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CLINICAL, HAEMATO-BIOCHEMICAL CHANGES IN GOATS WITH EXPERIMENTALLY- INDUCED COPPER DEFICIENCY WITH TRIALS OF TREATMENT

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A B S T R A C T

For assessment of the changes associated with induced copper deficiency in goats, mature castrated male Baladi goats (n=16) aged 1-1.5 years old and weighted 15-20 kg randomized into 2 groups: Group I (n=6) were apparently healthy (control) and Group II (n=10) were subjected to experimental induction of secondary copper deficiency by dietary supplementation of molybdenum (MO; 10-40 mg/kg dry matter) and Sulpher (S; 1.5-3 g/kg dry matter) daily for 24 weeks. Blood samples (serum and whole blood) were collected every 6 weeks (w) for determination of serum copper, iron and zinc levels, ceruloplasmin activity and erythrocyte superoxide dismutase (SOD) activity. Results showed that hypocuperimic goats had changes in hair color and texture (at the 9th w), paleness of the conjunctival mucous membrane (at the 18th w), emaciation and loss of body condition (at the 24th w). Hypocupermic goats showed a significant ($P<0.05$) decrease in body weight gain, RBCS count, haemoglobin concentration, serum copper, iron and zinc levels and reduced activity of ceruloplasmin and erythrocyte SOD (at the 6th week). As well as, there was a significant depression in hair copper content at the 12th week of the experiment. The abovementioned haemato-biochemical changes were successfully restored after treatment with oral copper sulphate for 4 week. These findings highlight the role of copper in maintaining the integrity of integumentary system, blood components, antioxidant activity, and animal growth. In addition, presence of more than 5mg Mo and 1g S /kg/dry mater intake should be avoided to overcome the occurrence of cupper deficiency.

Key Words: Ceruloplasmin, Goats, Hair analysis, Molybdenum, Sulfur.

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1. INTRODUCTION

The physiological role of copper (Cu) in the body is related to several functions, which include cellular respiration, bone formation, connective tissue development, and essential catalytic cofactor of some metallo-enzymes [42]**.** Copper is required for the activity of enzymes associated with ferrous metabolism, elastin and collagen formation, melanin production and integrity of central nervous system [2]. Copper (Cu) deficiency in ruminants is a problem worldwide [19] which can occur as a primary deficiency where Cu intake is inadequate, or as a secondary deficiency, where by other factors in the diet interfere with the absorption or metabolism of Cu e.g. molybdenum (MO) and sulfur (S) [32]. Ruminants, especially sheep and goats, are much more susceptible to Cu : Mo imbalance than are non-ruminant animals

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because of the sulphide generating bacteria present in the rumens [30].

Two copper-dependent enzymes, ceruloplasmin (CP) and superoxide dismutase (SOD), exhibit anti-inflammatory activity and play critical roles in the prevention of oxidative tissue damage resulting from infection and inflammation [8] CP may play an important role in the regulation of Cu transport to sites of inflammation for protection against tissue damage [40]. Copper deficiency is a common mineral deficiency condition in sheep and cattle [33]**.** Little is known about the condition in goats. Therefore, this study has the following aims: 1. Experimental induction of copper deficiency in goat. 2. Clinical, haematological and biochemical evaluation of goats with experimental copper deficiency. 3. Studying the effect of copper deficiency on the activity of antioxidant enzyme such as CP and SOD and 4. Treatment of hypocupermic goats and evaluation of the copper status.

2. MATERIALS AND METHODS

2.1. Experimental animals

A total number of 16 clinically healthy adult castrated Baladi male goats were used in this experiment. Their age and L.B.weight ranged from 1-1.5 years and 15-20 Kg respectively. The animals were placed in good hygienically well ventilated stable and kept under the same environmental, nutritional and hygienic conditions throughout the period of the experiment The animals were left for 2 weeks for acclimatization before the beginning of the experiment. They were subjected to periodic clinical, and laboratory examinations and were apparently healthy at the time of experiment.

