Egyptian J. Nutrition and Feeds (2018), 21 (1): 53-64

EFFECT OF DIFFERENT DIETARY SELENIUM SOURCES SUPPLEMENTATION ON NUTRIENT DIGESTIBILITY, PRODUCTIVE PERFORMANCE AND SOME SERUM BIOCHEMICAL INDICES IN SHEEP

E. M. Ibrahim[1] and M.Y. Mohamed[2]

[1] Anim. Prod. Depart. Fac. of Agric., Minia Univ., Minia, Egypt.

[2]Anim. Prod. Res. Institute, Agric. Res. Center, Ministry of Agric., Dokki, Giza,Egypt.

Email: emad_i@mu.edu.eg

(Received 11/6/2017, accepted 14/8/2018)

SUMMARY

A total number of 32 of Ossimi lambs averaged 29.25 ± 2.02 kg and 4 months old were used in this experiment to compare the effects of dietary supplementation of inorganic selenium (sodium selenite), organic selenium (Se-yeast) and Nano-Se particles on nutrients digestibility, nutritive value, productive performance and serum biochemical indices of lambs. The animals were allocated into four equal groups (8 lambs each). The lambs of control group were fed on basal diet containing 0.17 mg Se/kg dry matter (DM). The treated lamb groups fed on the same basal diet, in which Se at 0.30 mg/kg DM was provided as sodium selenite (SS), selenium yeast (SY) and Nano-Se particles (NS). The results showed that digestibility of DM was higher ($P<0.05$) for lambs fed SS, SY and NS than those fed control. Digestibility of OM, CP, CF, EE, NFE and the values of digestible crude protein (DCP) and total digestible nutrients (TDN) were increased ($P<0.05$) for lambs fed SY and NS compared with those fed SS or control. Averages of final body weight (FBW) were increased ($P<0.05$) for lambs fed SY and NS compared with those fed SS and control. Average of FBW was greater ($P<0.05$) for lambs fed NS than those fed SY. The averages of daily gain (ADG) were increased ($P<0.05$) for lambs fed SS, SY and NS *vs.* those fed control with significant ($P<0.05$) differences among treatments. No significant differences were detected in averages of feed intakes of Alfalfa, DM and total DM (TDM) for lambs fed SS, SY and NS *vs.* control. While, the intakes of DCP and TDN were greater ($P<0.05$) for lambs fed SS, SY and NS *vs.* those fed control with significant ($P<0.05$) differences among treatments. The averages of feed conversion (FC) of DM (FC-DM), DCP (FC-DCP) and TDN (FC-TDN) were improved ($P<0.05$) for lambs fed SS, SY and NS *vs.* those fed control. The highest values of productive performance parameters (FBW, ADG, DCPI, TDNI, FC-DCP and FC-TDN) were noticed for lambs fed NS followed by those fed SY and then SS and control. Lambs fed SY and NS had higher ($P<0.05$) values of serum total protein and globulin than those fed SS or control. Also, there was an increase ($P<0.05$) in serum glucose concentrations for lambs fed diets SS, SY and NS *vs.* control, with higher levels ($P<0.05$) in NS than in SS and SY. No significant differences were noticed in serum concentrations of albumin, cholesterol, alanine transaminase (ALT) and aspartate transaminase (AST) enzyme activities. Serum total antioxidant capacity (TAC) concentrations, glutathione peroxidase (GSH-Px) activity and testosterone levels were increased ($P<0.05$) for lambs fed SS, SY and NS *vs.* control. Higher ($P<0.05$) levels of TAC, GSH-Px and testosterone levels were observed for lambs fed NS than those fed SS and SY. It could be concluded that dietary supplementation of Nano-Se was more effective than sodium selenite and Se-yeast to improve nutrients digestibility, feeding values, growth performance, some serum metabolic indices, antioxidant status and reproductive efficiency of male lambs.

Keywords: *Selenium sources, nutrients digestibility, productive performance, serum biochemical indices, sheep.*

INTRODUCTION

Selenium (Se), as a trace mineral, has several biological functions in animals. As antioxidant, Se plays essential roles in animal nutrition, immunity, reproduction, protection of DNA, proteins from oxidation and thyroid hormone synthesis and metabolism (Lu and Holmgren, 2009; Yatoo *et al*., 2013). The enzyme I iodothyronine-5´-deiodinase is a selenoenzyme that required to convert thyroxin into the active T_3 hormone. Furthermore, Se is an integral part of the enzyme glutathione peroxidase (GSH-Px) which is important for neutralizing free radicals or oxidants (Huang *et al*., 2012). In sheep, deficiency of Se has been linked with a number of diseases mainly include white muscle disease and suppression of immune status (Rock *et al*., 2001). So, adequate supplementation of Se is of great important to avoid the risk of immune-suppression, liver necrosis, cardiovascular disease and myopathy (Hartikainen, 2005). Thus, animal health and performance negatively influenced by Se deficiency.

