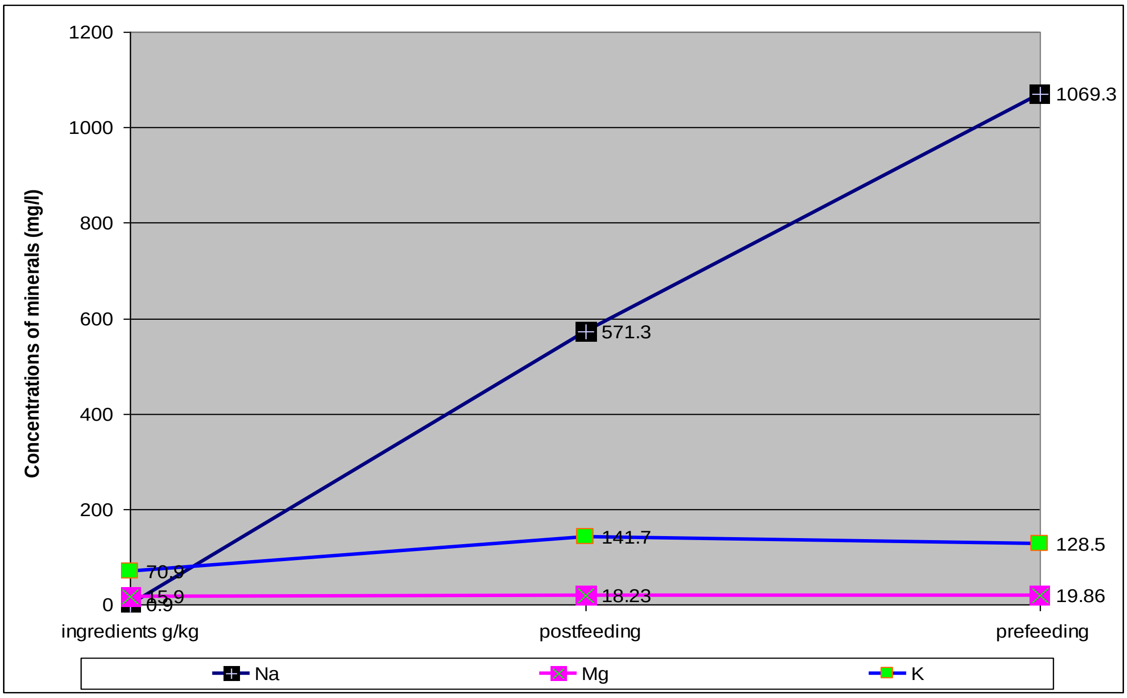

Figure 1 - Mean macro minerals (Na, Mg and K) concentrations in ingredients, post feeding and pre feeding of desert sheep.

DISCUSTION

In this study, the serum mineral profile of desert sheep was investigated systematically during normal cycling, pre feeding (fasting overnight) and post feeding (3hrs after feeding).the analysis of the minerals content in the feed offered to the animals revealed that it extend the recommended values of NRC standards for sheep however, The extended improvement of the plan of nutrition of supplemented sheep and the monitoring of physiological responses provided a detail account, which facilitated critical evaluation of the changes that occurred in mineral profile in desert sheep. The results indicate that pre feeding and post feeding were associated with changes in the profiles of macro and micro minerals in desert sheep.

The level of micro minerals (Cu, Mn and Zn) concentrations in the blood serum of the desert sheep in this study were within the limits of the normal values (NRC standards, 1985; Pamela et al., 2001; Simon and Gasmir, 2001), but the level of macro minerals (Na, Mg and K) concentrations were slightly lower than the above normal

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values, and had not shown any important deviation during the changes of the physiological states of the desert sheep, which is its characteristic.

Serum micro minerals

The status on serum micro minerals (Cu, Mn and Zn) concentrations in the desert sheep Pre feeding and post feeding shown in Table 4 and Figure 1. Revealed significant ($P<0.05$) increase in serum (Cu) and (Mn) level during post feeding compared to the values measured during pre feeding in desert sheep this could be related to the major way of homeostatic control of trace elements for certain essential divalent cations is modification of the percentage of intestinal absorption in response to physiological need and dietary intake (Miller, 1973). According to Underwood, 1981; who showed variation of absorption efficiency for copper in pre ruminating lambs and lambs with a functional rumen. In this study the higher ($P<0.05$) concentrations of (Mn) during post feeding could be to the migration of (Mn) to the other tissues (red blood cells, liver, bones, kidney etc), furthermore tag along to decline pre feeding. In support of our finding, Hidiroglou et al. (1978) reported that cows fed diets with 8 ppm Mn had 130 ng of Mn/mL of whole blood, compared to 210 ng of Mn/mL of whole blood in cows supplemented with 60 ppm Mn; hence the concentrations of (Mn) moved from plasma to the red blood cells and have been used to assess status. Similar pronouncement of some researchers who reported that some tissues remove (Mn) from plasma to liver, heart and bones (Bentley and Phillips, 1951; Masters et al., 1988). However, the serum (Zn) level during post feeding was lower (-15%) than pre feeding which could be attributed to the absorption from the gut (Kirchgessner, 1976; Suttle, 1988); the concentrations of Zn in plasma fluctuate with age, stress, infections, and feed restriction (Wegner et al., 1973; Kincaid and Hodgson, 1989; Wellinghausen and Rink, 1998; Kincaid, 1999). Additionally, Davies, 1984 indicated that (Zn) is bound primarily to albumin; the changes in albumin concentration may have a significant effect on (Zn) level. The author added that the level of circulating (Zn) reflects both serum albumin level and the affinity of albumin for (Zn).