2.2. Experimental ration

Ration offered to the animals was basically composed of: 50% yellow corn, 25% cotton seed cake and 17% wheat bran. Additionally, the animals were supplemented with seasonal green fodders essentially alfalfa (Green Barseem) in winter sweet corn (Green Maize) in summer. However, roughages (Wheat Straw and Rice Straw) were added at nights while fresh drinking water was offered *ad lib*. The ration offered to the animals all the period of the experiment was include: 50% yellow corn, 25% cotton seed cake, 17% wheat bran, 5% molace, 2% lime stone and 1% common salt (commercial sodium chloride). The ration was biochemically analyzed for detailed ingredients percentage as well as the recognized trace elements contents.

2.3. Experimental design

16 male goats were randomized into 2 groups:

Group I: Included 6 goats that were kept as a control group.

Group II: Included 10 goats that subjected to experimental induction of Cu deficiency by addition of Mo and S for about 24 weeks. At the end of the experiment, hypocupermic goats treated with copper sulphate as 2g orally (weekly) for 4 successive weeks according to Smith and Sherman [38].

2.4. Analysis of Experimental Ration

Feed samples of experimental diets and green ration were collected and chemically analyzed for detailed ingredients and nutritive values according to the techniques carried by Associated of Official Analytical Chemists (AOAC) [1]**.** Concentrations of N, P, K, Mg, Ca and Na were calculated as (%); whereas, total contents of Fe, Mn, Zn and Cu were calculated as (ppm).

2.5. Induction of copper deficiency

Induction of secondary copper deficiency carried by gradual addition of molybdenum and sulpher to the experimental ration according to Moeini *et al*. [25**]** with some relevant modification.

Table 1 Mineral supplements added to the ration during the experiment.

Minerals	Experimental period (week)			
	1	6	12	18
S (g/kg DM)	1.5	2	2.5	3
Mo(mg/kg DM)	10	20	30	40

2.6. Clinical examination

The clinical examination was conducted and recorded for detection of clinical signs of copper deficiency according to Radostits *et al*. [32]

2.7. Treatment

At the end of the experiment hypocupermic goats treated with copper sulphate as 2g orally (weekly) for 4 successive weeks according to Smith and Sherman [37].

2.8. Body Weight (BW) gain

The mean values of body weight gain every 6weeek (at 0 day, 6 weeks, 12 weeks, 18 weeks and 24weeks of experiment) was calculated for each group. The weight gain per day was calculated as follow: the weight gain at the beginning of the 6 weeks minus the weight gain at the end of 6 weeks.

2.9. Blood sampling

Blood samples were collected (at 0, 6, 12 and 24 weeks of the experiment and after treatment) from jugular vein according to Radostits *et al*. [32]. Blood samples with EDTA were collected for hematological studies. Blood samples without anticoagulant for obtaining a clear non-hemolyzed serum by centrifugation of the blood sample at 3000 rpm for 5 minutes. The clear sera were aspirated carefully by automatic pipette and transferred into clear dry labeled Eppendorf tubes and stored at -20 ◦C till analysis. Sera were used for determination of serum copper, zinc, and iron. Heparinized blood samples were collected for determination of erythrocyte SOD activity. Erythrocyte lysate was obtained from centrifugation of the blood sample at 1000rpm for 10 minutes for separation of plasma. The erythrocytes were lysed in 4 times its volume of ice cold HPLC grade water Centrifuged at 10,000 for 15 minutes at 4 °C. Erythrocytes lysate was then collected and stored at -80 ◦C till analysis according to Nishikimi *et al*. [29].