Dietary supplementation of Se can be provided using inorganic or organic sources. The supplemental inorganic forms of Se are commonly sodium selenite or selenate, while the organic are Se-enriched yeasts. Because of different metabolism, it has been noticed that inorganic forms of Se have lower bioavailability than the organic one (Weiss, 2005). In other words, organic Se has been shown to be more absorbed and utilized in ruminants when compared to inorganic sources (Gunter *et al*. 2003; Guyot *et al*., 2007). In beef heifers, switching from inorganic to organic Se improved meat quality and muscle Se content, confirming the greater bioavailability of the organic compared with the inorganic form (Sgoifo Rossi *et al*., 2015). The low inorganic Se absorption in ruminants could be resulted from reduction of dietary selenium (selenite and selenate) to insoluble forms such as elemental Se or selenides in the rumen environment (Mehdi *et al*. 2013).

The nanotechnology development holds unique properties for Se Nano-particles (Nano-Se), because of its novel characteristics such as high surface activity, great specific surface area, a lot of surface active centers, strong adsorbing ability and high catalytic efficiency (Skalickova *et al*., 2016). Nano-Se has been efficiently function on animal growth, reproduction and immunity systems (Shi *et al*., 2009). In sheep, Nano-Se had improved ruminal fermentation, nutrient digestibility (Shi *et al*., 2011a) and feed intake (Wang, 2011). In addition, some reports on rats and mice demonstrated that Nano-Se had higher efficiency than sodium selenite and other Se sources in up-regulating selenoenzymes, exhibiting lower toxicity (Zhang *et al*., 2001; Wang *et al*., 2007; Zhang *et al*., 2008). Subsequent studies also pointed out that Nano-Se has more beneficial effects to improve activity of glutathione peroxidase, blood biochemical indices with lower toxicity comparing with organic or inorganic Se sources (Yaghmaie *et al*., 2017).

The novel effects of supplemental Nano-Se on animal metabolism and related physiological responses, especially when comparing with selenium inorganic and organic sources, have not been fully clarified. Therefore, the presented study aimed to compare the effects of dietary supplementation of inorganic Se (sodium selenite), organic Se (Se-yeast) and Nano-Se on nutrients digestibility, nutritive value, productive performance and some serum biochemical indices of Ossimi lambs.

MATERIALS AND METHODS

Experimental design:

This study used 32 of Ossimi lambs (averaged 29.25 ± 2.02 kg and 4 months old). The experiment was carried out at the Farm of Animal Production Department, Faculty of Agriculture, Minia University during the months from January to April, 2016.

Animals were fed on concentrate feed mixture (CFM) to cover their nutrients requirements according to their live body weight (NRC, 2007). The animals were randomly divided into four equal groups (8 lambs each) of similar initial body weights. The lambs of control group were fed on basal diet containing 0.17 mg Se/kg DM. The treated lambs fed on the same basal diet, in which selenium at 0.3 mg/kg DM was provided as sodium selenite (SS), selenium yeast (SY) and Nano-Se particles (NS).

The animals were housed inside window stables for feeding lot groups. The experimental animals were fed on concentrate feed mixture, contained 48 % wheat bran, 17 % yellow corn, 13 % soybean meal,10.8 % sunflower meal, 4.2 % molasses, 4 % rice hulls, 2 % calcium carbonate and 1 % sodium chloride to cover their requirements according to their live body weight (NRC, 2007). In this study, alfalfa as roughage source was offered *ad libitum.* The calculated concentration of Se in the CFM was 0.17 mg/kg DM. The requirements of sheep for Se are between 0.1-0.3 ppm (NRC, 2007). Feed were offered twice a day at 8 am and 2 pm and drinking water were available along the experiment. The measurements of lambs' body weights were recorded at starting of the experiment and biweekly thereafter, while feed intakes recorded daily. Averages of daily gain and feed conversion rates of lambs were calculated. All the parameters were recorded at the morning before animals access to feed or water.

