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DIETARY SELENIUM CHANGES AND ITS RELATION WITH ADAPTABILITY IN SMALL RUMINANTS

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ABSTRACT

The objective of this study was to determine the various dietary levels of selenium (Se) as sodium selenate (Na_2 Se O_4) and its relation with adaptability of sheep. This study was carried out at Ras Suder (South Sinai Governorate) experimental station using eighteen weaned Barki ram lambs (4 months age and 13.81±1.60 kg average body weight) assigned to three groups (6 each).

Data showed that dry matter, crude protein of alfalfa treated with Se in treatment groups (G2, 0.7 ppm of Se and G3, 1.4 ppm of Se) were greater than those of the untreated group (G1). The body weight changes and average daily gain in G2 and G3 were higher than control (G1) while the opposite trend was obtained for feed efficiency. Contents of CF, Se and Cu in G2 and G3 were higher than G1. Retention of Se, Cu and p were improved specially for copper.

Average daily gain (ADG) of lambs recorded comparable values without significant differences for groups. The values ranged from 65.3 in G3 to 79.8 g/head/day in G2. Concentrations of albumin and activities of Alk Phos, AST, ALT, GGT, and CPK in serum collected at the termination of the experiment.

Selenium supplementation resulted significantly ($P<0.05$) for percentage yield of clean wool, staple strength and point of break. The mean values of staple strength in G2 and G3 were higher ($p<0.05$) than that of G1. Manipulation of dietary selenium source and level is an effective way to change the selenium content of animal tissues commonly consumed by mankind and improvement adaptability of sheep.

Keywords: Adaptability, Selenium, Trace elements, Liver function, wool biology

INTRODUCTION

Under desert conditions, small ruminant exposed to many of environmental constraints; acute deficiency in feed resources as a result of low rainfall rate and long drought periods, bad climatic conditions, shortage of water and parasites infection and disease due to immunity deficiency, which affected negatively their productive and reproductive performances .

Although trace minerals comprise less than 0.01% of the total mass of an organism, many are essential for normal function (Fisher, 1975, Underwood, 1977 and Freer and Dove 2002). Selenium is an essential trace element to poultry, horses, cattle, and sheep (Schwarz, 1976 and Underwood, 1977). Selenium is important in sulfur amino acid synthesis (Larry, 2006).

The deficiency of selenium was found to be common in ruminants (Jeffery, 2005). Compared with non-ruminants, the absorption of selenium is much lower in ruminant animals (Jerry, 2003). Selenium supplementation was reported to increase wool growth (Langlands *et al.,* 1991a and 1991b and Whelan *et al.,* 1994). Selenium (Se) supplementation as sodium selenate is the most common source used to increase dietary Se in diets of farm animals (Reis, 1989). When marginal selenium deficiency is underestimated because of the absence of clinical symptoms; the deficiency may only be detected by careful measurement of body weight or wool production (Hill *et al.,* 1969, Whelan *et al*., 1994). Wool production is more susceptible to selenium deficiency in growing ewes than in matures (Wilkins *et al.,* 1982). Fry *et al.* (1996) stated an increase in wool length and fibre diameter in response to selenium supplementation.

Selenium is known primarily for its antioxidant activity and like other trace elements is essential for the maintenance of health, growth and a myriad of biochemical physiological functions (Scott *et al*., 1982). In young sheep, two selenium responsive conditions are recognized; one a myopathy of lambs, white muscle disease (WMD), the other syndrome of lowered productivity varying in severity from sub-clinical depression of wool production to a clinical condition of poor wool growth and increased mortality rates. In sheep and goats, there is evidence that selenium deficient animals are no less able to produce antibodies against bacterial antigens and no less able to prevent the establishment of internal parasites than sheep with adequate selenium intake (Davis *et al.*, 2008).

Absorbed Se travels in the plasma on a protein to its destination tissue. Tissue concentrations vary; the kidneys retain a large amount of Se, along with cardiac and skeletal muscle, and the liver. It is deposited more readily when it is in an organic form. Selenium is readily transferable through the placenta, the mammary barrier, and from hen to egg so the animal's status will affect offspring and milk concentrations. With acute decline; depression in fertility rate, increased abortion rate, retained placenta, stillbirths and white muscle disease usually occurred (Zafar *et al.*, 2008).

In Sinai Peninsula, sheep and goats considered the main source of meat and milk for Bedouins. The high mortality rates as well as lower milk production represent the main features that affect animal productivity. In South Sinai, agricultural activities decreased as a result of higher salinity and desertification. Soil are poor in some trace elements as (Se, Zn, Co and P) as well as range plants available (Alfalfa), especially deficient in Se, (Fahmy *et al.,* 2009).