2.10. Haematological examination

The total number of erythrocytes was calculated using the improved neubauer haemocytometer according to Bernard *et al*. [7]. The total number of leukocytes was calculated by haemocytometer according to Coles [12]. The haemoglobin content was estimated in gm/100 ml by using sahli's apparatus according to Schalm *et al*. [34]. The volume of erythrocytes (packed cell volume) per 100 ml blood was determined according to Frankel *et al*. [15]. Stained blood films by Giemsa stain were examined and differential leukocytic count was done by using cross-sectional method according to Jain [21].

2.11. Vital hair analysis for detection of copper

Collected hair samples were washed thoroughly with bi-distilled water then dried in a hot air oven. Concentrated sulphoric acid and hydrogen peroxide were added on hair samples then heating the mixture until being transparent like water after performing a wet ash digestion technique according to method of Chapman and Pratt [11]. Copper was determined in hair samples using atomic absorption spectrophotometer technique according to method of Issac and Kerber [20]

2.12. Serum biochemical analysis

Copper (Cu), Zinc (Zn) and Iron (Fe) concentrations were estimated in serum using Flame Atomic Absorption Spectrophotometer according to Fernandez and Kahan [14]. Erythrocyte superoxide dismutase activity was assayed by using diagnostic kit (Bio-diagnostic Co. Egypt). This assay relies on the ability of the enzyme to inhibit the phenazine methosulphate-mediated reduction of nitro blue tetrazolium dye. Erythrocyte SOD activity was carried out according to Nishikimi *et al*. [29]. CP oxidase activity was assayed according to the method described by Schosinsky *et al*. [35].

2.13. Statistical analysis

Statistical analysis of the results was carried out using two-way analysis of variance (ANOVA test) according to Bailey [6] using SPSS software. The means were compared considering the time and Cu deficiency. The differences in means were consider statistically significance when $P<0.05$.

3. RESULTS

The result of ration analysis demonstrated that the ration was composed: 1.95% Total nitrogen, 0.30% phosphorous, 0.92% potassium, 0.34% calcium, 0.27% Magnesium, 0.54% sodium, 61ppm iron, 27 ppm manganese, 81 ppm zinc and 8 ppm copper.

3.1. Clinical examination

Clinical examination of goats with experimentally induced copper deficiency showed hair depigmentation and steely appearance (Figure 1), pale mucosa (Figure 2) and emaciation with loss of body condition (Figure 3). Significant loss of body weight gain was observed after the 12th week after induced copper deficiency in goats (Table 2).

Haematologial changes showed that the mean values of RBCS count, haemoglobin concentration and PCV % in experimentally induced copper deficient goats were significantly ($P<0.05$) lower than the apparently healthy control animals at 12, 18 and 24 weeks of the experiment (Table.3). The mean values of total leukocytic count showed non-significant difference between experimentally induced copper deficient and apparently healthy control group (Table.3).

Differential leuckocytic count indicated a non-significant decrease in lymphocyte % and non-significant increase of neutrophil % in experimentally induced copper deficient goats compared with control group (Table.4).

Biochemical analysis of serum samples revealed that there was significant ($P<0.05$) decrease in serum copper, iron and zinc (Table. 5). Moreover, biochemical analysis of copper content of hair showed significant ($P<0.05$) depression in experimentally copper deficient goats at the 12th week of the experiment (Table. 6).

Fig. 1 Hypocupremic goat showed hair depigmentation and steely appearance.

Fig. 2 Hypocupremic goat showed palness of conjunctival mucous membrane

Fig. 3 Hypocupremic goat showed emaciation and loss of body condition

The result obtained table (7) showed significant ($P<0.05$) decrease in serum CP activity of experimental copper induced animals in compared with apparently healthy controls at the 12, 18, 24 week of the experiment. Moreover, there was significant ($P<0.05$) decrease in mean values of erythrocyte superoxide dismutase (SOD) activity in experimental induced copper deficient goats in compared with control group (Table. 7).