Dietary Sampling and laboratory analysis:

Dietary samples were collected daily in the last week of each month along the experiment period and a composite sample was performed. A portion of the composite sample was dried at 105 °C in a forced air oven till constant weight for DM determination. The rest of composite sample was dried at 70 °C for a constant weight, ground and kept in closely tied jars for laboratory analysis. Diets were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash according to AOAC (2003). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Goring and Van Soest (1970). Grasp fecal samples were collected before feeding at 7 am and 1 pm for each lamb at last week of each month and mixed together, dried on 70 °C till constant weight and analyzed for DM, OM, CP, CF, NDF, ADF, EE and ash. Total tract digestibility of DM, OM, CP, CF, NDF, ADF, EE and NFE were determined using acid insoluble ash as an internal marker according to Van Keulen and Young (1977). Approximate analysis of concentrate feed mixture (CFM), Alfalfa and total mixed ration (TMR) are presented in Table (1).

Table (1): Approximate analysis of concentrate feed mixture (CFM), Alfalfa and total mixed ration (TMR) fed to lambs (% on DM basis).

Item	CFM [1]	Alfalfa	TMR
DM	86.08	94.20	87.30
OM	95.98	89.58	95.02
CP	18.93	15.48	18.42
EE	3.15	0.76	2.79
CF	10.34	32.95	13.73
NDF	31.97	53.81	35.24
ADF	14.70	43.21	18.98
NFE	63.56	40.39	60.08
Ash	4.02	10.42	4.98

CFM[1] = Concentrate feed mixture contained 48 % wheat bran, 17 % yellow corn, 13 % soybean meal,10.8 % sunflower meal, 4.2 % molasses, 4 % rice hulls, 2 % calcium carbonate and 1 % sodium chloride.

Serum bio-indices analysis:

Non-heparinized blood samples were collected from the jugular vein of each animal. The samples were left to clot at room temperature for at least 4 h, then the clots were removed and sera were cleared and stored at -20 ºC for later assay. Serum glucose, total protein, albumin, cholesterol, alanine transaminase (ALT) and aspartate transaminase (AST) were determined colorimetrically using commercial kits. Serum globulin concentrations were calculated by difference between total protein and albumin concentrations. Serum total antioxidant capacity (TAC) and glutathione peroxidase (GSH-Px) activities were analyzed colorimetrically by STAT-LAB SZSL60-SPECTRUM, using commercial kits. Serum testosterone concentrations were measured by the radioimmunoassay technique using Coat-a-Count I^{125} commercial kits (DCP, CA 90045-5597, USA). The analyses were performed at Cairo University Research Park (CURP), Faculty of Agriculture, Cairo University.

Statistical analysis:

Data were analyzed by least square means analysis of variance using General Linear Models (GLM) procedure of the statistical analysis system (SAS, 2000). The model used to analyze the different treatments studied for lambs was as follows:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where: Yij = Observation, µ = Overall mean; Ti = Effect of i^{th} treatments and eij= Experimental error. Duncan's Multiple Range test was used to detect differences between means of the experimental groups (Duncan, 1955).

RESULTS AND DISSCUSION

Nutrients digestibility:

The data presented in Table (2) showed that digestibility coefficients of DM were higher (P<0.05) for lambs fed SS, SY and NS-supplemented diets than those fed control. Digestibility of DM, OM, CP, EE, CF, NDF and NFE was increased (P<0.05) for lambs fed SY and NS compared with those fed SS or control. There was no significant different in digestibility of ADF due to the experimental dietary treatments of selenium compared with control. The results of nutritive values indicated that the DCP and TDN values were greater (P<0.05) with feeding SY and NS compared with those fed SS and control.

Table (2): Effects of supplemental Se sources on nutrient digestibility coefficients and nutritive values of experimental treatments (Mean ± SE).

Parameter	Treatment				± SE
	Control	SS	SY	NS	
		Nutrients digestibility (%)			
DM	68.29 ^{d}	70.12 ^{c}	72.40 ^{b}	74.81 ^{a}	0.122
OM	70.28 ^{c}	71.10 ^{bc}	72.82 ^{b}	74.80 ^{a}	0.538
CP	62.13 ^{b}	63.97 ^{b}	66.36 ^{a}	68.30 ^{a}	0.686
EE	55.74 ^{c}	60.76 ^{b}	62.31 ^{b}	65.65 ^{a}	0.775
CF	59.65 ^{b}	60.27 ^{b}	64.44 ^{a}	66.29 ^{a}	0.778
ADF	55.67	56.25	57.29	60.61	1.700
NDF	60.26 ^{b}	61.82 ^{b}	63.89 ^{ab}	65.98 ^{a}	1.190
NFE	70.80 ^{b}	71.97 ^{b}	74.07 ^{a}	76.02 ^{a}	0.641
		Nutritive value (%)			
DCP	11.44 ^{b}	11.78 ^{b}	12.22 ^{a}	12.58 ^{a}	0.126
TDN	65.67 ^{b}	67.11 ^{b}	69.48 ^{a}	71.48 ^{a}	0.731

a,b,c and d : Means within the same row having different superscripts significantly different (P<0.05).
SS = Sodium selenite, SY = Selenium yeast, NS = Nano-Selenium.