The objective of this research was to determine the influence of two levels of selenium supplementations (0.7 and 1.4 ppm) on some blood parameter and coat characteristics in sheep raised in Sinai Peninsula.

MATERIALS AND METHODS

The present study was carried out at Ras Suder (South Sinai Governorate) experimental station (180 km north eastern of Cairo) belongs to the Desert Research Center. Three areas at the station were cultivated with alfalfa (Medicago sativa) seeds; the first area was served as control without any treatment (G1), while the second and third areas were cultivated with alfalfa seeds treated by soaking in 0.7 ppm (G2) and 1.4 ppm (G3) selenium as sodium selenate (Na_2SeO_4) solution, respectively. After the growth of alfalfa (30 days after plant germination), 0.1 ppm selenium as sodium selenate solution was sprayed on plants as a foliar fertilizer. The second cut of alfalfa plants was harvested, air dried, chopped into small particles (2-5 cm) and stored for animal feeding.

The chemical composition of the experimental rations (Table, 1) was determined according to A.O.A.C. (1990).

Table (1) Chemical composition and some mineral contents of alfalfa plants treated with Selenium

Item	Treatment		
	G1	G2	G3
Chemical composition			
DM	90.0	87.9	88.7
Ash	12.1	9.10	6.61
CP	20.9	17.1	18.8
CF	20.1	24.6	23.2
EE	6.30	7.00	6.65
NFE	40.6	42.2	41.74
Mineral contents			
Se, ppm	6.9	8.1	8.6
Cu, µmol/L	7.5	12	17.5
Zn, mmol/L	36	23	23
P, %	0.35	0.32	0.32

Eighteen weaned Barki ram lambs (4 months age and 13.81±1.60kg average body weight) were assigned to three groups (6 each) and were fed on alfalfa harvested from the three respective areas. Animals were healthy and clinically free of internal and external parasites and kept in semi open pens covered with asbestos sheets and fresh water was available twice daily.

Samples of Blood were taken from all animals a 10-mL sample of blood was collected using an 18-gauge needle into a vacutainer, centrifuged at 700×g for 25 min, and serum frozen at 0 ◦C for analysis of albumin and the following enzymes: alkaline phosphatase (Alk Phos), alanine transaminase (ALT), aspartate transaminase (AST), creatin phosphokinase (CPK), and gamma glutamyl transferase (GGT). Serum albumin, Alk Phos, ALT, AST, CK, GGT were evaluated on a Hitachi 911 analyzer with reagents from Sigma (Sigma Chemical Co., St. Louis, Mo.). Selenium (Se) Concentration in feeds and blood serum samples were determined using Atomic absorption with hydride generation whereas Cupper (Cu) and Zinc (Zn) were analyzed using atomic absorption. Phosphorus (P) was analyzed by spectrophotometer.

Wool fibre diameters were measured by using an image analyzer (LEIA-Q 500 MC) with lens.40/065. Wool samples from 10 cm^2 patch of mid-side position were taken from each animal as close as possible to the skin surface using fine scissors, and then kept in plastic bags for further analysis. Ten staples were taken randomly from each wool sample to measure staple length to the nearest 0.5 cm using a ruler till the dense part of the staple.

Clean scoured yield was calculated using the method suggested by Chapman (1960). Five hundred fibers from each sample were used to calculate the average fiber diameter and its standard deviation as well as medullated fiber percentage using optical fiber diameter image analyzer (LEICAQ 500 MC) with lens 4/0.12.

Table (2): Some trace elements balance for lambs in experimental groups

Items	Treatment			
	G1	G2	G3	±SE
Se, mg/Kg BW				
INTAKE	0.224[b]	0.308[a]	0.314[a]	0.017
Excreted in feces	0.089	0.069	0.095	0.13
Excreted in urine	0.083	0.058	0.063	0.007
Total execration	0.172	0.127	0.158	0.015
Balance	0.052	0.181	0.157	0.029
Cu, mg/Kg BW				
INTAKE	0.244[c]	0.456[b]	0.641[a]	0.059
Excreted in feces	0.277	0.361	0.308	0.024
Excreted in urine	0.222	0.074	0.072	0.038
Total execration	0.499	0.435	0.380	0.035
Balance	-0.255	0.021	0.261	0.078
Zn, mg/Kg BW				
INTAKE	1.17[a]	0.875[b]	0.841[b]	0.059
Excreted in feces	1.25	1.39	1.990	0.142
Excreted in urine	0.404	0.358	0.342	0.094
Total execration	1.654	1.748	2.332	0.157
Balance	-0.484[a]	-0.872[ab]	-1.491[b]	0.182
P, mg/Kg BW				
INTAKE	0.113	0.125	0.117	0.004
Excreted in feces	0.052	0.056	0.034	0.006
Excreted in urine	0.013	0.012	0.011	0.005
Total execration	0.065	0.068	0.045	0.006
Balance	0.048	0.057	0.072	0.006