3.2. Clinical signs

The clinical signs of secondary copper deficiency in goats included hair depigmentation and steely appearance (Fig. 1), pale mucosa (Fig. 2) and emaciation with loss of body condition (Fig. 3). Significant loss of body weight gain was observed after the 12th week after induced copper deficiency in goats (Table 4).

4. DISCUSSION

Copper content of the ration was 8 ppm which considered being sufficient for growth and production of goat according to NRC [28] which cited that copper requirements for goats were established at 8-10 ppm.

Table 2 Body weight gain (kg/6week) in control and experimentally induced copper deficient goats for 24weeks and after treatment with copper sulphate for 4 weeks.

Animal groups	Time (weeks) 0-6	6-12	12-18	18-24	Post-treatment
Control	3.66±0.56^{a}	2.33±0.56^{ab}	2.50±0.67^{ab}	2.33±0.49^{ab}	2.66±0.49^{ab}
Cu deficiency	2.67±0.42^{ab}	1.67±0.82^{bc}	0.83±0.31^{c}	0.67±0.33^{c}	1.33±0.33^{bc}

Data presented (mean± S.E.) with different superscript letters are significantly different at $P<0.05$.

Table 3 Haematological parameters in control and experimentally induced copper deficient goats for 24weeks and after treatment with copper sulphate for 4 weeks.

Parameters	Groups	Time (weeks) 0	6	12	18	24	Post-treatment
RBC(10^6/µl)	Control	14.31±1.27^{a}	14.27±0.69^{a}	14.17±0.25^{a}	14.44±0.49^{a}	14.01±1.07^{a}	13.95±0.92^{a}
	Cu deficiency	14.51±1.15^{a}	13.97±0.87^{a}	12.2±0.34^{ab}	10.24±0.68^{bc}	9.46±0.44^{c}	12.41±0.31^{ab}
HB (g/dl)	Control	12.18±0.52^{a}	12.03±0.72^{a}	12.13±0.41^{a}	12.00±0.55^{a}	12.10±0.61^{a}	12.13±0.41^{a}
	Cu deficiency	12.16±0.60^{a}	11.83±0.38^{a}	10.01±0.76^{bc}	9.87± 0.69^{bc}	8.75±0.16^{c}	11.30±0.41^{a}
PCV (%)	Control	38.56±0.54^{a}	38.50±1.00^{a}	38.66±1.46^{a}	38.33±0.86^{a}	38.37±1.31^{a}	38.60±0.64^{a}
	Cu deficiency	38.53±1.15^{a}	37.63±0.72^{a}	34.33±0.93^{bc}	33.30±1..01^{cb}	31.83±0.47^{c}	35.76±0.36^{ab}
Total leukocytic count (10^3/l)	Control	12.80±0.63^{a}	12.00±1.0^{a}	12.61±1..30^{a}	13.49±1.80^{a}	12.78±0.64^{a}	12.36±0.44^{a}
	Cu deficiency	12.38±1.60^{a}	11.63±1..30^{a}	12.01±1.50^{a}	12.00±0..57^{a}	11.96±0.52^{a}	12.11±0.98^{a}

Data presented (mean± S.E.) with different superscript letters are significantly different at $P<0.05$.

Table 4 Differential leuckocytic count in control and experimentally induced copper deficient goats for 24weeks and after treatment with copper sulphate for 4 weeks.