The present study clearly demonstrated that supplemental SY or NS at 0.3 mg/kg DM were more efficient than SS to improve (P<0.05) nutrients digestibility and the nutritive values (DCP and TDN). In case of supplemental SS at 0.3 mg/kg DM, there was a significant (P<0.05) increase in digestibility of DM and EE with tendency to improve other nutrients digestibility and their nutritive values compared with control. This result could be discussed in the light of the finding that organic or Nano-elemental forms of selenium are absorbed more readily by ruminants than inorganic forms (Xu *et al*., 2003). These results are mostly consistent with the previous studies dealt with the effects of dietary supplementation of selenium sources on nutrients digestibility. As regard to SS, supplemental selenium at 0.2 mg/kg DM to suckling ewes significantly (P<0.05) improved their nutrient digestibility of DM, OM, EE, CF and NDF and the nutritive values of DCP and TDN, reflecting on increased birth weight and daily gain of their lambs (Ibrahim, 2016). Such improvement in nutrients digestibility was also noticed for OM and NDF in male lambs when high selenium at 0.9 mg/kg DM, as sodium selenite, was supplemented, suggesting that absorption and availability of selenium in the rumen facilitates its use by the ruminal microorganisms (Del Razo-Rodriguez *et al*., 2013).

In the current study, the finding that supplemental SY was more efficient than SS in enhancing nutrients digestibility and nutritive value could be explained in the light of the view that absorption and bioavailability of selenium is considered one of the most important factors in its utilization because selenium must be absorbed before utilization (Mahima, 2012). At this point, several studies have been compared the bioavailability of dietary supplementation of inorganic *vs*. organic selenium. They have proved that organic selenium has 120-200 % more bioavailability than sodium selenite in sheep (Hall *et al*., 2011). In ruminants, the low absorption of inorganic selenium, comparing to organic one, could be attributed to the reductive rumen environment where the microorganisms convert selenium compound to insoluble form impairing its absorption in the intestine (Serra *et al*., 1994). So, the inorganic selenium becomes less available for absorption than organic selenium. Thus the beneficial effects of organic selenium predominate over the inorganic one in ruminants (Gammelgaard *et al*., 2012; Mehdi *et al*. 2013). To this point, when Se was supplemented at 0.4 ppm, Se yeast was more effective than sodium selenite to increase (P<0.05) digestibility of DM, OM, CP, NDF and ADF in sheep (Alimohamady *et al*., 2013). In addition, dietary supplementation of SY at high levels (150 and 300 ppm) was also efficient to enhance digestibility of DM and CP in lactating dairy cows (Wang *et al.*, 2009). In goats, although supplementation with either organic or inorganic Se had no significant effect on nutrients digestibility, however, the dry matter, organic matter and crude protein intake significantly increased with organic Se than inorganic one as reported by Zohreh *et al*. (2016). They concluded that organic Se seems to be a better choice, considering the nitrogen and energy available for metabolism.

The present study illustrated that dietary supplementation of NS at 0.3 mg/kg DM to lambs significantly improved all their nutrients digestibility and nutritive values of DCP and TDN. This effect of

NS predominates over SS in enhancing all nutrients digestibility and nutritive values. This difference could be ascribed to the different metabolic way between NS and inorganic selenium in the rumen. Supplemental NS was also more potent than SY to improve digestibility of DM, OM and EE. The beneficial effects of NS on animal metabolism and nutrients digestibility could be related to its role in improving rumen fermentation and feed utilization, stimulating rumen microbial activity, digestive microorganisms or enzyme activity (Shi *et al*., 2011a). Similar results were obtained by Xun *et al.* (2012) who found that dietary supplementation of NS at high dose (4 g/kg DM) improve ($P<0.01$) ruminal fermentation and digestibility of DM, OM, CP, EE, NDF and ADF in the total tract in sheep. They also added that feeding supplemental NS could significantly increase growth and activity of cellulolytic bacteria compared to SY, and thus improved rumen fermentation. So, these studies, together with the present results, may be signifying different metabolic mechanisms exist between the different Se forms in the rumen.