Values with different superscripts within the same row are significantly different ($p<0.05$).
SE: Standard error

Three greasy staples from each sample were used to measure staple strength using Agritest Staple Breaker with the procedure displayed by El-Gabbas *et al*. (1999). The increase in length as a proportion of the original staple length (Elongation) as well as the length and weight of top as a proportion of the length and weight in both top and base were calculated to measure the point of break by length and weight respectively at the time of measuring staple strength.

Sub samples "not less than 300 fibers" were classified into kemp, medullated and fine categories; according to its coarseness and the percentage of medulla (kemp: very coarse fibers with medulla occupying more than 90% of the fiber, medullated: with about 30-70% medulla and Fine: non medullated fibers. Fiber type percentages were also counted (Guirgis, 1967).

Data were statistically analyzed using one way analysis of variance utilizing General Linear model (GLM) of SAS (1998) and differences between means were tested using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

1. Body performance

Average daily gain (ADG) of lambs recorded comparable values (Table 3) without significant differences for groups. The values ranged from 65.3 in G3 (1.4 ppm of Se) to 79.8 g/head/day in G2 (0.7 ppm of Se) this result agree with previous studies reported no effect of Se fed above requirements on body weight of feedlot cattle (Perry *et al.,* 1976; Lawler *et al.,* 2004) and no effects on body weight when Se was included up to 10 mg/kg in the diets of wether sheep (Cristaldi *et al.,* 2005). Likewise, Ullrey *et al.* (1977) reported that lamb body weight was unaffected by dietary Se level in feeds containing differing proportions of organic and inorganic Se. However, Kim and Mahan (2001) reported a quadratic decrease in final body weight of swine as dietary Se level was increased using sodium selenite or Se yeast. Those authors observed the most drastic decreases when selenate Se was added above 10 mg/kg and when Se yeast was added at 20 mg/kg. The present results differ from the findings with swine, as organic Se had a more dramatic deleterious affect on body weight than did selenite Se. This could be explained by organic Se not being subject to reduction to selenides by rumen microorganisms as suggested by previous research (Whanger *et al.,* 1968; Van Ryssen *et al.,* 1989 and Whanger, 2002) and thus, being more available to cause toxic effects in ruminant livestock.

From the previous results, it could be concluded that Se treatment with low levels for cultivated alfalfa plants under conditions of experimental region increased its productivity of dry matter, crude protein. Selenium and Cu concentrations were also increased (Table 1) Feed intake and feed efficiency of growing lambs was unaffected.

Table (3): Body performance, daily gain and feed efficiency in experimental groups

Items	Treatment		
	G1	G2	G3
Initial body weight, Kg	13.50	13.90	13.90
Final body weight, Kg	19.250	18.500	19.750
Body Wight changes, Kg	7.2	7.4	7.6
Body Wight changes , %	44.46	32.64	58.88
Average daily gain, g/head/day	80	82	85
Feed intake, g/head/day	733	700	700
Feed efficiency, g feed/g growth	9.16	8.54	8.23

2. Blood

The trace elements were determined in serum are shown in Table (4) with regard to Se, P, and Zn concentrations, no significant differences were observed among groups. Because of Se concentrations in serum of animals groups were in the normal ranges (0.047 – 0.050 ppm), there were no incidences of white muscle disease (WMD). On the other hand, Cu concentration in serum significantly ($P<0.05$) decreased as a result of selenium inclusion. Retention of Se, Cu and p were improved specially for copper (Table 2).

Table (4): Least squares means ± SE of Se, P, Cu, and Zn in serum of experimental groups

Items	Treatment			
	G1	G2	G3	±SE
Se, mg/dl	0.050	0.047	0.049	0.0040
P, mg/dl	4.82	4.61	4.43	0.1210
Cu, mg/dl	0.0027[a]	0.0019[b]	0.021[b]	0.00014
Zn, mg/dl	2.36	2.85	2.32	0.230

Values with different superscripts within the same row are significantly different ($p<0.05$).
SE: Standard error

Copper concentrations in serum of all animals groups were below critical levels. The normal levels of Cu ranged from 0.7 to 2.0 ppm. Serum or plasma levels are not consistently reliable of Cu deficiency. To determined maximum tolerance level of Se, three experiments were carried out with sheep by Cristaldi *et al.* (2005). The authors reported Selenium toxicosis was not found in any experiment and, therefore it was suggested that sheep and likely other ruminants can tolerance over 10.00 ppm of selenium for relatively long period of time. The present results are in harmony with the findings of Ullrey *et al.* (1977); Cuesta *et al*. 1995) Cristaldi *et al.* (2005), Davis *et al*. (2008) and Zafar *et al.*, (2008).