Parameters	Groups	Time (weeks) 0	6	12	18	24	Post-treatment
Lymphocytes %	Control	55.33±3.84^{a}	52.00±4.04^{a}	54.66±5.04^{a}	55.00±5.29^{a}	53.00±5.00^{a}	52.6±2.84^{a}
	Cu deficiency	53.66±4.91^{a}	52.33±5.36^{a}	54.66±3.48^{a}	52.66±4.91^{a}	49.33±5.36^{a}	50.00±3.48^{a}
Granulocytes %	Control	43.33±4.17^{a}	45.33±4.09^{a}	44.00±4.72^{a}	43.00±4.93^{a}	44.66±4.84^{a}	45.33±3.33^{a}
	Cu deficiency	45.00±4.04^{a}	45.66±5.78^{a}	44.00±3.78^{a}	45.00±5.03^{a}	49.33±2.60^{a}	48.00±5.00^{a}
Monocytes %	Control	1.33±0.33^{a}	2.66±0.66^{a}	1.33±0.33^{a}	2.00±0.57^{a}	2.33±0.33^{a}	2.00±0.57^{a}
	Cu deficiency	1.66±0.88^{a}	2.00±0.57^{a}	2.00±0.57^{a}	2.33±1.20^{a}	2.33±0.66^{a}	2.00±1.15^{a}

Data presented (mean± S.E.) with different superscript letters are significantly different at $P<0.05$.

The results showed that addition of 10-40mg Mo /kg DM and 1.5- 3 g S /kg DM to the experimental ration of the goat succeeded to induce a secondary copper deficiency status in goats. This result coincided well with that obtained by former studies [10, 24, 25, 41] used 10 mg Mo and 3g S /kg dry matter in compound ration of lambs for induction of secondary copper deficiency**.** The specific effect of molybdenum in producing clinical copper deficiency symptoms can be detected when Mo combined with S in the rumen to form thiomolybdates which bind with high affinity to dietary Cu in addition to antagonizing Cu metabolism by decreasing absorption, increasing biliary excretion of Cu, and chelating Cu from metalloenzymes [16]. The clinical signs of secondary copper deficiency are likely to be from formation of thiomolybdate (MoS4) in the body.

Careful clinical examination of experimental induced hypocuperimic goats revealed changes in hair color and texture at the 9th week of the experiment. Later on the fine hair becomes limp and steely appearance. Moreover, the black hair showed depigmentation (Fig.1) and became easily to be detached. The clinical signs of hair changes and depigmentation became more obvious at the end of the experiment. Hair depigmentation associated with cu deficiency in cattle may attributed to reduction in the activity of tyrosinase which is cu-dependent enzyme required for melanin synthesis [16].

Table 5 Serum copper, iron and zinc concentration (μg/dl) in control and experimental induced copper deficient goats for 24 weeks and after treatment with copper sulphate for 4 weeks.

Parameters	Groups	Time (weeks) 0	6	12	18	24	Post-treatment
Copper (μg/dl)	Control	94.83±0.60^{a}	96.33±1.45^{a}	97.33±3.84^{a}	97.00±1.52^{a}	97.66±3.71^{a}	98.66±3.71^{a}
	Cu deficiency	95.66±3.84^{a}	80.16±3.44^{b}	64.76±3.74^{c}	57.33±2.92^{c}	55.16±9.41^{c}	89.66±4.63^{ab}
Iron (μg/dl)	Control	206.0±3.5^{a}	207.0±3.6	206.0±3.5^{a}	208.0±4.4^{a}	206.3±2.3^{a}	207.7±5.04^{a}
	Cu deficiency	207.7±5.9^{a}	199.0±2.3^{ab}	195.3±3.2^{bc}	193.7±4.5^{bc}	185.3±2.9^{c}	197.00±1.5^{ab}
Zinc (ug/dl)	Control	88.66±4.05^{a}	87.66±5.36^{a}	89.33±4.05^{a}	85.33±1.85^{a}	82.66±6.33^{a}	85.66±2.60^{a}
	Cu deficiency	91.66±2.9^{a}	88.00±1.00^{a}	87.33±1.45^{a}	86.30±4.91^{a}	71.00±4.93^{b}	84.00±2.51^{a}

Table 6 Copper concentration in pulled hair (mg Cu/kg DM) in control and experimentally induced copper deficient goats for 24weeks and after treatment with copper sulphate for 4 weeks.