In the present study, supplemental NS was more effective to increase CP digestibility by 3.5 and 6.9 % than SY and SS, respectively. These results agree with those reported by Xun *et al.* (2012) on sheep. They found that the digestibility of CP was higher with feeding NS than SY treatment, suggesting that NS supplementation could significantly increase activity of protein-decomposing bacteria and promote proteolytic digestive enzymes activity. The beneficial effect of supplemental NS to increase CP digestibility, shown in the present study, agree also with similar results reported in sheep by Shi *et al*., (2011a) and in dairy cows by Wang *et al*. (2009).

On the other hand, some studies did not signify any difference in selenium absorption and metabolism with supplementation of inorganic and organic selenium sources in goats (Palvata *et al*., 2011**)**. In addition, other study showed no significant effect of organic selenium on all nutrients digestibility's of cross-bred calves; however the disease occurrence was low in Se supplemented-calves (Vinu *et al*., 2012).

Productive performance:

The data presented in Table (3) showed that the averages of final body weight (FBW) were increased ($P<0.05$) for lambs fed SY and NS compared with those fed SS or control. Average of FBW was also greater ($P<0.05$) for lambs fed NS than those fed SY. The averages of FBW were comparable for lambs fed SS and SY. The averages of daily gain (ADG) were increased ($P<0.05$) for lambs fed SS, SY and NS compared with those fed control. Also, the differences in ADG among selenium source treatments were significant ($P<0.05$). Data showed no significant differences in averages of feed intakes of alfalfa, DM and TDM for lambs fed SS, SY and NS compared with control. Meanwhile, the intakes of DCP and TDN were greater ($P<0.05$) for lambs fed SS, SY and NS compared with those fed control with significant ($P<0.05$) differences among selenium sources treatment. The results also indicated that the averages of feed conversion (FC) of DM (FC-DM), DCP (FC-DCP) and TDN (FC-TDN) were significantly ($P<0.05$) improved for lambs fed SS, SY and NS compared with those fed control. The highest values of the previous productive performance parameters were noticed for lambs fed NS followed by those fed SY and SS.

The present results indicated that dietary supplemental SS, SY and NS were significantly able to improve FBW and ADG in sheep. Supplemental NS was more potent ($P<0.05$) to enhance ADG of lambs than SS and SY by 35.6 and 17.5 %, respectively. Also, supplemental SY was effective by 15.4 % than SS treatment. The higher improvement noticed in growth performance for lambs fed SY and NS than those fed SS could be attributed to the significant increase ($P<0.05$) in their nutrients digestibility and nutritive value, feed intakes and feed conversion, which reflected on their growth performance. The results are consistent with similar findings reported by Shi *et al*. (2011b) working on growing male goats. They found that FBW was increased ($P<0.05$) in different selenium sources-supplemented bucks compared with control, and the ADG was greater ($P<0.05$) with feeding Nano-selenium and selenium yeast than sodium selenite. Kumar *et al*. (2009) concluded that supplemental organic selenium was more effective than inorganic in improving growth performance in male lambs. In addition, FBW and ADG were significantly ($P<0.05$) improved for growing rabbits fed organic Se at 0.3 ppm (Ebied *et al*., 2012). In the same way, ADG was enhanced with supplemental selenium sources in goats (Yue *et al*., 2009).

However, some studies, showed no effect of selenium sources on ADG in calves (Gunter *et al*., 2003) and in lambs (Vignola *et al.*, 2009). Also, growth performance was not affected by supplemental organic selenium; but the disease occurrence was low in selenium supplemented-calves (Vinu *et al*., 2012). In beef heifers, also, supplemental selenium at 0.2 mg/kg DM as sodium selenite or selenium yeast did not affect their final body weight and average daily gain, however switching from inorganic to organic selenium in the last two months of fattening improved some traits of their meat quality (Sgoifo Rossi *et* *al*., 2015). The observed differences in ADG response to selenium sources between studies possibly attributed to the variation in background selenium in feedstuffs, breeds or the environmental conditions.

Table (3): Effects of supplemental Se sources on productive performance of growing lambs (Mean ± SE).