Concentrations of albumin and activities of Alk Phos, AST, ALT, GGT, and CK in serum collected at the termination of the experiment were, in general, in or below the normal range for adult sheep (Table 5). With regard to albumin, Alk Phos, AST, ALT, GGT, and CK concentrations, no significant differences were observed among groups.

Table (5): Least squares means ± SE of serum albumin and tissue enzyme activities present in experimental groups

Items	Treatment			
	G1	G2	G3	±SE
Albumin (g/dl)	3.1	3.0	2.9	0.42
Alk Phos (IU/L)	122.7	135.5	142.8	34.0
AST (U/l)	18.7	14.5	13.2	1.24
ALT (U/l)	10.7	15.50	8.00	1.65
GGT (IU/L)	42.8	49.5	54.8	14.0
CPK (IU/L)	11.25	12.78	11.74	2.20

SE: Standard error

In instances of Se toxicosis, the activities of these enzymes would have been increased due to tissue necrosis. Our observations agree with those reported by Cristaldi *et al.* (2005) and Davis *et al.* (2008) as albumin and enzyme activities in wether sheep after receiving up to 10 mg/kg Se were in the normal ranges. The lack of elevated enzymes, which are suggestive of tissue necrosis, further indicates that the lambs on present study were not suffering from Se toxicosis.

3. Wool characteristics

Selenium supplementation resulted significantly (P<0.05) for percentage yield of clean wool, staple strength and point of break. However there were no significant differences in wool production (g/10 cm2), average fiber diameter, staple length and staple elongation (Table, 6). Also, there were no significant differences in percentage type of medulla, percentage medullated fibers and percentage non medullated fibers (Table, 6). These results were in agreement with those reported by Cristaldi *et al.* (2005) and Freer and Dove (2002) observed that a linear increase in the wool of growing sheep as dietary Se was increased and also observed differences in wool Se of wethers receiving 6, 8, or mg of Se/kg *vs*. controls.

Although no significant differences were detected among the experimental groups in wool production, the clean yield percentage increased (P<0.05) in coincidence with the level of supplementation, where it scored for 53.51, 64.81 and 75.97 % in G1, G2 and G3, respectively.

Wool production, clean wool yield and different wool characteristics in experimental groups were showed in Table (6). Average fiber diameter and staple length showed similar trend to that of the wool production where they did not differ significantly between the experimental groups. Fry *et al.* (1996) and Wilkins *et al.* (1982) reported that the increase in wool length and fiber diameter which occurred in response to Se supplementation.

Table (6): Least squares means (± SE) of wool production, clean wool yield and different wool characteristics in experimental groups

Items		Treatment	
	G1	G2	G3
Wool production (g/10 cm^2)	9.21±1.47	9.78±1.47	11.70±1.47
Yield (%)	53.51±1.52 ^{c}	64.81±1.52 ^{b}	75.97±1.52 ^{a}
Fiber diameter (µm)	25.54±1.60	27.23 ±1.60	24.70±1.60
Staple length (mm)	4.63±0.68	5.88±0.68	6.88±0.68
Staple Strength (N/Ktex)	16.64±5.98 ^{b}	20.79±5.98 ^{ab}	38.83±5.98 ^{a}
Staple elongation (%)	19.19±3.15 ^{a}	19.86±3.15 ^{b}	17.72±3.15 ^{b}
Point of staple break (%)	49.42±3.39 ^{a}	32.67±3.39 ^{b}	43.16±3.39 ^{b}
Kemp (%)	0.33±1.37	3.50±1.37	2.92±1.37
Continues (%)	0.75±0.53	1.08±0.53	1.08±0.53
Interrupted (%)	0.09±0.16	0.17±0.16	0.42±0.16
Fine (%)	6.75±2.01	3.67±2.01	2.83±2.01
Medullated fibers (%)	7.92±2.09	8.42±2.09	7.25±2.09
Non medullated fibers (%)	92.09±2.09	91.58±2.09	92.75±2.09

Values with different superscripts within the same row are significantly different (p<0.05).
SE: Standard error

The mean values of staple strength in G2 and G3 were higher (p<0.05) than that of G1 (Table 6). This increment in staple strength might be attributed to the treatments (G2 and G3) and related with increase in fiber diameter. These findings agree with previous studies by Thompson (1998) and Thompson and Hynd (2009) who found that an increase of 1 µm in minimum fiber diameter was associated with an increase in staple strength of about 5 N/ktex.