Parameters	Groups	Time (weeks) 0	6	12	18	24	Post-treatment
Copper in hair (mg Cu/kg DM)	Control	12.14±1.33^{a}	12.01±0.66^{a}	11.31±1.55^{a}	11.38±0.59^{a}	11.79±0.73^{a}	12.18±0.69^{a}
	Cu deficiency	11.31±1.83^{a}	9.59±0.51^{ab}	7.43±0.92^{bc}	7.21±1.45^{bc}	5.24±0.52^{c}	10.39±0.89^{ab}

Table 7 Serum Ceruloplasmin (u/ml) and erythrocytesuperoxide dismutase (U/g HB) activity in control and experimentally induced copper deficient goats for 24weeks and after treatment with copper sulphate for 4 weeks.

Parameters	Groups	Time (weeks) 0	6	12	18	24	Post-treatment
Ceruloplasmin (u/ml)	Control	5.83±0.56^{a}	5.47±0.49^{a}	5.26±0.53^{a}	5.48±0.35^{a}	5.76±0.24^{a}	5.54±0.75^{a}
	Cu deficiency	5.84±0.45^{a}	4.48±0.30^{ab}	3.48±0.29^{b}	3.09±0.49^{b}	3.02±0.16^{b}	48±0.50^{b}
SOD (U/g HB)	Control	4.65±0.26^{a}	4.45±0.51^{a}	4.77±0.23^{a}	4.54±0.60^{a}	4.65±0.26^{a}	4.65±0.26^{a}
	Cu deficiency	4.53±0.63^{a}	3.49±0.14^{ab}	2.97±0.17^{bc}	2.30±0.55^{bc}	2.22±0.24^{c}	4.53±0.63^{a}

Hypocupermic goats showed paleness of the conjunctival mucous membrane (Fig. 2) from the beginning of the 18^{th} week of the experiment which considered a sign of anemia. This result was similar to those obtained by previous authors [19, 24, 37, 39]. Copper deficiency has been found to cause anemia due to disturbances in iron metabolism resulting in sequestration of iron by the liver due to decrease plasma ceruloplasmin activity which involved in the mobilization of tissue iron [40]. At the beginning of the 21st week of the experiment, clinical examination showed hyperthesia, nervous manifestation and stiffness in gait. These results coincided well with those of a previous study [5] that explained the defects which affect the skeleton of Cu-deficient animals as being biochemically related to disorder cross-linking of connective tissue proteins caused by a deficiency of lysyl oxidase. Disorders of the nervous system have been linked to a lack of cuproenzymes dopamine-ß- hydroxylase involved in the conversion of dopamine to norepinephrine Cerone et al. [8]. Soetan et al. [39] explained that Cu is necessary for formation of myelin sheath, thus Cu deficient animal exhibit nervous disorders.**.** Emaciation and loss of body condition (Fig.3) became more obvious signs at the 24^{th} week of the experiment. This result was coincided with former studies [9, 17, 19]. The signs of growth retardation in copper deficiency animal are related to reduction the activity of cuproenzymes such as cytochrome c oxidase which is important in energy production [27]. The result obtained table (2) showed that there was a significant ($P<0.05$) decrease in body weight gain in hypocupermic goats compared with apparently healthy control goats. this result was coincided with earlier studies [19, 23, 24, 37] found that the mean values in the body weight gain were 59.9±18.0, 66.6±17.0 and 73±16 g/day in copper deficient lambs and were 193.0±19.7, 179.0±18.6 and 152±14 g/day for control group at 30, 60, 90 days of the experiment, respectively. Moreover, Gengelbach et al. [17] observed that there was a depression in growth rate when more than 5mg Mo/kg DM was given to calves. A reduction in the food intake and food utilization was probably the cause of the depressed weight gains founded in treated animal with more than 20mg Mo/kg DM [25].