Parameter	Treatment				± SE
	Control	SS	SY	NS	
		Body weight:			
IBW (kg)	29.37	29.50	28.75	29.37	2.016
FBW (kg)	41.57 ^{c}	43.0 ^{c}	44.33 ^{b}	47.67 ^{a}	2.173
ADG (g/day)	135.56 ^{d}	150.00 ^{c}	173.11 ^{b}	203.33 ^{a}	0.007
		Feed intake (kg / day):			
Alfalfa	0.22	0.23	0.23	0.24	0.013
DMI	1.23	1.26	1.27	1.33	0.071
TDMI	1.45	1.49	1.50	1.57	0.083
DCPI	0.166 ^{d}	0.176 ^{c}	0.183 ^{b}	0.198 ^{a}	0.002
TDNI	0.953 ^{d}	1.000 ^{c}	1.042 ^{b}	1.122 ^{a}	0.011
		Feed conversion (FC, kg feed / kg gain):			
FC-DM	10.70 ^{a}	9.93 ^{b}	8.67 ^{c}	7.72 ^{d}	0.034
FC-DCP	1.23 ^{a}	1.17 ^{b}	1.06 ^{c}	0.97 ^{d}	0.011
FC-TDN	7.03 ^{a}	6.67 ^{b}	6.02 ^{c}	5.52 ^{d}	0.057

a,b,c and d : Means within the same row having different superscripts significantly different (P<0.05).
SS = Sodium selenite, SY = Selenium yeast, NS = Nano-Selenium.

Serum biochemical metabolites:

As shown in Table (4), there were significant (P<0.05) increase in serum concentrations of total protein (TP) and globulin, but not albumin, for lambs fed SY and NS compared with those fed SS and control. This means that either supplementation with SY or NS was more effective than SS to improve protein synthesis and metabolism. The increase in serum TP could be related with the significant (P<0.05) improvement observed in digestibility of CP, DCPI and nutritive value of DCP for lambs fed SY or NS supplemented diets, reflecting the significant improvement gained in their FBW and ADG. According to Pechova *et al.* (2012), working on goats, supplementation of mothers with selenium both in organic (SY) and inorganic (SS) forms was sufficient to prevent selenium deficiency in kids at the time of weaning. They found similar response of increased (P<0.05) serum TP concentrations for bucks whose mothers supplemented with SY, however, their serum TP levels remains unchanged with supplemental SS.

Table (4): Effects of supplemental Se sources on biochemical parameters of growing lambs (Mean ± SE).

Parameter	Treatment				± SE
	Control	SS	SY	NS	
Total protein (g/dl)	5.40^{b}	5.40^{b}	5.83^{a}	5.75^{a}	0.105
Albumin (g/dl)	3.70	3.63	3.82	3.63	0.043
Globulin (g/dl)	1.70^{b}	1.77^{b}	2.01^{a}	2.12^{a}	0.085
Glucose (mg/dl)	59.92^{c}	65.34^{b}	67.66^{b}	72.75^{a}	1.454
Cholesterol (mg/dl)	95.05	96.42	95.79	92.59	1.905
ALT (U/L)	14.82	14.38	14.03	14.30	0.337
AST (U/L)	109.74	108.57	109.41	109.89	2.220
TAC (mM/L)	1.57^{c}	2.0^{b}	2.20^{b}	2.96^{a}	0.127
GSH-Px (mU/ml)	93.41^{c}	115.92^{b}	130.49^{ab}	143.76 ^{a}	6.378
Testosterone (ng/ml)	245.21^{c}	288.88^{b}	297.01^{b}	383.65 ^{a}	20.007

a,b,c: Means within the same row having different superscripts significantly different (P<0.05).
SS = Sodium selenite, SY = Selenium yeast, NS = Nano-Selenium.

The data indicated that serum globulin concentrations were higher ($P<0.05$) by 13.6 and 20.0 % with feeding SY and NS, respectively than SS. Although the levels of serum globulin were comparable with SY and NS, supplemental NS increased serum globulin by 5.5 % compared with SY. These findings may be indicated that either supplementation with Nano-Se or organic Se (SY) was more effective than inorganic Se (sodium selenite) to increase serum globulin concentrations. These results agree with similar response of Wistar male rats fed sodium selenite and Se nanoparticles at 150 ppb Se, where Nano-selenium was potent ($P<0.05$) to increase serum globulin concentrations by 8.5 % than sodium selenite (Bunglavan *et al*., 2014). The presented results are also consistent with similar increased serum globulin levels in layer chicks fed Nano-Se at 0.3 ppm (Mohapatra *et al.*, 2014), male buffalo calves supplemented with 0.3 ppm Se (Mudgal *et al*., 2008), and buffalo heifers supplemented with Se at 0.2 ppm (Ganie *et al*., 2012). In addition, serum globulin levels were increased ($P<0.05$) concomitant with improving immune response and antioxidant function for growing rabbits fed organic Se at 0.3 ppm (Ebied *et al*., 2012).