General Discussion

Where soil conditions allow, plants take up soil selenite, selenate and selenomethionine, though no requirement by higher plants for selenium has yet been found. Selenate is absorbed by roots in strong preference to selenite; and for this reason the selenate form is preferred for addition to fertilizers (Oldfield, 1999). Plants are considered in three categories with respect to selenium content. The first two groups, accumulator plants and selenium indicator plants, absorb high quantities of selenium when grown on high selenium soils. While animals normally avoid such species, selenosis or selenium toxicity occurs when they are grazed. The third group, non-accumulator plants, includes grains and grasses of nutritional and agronomic importance and many forbs that do not accumulate selenium in levels toxic to animals when grown on seleniferous soils.

The deficiency of selenium was found to be common in ruminants (Jeffery, 2005). Compared with non-ruminants, the absorption of selenium is much lower in ruminant animals (Jerry, 2003).

The amount of absorbable inorganic selenium presented at absorption sites depends on interactions with a range of interfering substances in the diet or drinking water including iron, sulfur, phytate and antioxidants, among others. The amount of selenomethionine in forage or grain available for absorption will depend on the digestibility of the source, which is a function of both the species of animal and the nature of the ingredient, as well as the nutritional adequacy of the diet. Previously, the range between optimal and toxic levels of selenium was reported to be narrow; however, data from the present study would suggest that this range is relatively wide. Increasing dietary selenium level, regardless of source, is an effective means of increasing selenium in blood and tissues in sheep. Although trace minerals comprise less than 0.01% of the total mass of an organism, many are essential for normal function (Fisher, 1975).

CONCLUSION

Conclusively, the various dietary levels of Se affected on some physiological traits; liver function, albumin, Alk Phos and wool characteristics. Selenium is essential for normal function and interaction between trace elements which related to adaptability of small ruminants. Manipulation of dietary selenium source and level is an effective way to change the selenium content of animal tissues commonly consumed by mankind and improvement adaptability of sheep.

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لتغير فى مستوى السيلينيوم فى الغذاء وعلاقته بالقدرةعلى التأقلم فى المجترات الصغيرة

فوزى العيسوى مصطفى يونس
قسم فسيولوجى الحيوان و الدواجن – مركز بحوث الصحراء

تهدف الدراسة الى تقدير المستويات الغذائية المختلفة من السيلينيوم والمغذاه على صورة سلينات الصوديوم وعلاقته بتأقلم الاغنام. أجريت هده الدراسة بمحطة رأس سدر بمحافظة شمال سيناء والتابعة لمركز بحوث الصحراءوتمت على (١٨) حمل من الاغنام البرقى عمرها ٤ شهور ومتوسط أوزانها ١٣,٨١كم وقسمت الحيوانات الى ثلاثة مجموعات بواقع ٦حيوان بكل مجموعة.

أوضحت النتائج أن المادة الجافة والبروتين الخام للبرسيم المعامل بالسيلينيوم (فى المجموعتين الثانية والثالثة) كان اعلى مقارنة بالمجموعة المقارنة (المجموعة الاولى) بينما وجد اتجاه معاكس بالنسبة للكفائة الغذائية فى المجموعات السابقة. كما كان المحتوى من الالياف الخام والسيلينيوم والنحاس فى المجموعتين الثانية والثالثةاعلى مقارنة بالمجموعة الاولى كما سجل متوسط الزيادة اليومية للحملان خلال فترة التجربة ولم يظهر أى اختلافات معنوية بين المجموعات الثلاثة وتراوحت القيم من ٦٥,٣ الى ٧٩,٨ جم/رأس/يوم فى المجموعتين الثالثة والثانية على الترتيب. كما أن تركيز النحاس اختلف معنويا بين المجموعات التجريبية. كما كان مستوى كل من انزيم الفوسفاتيز القاعدى ، وبعض انزيمات الكبد، والكرياتنين فوسفتيز جميعها فى المستوى الطبيعى لمثل هدة الحيوانات. كما اثر التغير فى مستوى السيلينيوم تأثيرا معنويا فى نسبة محصول الصوف النظيف ومتانة الخصلة ونقطة القطع.

واتضح أن التغير فى مستوى السيلينيوم يقوم بدور فعال فى محتوى الأنسجة الحيوانية وبعض العناصر الاخرى كالنحاس وكذلك تحسن أقلمة الاغنام.

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