The result of blood picture indicated that the mean values of RBCS count, haemoglobin concentration and PCV % (Table.3) in experimentally induced copper deficient goats were significantly ($P<0.05$) lower than the apparently healthy control animals at 12, 18 and 24 weeks of the experiment. The result was similar to that obtained by Mobarak [24] and Sharma et al. [37]**.** This decrease might be due to disturbance in the regular metabolism of iron as copper deficiency decreases the absorption of iron, releasing of iron from body stores and utilization in haemoglobin synthesis [2]. However, copper is essential for erythrocyte production [32]. Moreover, haemolysis may contribute to the development of anaemia [37]**.**

The mean values of total leukocytic count (Table 3) showed non-significant difference between experimental induced copper deficient and apparently healthy control group. These results agreed with those obtained by Mobarak [24], Cerone et al. [9] and Abd El-Raof and Ghanem [2]**.** Moreover, differential leuckocytic count (Table.4) indicated a non-significant decrease in lymphocyte % and non-significant increase of neutrophils %. These findings are in concurrence with the findings of Arthington et al. [4], Mobarak [24] and Abd El-Raof and Ghanem [2]**.**

The data obtained in Table (5) showed that the mean values of serum copper in experimental induced copper deficient animal were significantly ($P<0.05$) low at 6weeks in compared with apparently healthy control goats. This result may be attributed to presence of potent Cu antagonists such as Mo and S which form thiomolybdates In the rumen which bind with high affinity to dietary Cu in addition to antagonize Cu metabolism by decreasing absorption, increasing biliary excretion of Cu, and chelating Cu from metalloenzymes [16, 36, 42].

Results obtained in Table (5) revealed that the mean values of serum iron showed significant (P<0.05) decrease in experimentally copper deficient animals compared with apparently healthy control group. This result was coincided with Soetan et al. [39] who reported that copper helps in the incorporation of iron in haemoglobin, assists in the absorption of iron from the gastrointestinal tract (GIT) and in the transfer of iron from tissues to the plasma. Moreover, serum zinc (Table.5) was significantly (P<0.05) decreased in at 24^{th} week of the experiment in compared with apparently healthy controls. This result was similar to that obtained by Mobarak [24] who considered that result may be attributed to reduction of food intake. The mean values of copper content in hair (Table 6) showed significant depression in copper content of hair in experimentally copper deficient goats at 12th week of the experiment. These findings are in concurrence with the findings of Moeini et al. [25]**.** In addition, Suttle [41] who showed that in prolonged copper deficiency the copper level of the fleece decreased to 2-3mg/kg DM. Ceruloplasmin is a single chain α2-glycoprotein that binds up to 95% of serum copper. It's most important functions are the transport of copper from liver to peripheral, nonhepatic tissues, catalysis of the oxidation of ferrous ions, and action as an extracellular antioxidant [8]. The result obtained table (7) showed significant (P<0.05) depression in serum ceruloplasmin activity of experimental copper induced animals in compared with apparently healthy controls at 12, 18, 24 week of the experiment. This result was similar to that obtained by Cerone et al. [8], and Sharma et al. [37]**.** Ceruloplasmin appears to be one of the enzymes which is most sensitive to molybdenum-induced copper deficiency. It is probable that the observed decrease in ceruloplasmin activity is related to the levels of thiomolybdates in plasma, which can produce an inactivation of this enzyme [9].

Erythrocyte superoxide dismutase (SOD) is an enzyme that catalyzes the conversion of superoxide into hydrogen peroxide and oxygen. It is a metal containing antioxidant enzyme that reduces harmful free radicals of oxygen formed during normal metabolic cell processes to oxygen and hydrogen peroxide. Free radicals play an important role in the biological system. They are highly reactive, unstable molecules formed when oxygen interacts with certain molecules. Their chief danger comes from the damage they can do when they react with important cellular components such as DNA. These damages can be neutralized with natural antioxidants such as superoxide dismutase [26]. The obtained result table (7) showed significant (P<0.05) decrease in mean values of erythrocyte superoxide dismutase activity in experimental induced copper deficient goats in compared with control group. These findings are in concurrence with the findings of Sharma et al. [37]**.** Significant decrease in SOD resulted in partial oxygen reduction leading to an increase of free radicals together with an insufficient antioxidant activity which would increase oxidative stress [31]. Oxidative stress may be defined as an imbalance between cellular production of reactive oxygen species (ROS) and antioxidant defense mechanisms [26].