Data in Table (4) indicated that, There were significant (($P<0.05$) increase in serum glucose concentrations for lambs fed diets SS (65.34), SY (67.66) and NS (72.75) *vs*. control (59.92 mg/dl). The values of serum glucose concentrations were higher (($P<0.05$) with feeding NS than those of SS and SY. This response of elevated serum glucose levels for lambs fed SS, SY and NS-supplemented diets could be explained by the significant ($P<0.05$) improvement occurred in their nutrients digestibility of CF and NFE. Otherwise, the increase in serum glucose concentrations may be an indication of shifting the site of carbohydrate digestion from the rumen to the intestinal section (McDonald *et al.,* 1994). In this way, these increments in serum glucose concentrations for lambs fed different selenium sources, in the present study, may account for the significant ($P<0.05$) improvement that was noticed in their productive performance of FBW and ADG.

The data showed no significant differences in serum concentrations of ALT and AST enzymes activity in lambs fed supplemental selenium sources of SS, SY and NS compared with control. This finding agree with similar trend of unchanged serum ALT and AST enzyme activities in lambs supplemented with organic SY at 0.3 mg/kg DM (Faixova *et al*., 2007). In the same way, these enzymes activity did not change in Merino lambs fed either inorganic SS (sodium selenite) or organic selenium (Se-plex) at 0.3 mg/kg (Antunovic *et al*., 2014). Also in goats, similar unchanged trend of serum AST enzyme activity was detected for bucks whose mothers supplemented with either sodium selenite or selenium yeast at 0.3-0.9 mg/goat/day (Pechova *et al.*, 2012). These studies, together with the present results, may be indicated a case of normal hepatic metabolism in sheep fed diets supplemented with either inorganic or organic selenium sources.

Data in Table (4) showed no significant differences in serum concentrations of albumin and cholesterol with feeding lambs different selenium sources. This results agree with similar trend of unchanged serum albumin and cholesterol levels in male goats fed either sodium selenite or selenium yeast at 0.3 mg selenium /kg DM (Kamdev *et al*., 2015); and in growing male rabbits fed organic Se at 0.3 ppm (Ebied *et al*., 2012). Also, similar results had been shown in Merino lambs fed either inorganic Se (sodium selenite) or organic selenium (Se-plex) at 0.3 mg/kg (Antunovic *et al*., 2014).

There were significant (($P<0.05$) increase in serum total antioxidant capacity (TAC) concentrations for lambs fed SS, SY and NS *vs*. control. The values of serum TAC concentrations were higher ($P<0.05$) with feeding NS than those of SS and SY (Table, 4). In addition, data showed that serum glutathione peroxidase (GSH-Px) activity was increased ($P<0.05$) for lambs fed diets SS, SY and NS *vs*. control. Serum GSH-Px activity was higher ($P<0.05$) with feeding NS than those of SS and SY. Generally, the present results indicated that dietary supplementation at 0.3 mg/kg DM of different Se sources as SS, SY and NS to growing lambs were effective to significantly increase serum TAC and GSH-Px activity, improving their antioxidant status. To compare the potency of these Se sources in improving antioxidant function, supplemental NS was more effective than SS and SY by 48.0, 34.5 % with serum TAC and by 25.9, 11.4 % with serum GSH-Px activity, respectively. These findings on sheep strongly agree with similar observations of Shi *et al*. (2011b) on growing male goats fed Se at 0.3 mg/kg DM as sodium selenite, selenium yeast and Nano-Se. They found that serum GSH-Px activity was higher ($P<0.05$) with feeding Nano-Se than sodium selenite and selenium yeast concomitant with increased serum Se concentrations and improved growth performance, suggesting that elemental Nano-Se could be utilized more effectively comparing with inorganic or organic Se. The highest activity of serum GSH-Px detected with supplemental NS, in the present study on sheep and others on goats (Shi *et al.*, 2011b), could be discussed in the light of the view that Nano-Se particles displayed a preeminent bioavailability because of its specific properties such as high catalytic efficiency, strong adsorbing ability and low toxicity, explaining the greater bioavailability of Nano-Se when compared with organic or inorganic Se forms (Zhang *et al.*, 2008).