Serum macro minerals

The status on serum macro minerals (Na, Mg and K) concentrations of the desert sheep Pre feeding and post feeding represented in Table 5 and Figure 2. revealed that the serum (Na) concentration increased significantly ($p<0.05$) in pre feeding than post feeding state, while serum (k) was lower during pre feeding than post feeding (128.5 mg/L to 141.7 mg/L) with percentage difference of (10%), this is in the main line of a high level of potassium appears to increase the requirement for sodium and vice versa (Merck, 1986). The fluctuation of serum (Na) in pre feeding and post feeding and interrelationships with (k) could be due to the absorption and excretion from body tissues to circulate through the body to organize osmotic pressure or losses in perspiration and stress conditions; similar finding was reported by (Hays and Swenson, 1985). The mean value of serum (Mg) during pre feeding was (19.86 mg/L) higher than that of post feeding (18.23 mg/L) with percentage difference amounting for (-8%), could be due to the mechanism reaction of the magnesium through the blood to cells and tissues, as reported by (Murray et al. (2000) showed that Mg is an essential activator for the phosphate-transferring enzymes myokinase, diphophopyridinenucleotide kinase, and creatine kinase. It also activates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzyme for the reactions in the citric acid cycle. It is also a constituent of bones, teeth, enzyme cofactor, (kinases, etc).

Minerals of ingredients and requirements in desert sheep

As shown in table 6, the contents of minerals in ingredients fairly changed among species which had been analyzed from FAO's Animal Feed Resources Information System (1991-2002), and this could be mainly due to the difference in mineral contents of the soil on which the herbages were grown, concerning the minerals contents of ingredients, it will better to discuss and/or compare the contents of minerals in the ingredients with the amounts required generally in the feed (such as feeding standard). The amounts (or extent) of some minerals required in the feed for sheep (NRC, 1985) were extracted in table 2. The magnesium content of groundnut cake and potassium content of Sorghum hay were quite high as compared with that of standard, and this could be due to the characteristic of sugar cane plant and legume plant accepted generally (Cullison, 1979), and this may explain the increase of these minerals in this study. However, the obtained copper values listed in table 3 are obviously higher than that required for feeding of sheep, although the values of (Mg, K and Cu) in the ingredients were higher than the required for sheep feeding recommended by (NRC, 1985),it is worth to mention that the sheep were appeared healthy during the period of the study (1moth), this could be due to the sufficient amount of minerals offered in the ration and also the absorption and excretion through the body tissues and interrelationships among the minerals and minerals metabolic (Pierson and Aenes, 1958; Hays and Swenson, 1985).

Implications

In general, the requirement of minerals for animals nutrition will differ from that of other major nutrients, such as protein or carbohydrates, which could be needed daily in relatively large amounts at a time, than they will be needed to constantly maintain a normal condition in the physiology of the animal. Therefore, some minerals will be excreted, in principles, into the urine or into the gut. when Mg, K and Cu were absorbed in an excess amount(greater than the upper limits), as shown in table 6, then the toxic symptoms seems to appear for all the minerals (McDowell, 1985b). Also there are also many metabolic and absorption interrelationships among the mineral elements which contribute to variations in the degree of physiological responses to deficient or toxic levels. These relationships make

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it difficult to determine the optimum dietary level for the individual elements required for domestic animals. As a result of this, the recommended dietary level of any element should rarely be considered independent of the level of other essential nutrients (Hays and Swenson, 1985). The functions of minerals in animals are interrelated; therefore, there is a certain limit to the use of plasma levels of some minerals as an index for checking the conditions for minerals nutrition (Gibbons et al., 1976; Kincaid, 1999). To offer a more pertinent criterion for judging the nutritional status of mineral in desert sheep of the study, it will be better to discuss the mineral contents of main organs (liver, kidney etc) together with the concentrations of minerals in blood plasma.

CONCLUSION

The study indicates that the mineral profile in desert sheep is affected by physiological states including feed interval. The pattern changes were influenced by dietary minerals content. The results were obtained pre feeding (fasting overnight) and post feeding (3hrs after feeding). Serum level of (Cu and Mn) increased significantly post feeding than pre feeding, while Serum level of (Zn) was higher pre feeding when compare with the post feeding with percentage of changes (15%). Serum level of (Na) was significantly higher during pre feeding than post feeding. Serum level of (Mg) was higher, while Serum level of (K) was lower during pre feeding than post feeding with percentage of changes (8%) and (10%), respectively. Also critical investigations should provide information regarding to actual mineral requirements of sheep so that appropriate nutritional strategies can be managed.

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