Treatment of hypocuperimic goats with oral copper sulphate for 4 week successfully restored haemato-biochemical changes which occur due to secondary copper deficiency. Therefore, we concluded that copper is an extremely important element in maintaining the integrity of integumentary system, blood components, antioxidant activity, vital enzymatic activity and animal growth. Therefore, at least the minimum required level of copper should be achieved while composition of rations for farm animals. In addition, presence of more than 5mg Mo and 1g S /kg dry mater should be avoided to overcome the occurrence of secondary deficiency.

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مجلة بنها للعلوم الطبية البيطرية

BENHA UNIVERSITY
FACULTY OF VETERINARY MEDICINE

التغيرات الإكلينيكية، الدموية، البيوكيميائية في الماعز المحدث بها نقص النحاس الثانوى تجريبياً مع محاولات العلاج

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الملخص العربى

اجريت هذه الدراسه على عدد ستة عشر من ذكور الماعز تراوح عمرها بين 1-1.5 عام ووزنها بين 15-20 كجم و ذلك لدراسه التغيرات الاكلينيكيه، الدمويه، والبيوكيميائيه لنقص النحاس المحدث تجريبياً فى الماعز حيث قسمت الحيوانات الى مجموعتين: المجموعه الاول تكونت من 6 حيوانات سليمه اكلينيكياً (مجموعه ضابطه). المجموعه الثانيه فشملت على 10 حيوانات تعرضت لاحداث تجريبى لنقص النحاس الثانوى عن طريق اضافه 10-30 مجم موليبدات و1.5 -3جم كبريت لكل كجم من العليقه الجافه يوميا لمده 24 اسبوع . تم تجميع عينات الدم لفحص صوره الدم، قياس مستوى النحاس، الزنك، و الحديد. بالاضافه الى قياس نشاط السيريلوبلازمين و السوبر اوكسيد ديسميوتيز. اوضح الفحص الاكلينيكى للماعز تغير فى لون وملمس الشعر (الاسبوع التاسع)، شحوب فى لون الغشاء المخاطى المبطن للعين (الاسبوع الثامن عشر)، هزال وضعف عام (الاسبوع الرابع و العشرين). كما وجد انخفاض معنوى فى وزن الحيوانات، نسبه الهيموجلوبين، عدد خلايا الدم الحمراء، مستوى النحاس، الزنك، الحديد. اضافه انخفاض معنوى فى نشاط السيريلوبلازمين فى مصل الدم، و نشاط السوبر اوكسيد ديسميوتيز فى خلايا الدم الحمراء (الاسبوع السادس). كما وجد نقص معنوى فى مستوى النحاس فى الشعر (الاسبوع الثانى عشر). كل هذه التغيرات الدمويه والبيوكيميائيه اظهرت تحسن ملحوظ بعد العلاج بكبريتات النحاس عن طريق الفى لمده اربعة اسابيع مما يؤكد دور النحاس فى الحفاظ على سلامه النظام الغلافى، مكونات الدم، النشاط المضاد للاكسده، و كذلك نمو الحيوانات. توصى هذه الدراسة الى التاكد من وجد عنصر النحاس فى العليقة بنسبه تفى باحتياجات الحيوان. الاضافه الى ان وجود الموليبدات (5 مجم) و كبريت (1 جم) فى العليقه مسبب لحدوث نقص النحاس الثانوى.

(مجلة بنها للعلوم الطبية البيطرية: عدد 23(2)، ديسمبر 2012: 137-147)