The presented data illustrated that, supplemental SS and SY led to increasing serum GSH-Px activity was comparable, are in agreement with similar results observed in Merino lambs fed inorganic or organic Se at 0.3 mg/kg (Antunovic *et al*., 2014). These findings are also standing with results reported on sheep supplemented with Se yeast alone (Faixova *et al*., 2007) or various forms of selenium (Palvlata *et al*., (2013). Although the levels of serum GSH-Px activity were statistically comparable with SS and SY, supplemental SY increased serum GSH-Px activity by 13.0 % compared with SS. To this point, supplemental Se was noticed to increase plasma GSH-Px activity, but this increase was less pronounced with inorganic compared with organic Se (Wang and Xu, 2008). In addition, dietary supplementation with organic Se at 0.3 ppm significantly improved serum TAC and reduced lipid peroxidation, enhancing humeral immune response and antioxidant status in growing rabbits (Ebied *et al*., 2012). However, in contrast to the above mentioned observations, some studies showed no effect of Se sources or concentration on blood GSH-Px activity in broilers (Payne and Southern, 2005) or GSH-Px activity increase much faster with selenite compared to organic Se in goats (Pavlata *et al*., 2011).

In the present study, it was interesting to note that the higher ($P<0.05$) serum TAC and activity of serum GSH-Px for Ossimi lambs fed supplemental NS was concomitant with greater ($P<0.05$) FBW and ADG compared to those fed SS or SY. These findings agree with recent results reported by Yaghmaie *et al*. (2017) on Makuei lambs received sodium selenite and Nano-Se treatments. They found out that supplemental Se increased ($P<0.05$) serum Se concentrations and GSH-Px activity in which it was predominant in Nano-Se than in sodium selenite group, detecting a positive relationship ($r= 0.98$, $P<0.01$) between weight gain and serum GSH-Px activity in lambs received Nano-Se treatment compared with sodium selenite. So, the present results, together with the reports of Shi *et al.* (2011b) on growing male goats and Yaghmaie *et al*. (2017) on Makuei lambs, may suggest that effect of supplemental Nano-Se in improving antioxidant status and increasing weight gain is acceptable and preferable than sodium selenite in sheep.

Data presented in Table (4) showed that serum testosterone concentrations were higher ($P<0.05$) for lambs fed diets SS, SY and NS than the control. Also, serum testosterone levels were higher ($P<0.05$) with feeding NS than SS and SY. These results indicated that serum testosterone levels were increased by 17.8, 21.2 and 56.45 % due to supplemental SS, SY and NS compared with control, respectively. The positive effect of supplemental SY on increasing serum testosterone levels of lambs agree with similar response of significant increase in serum testosterone observed in male Baladi goats fed a diet supplemented with selenium yeast at 0.15 ppm, improving their reproductive efficiency (El-Sisy *et al*., 2008). It has also been reported that supplementation of 0.6 mg / head / day Se as sodium selenite for 100 days increased the percentages of spermatids in male goats (Ganabadi *et al*., 2010). In this way, selenium is stated to be essential in maintaining male fertility (Brown and Arthur, 2001); and it is required for biosynthesis of testosterone and for formation and normal development of spermatozoa (Behne *et al*., 1996). Also, both the testis and epididymis require bioavailability of selenium to synthesize selenoproteins (Shalini and Bansal, 2007). That is why serum testosterone levels were significantly lowered in Se-deficient than Se-adequate rats (Behne *et al*., 1996).

The beneficial effects of different Se sources in increasing serum testosterone levels, shown in the present study with feeding SS, SY and NS could be associated with their significant effectiveness in enhancing serum GSH-Px activity. Selenium is an essential component of GSH-Px, an enzyme involved in detoxification of hydrogen peroxide and lipid hydroperoxides. The enzyme GSH-Px has been localized immunocytochemically in the cytoplasm of Leydig cells (Murakoshi *et al*., 1983). So, it is possible that the metabolic pathway of testosterone biosynthesis requires higher activity of GSH-Px to protect against peroxidation (Behne *et al*., 1996). Accordingly, the significant increases in serum testosterone concentrations for lambs fed different Se sources may be related to the significant concomitant increase in their serum GSH-Px activity, protecting the testes and Leydig cells against peroxidation and thus improving its steroidogenic function.

CONCLUSION

Based on the results of the present study, dietary supplementation of Nano-Se could be utilized more effectively than sodium selenite and Se-yeast to improve nutrients digestibility, feeding values, growth performance, some serum metabolic indices, antioxidant status and reproductive efficiency of male Ossimi lambs.

REFERENCES

Alimohamady, R.; H. Aliarabi; A. Bahari and A. H. Dezfoulian (2013). Influence of Different Amounts and Sources of Selenium Supplementation on Performance, Some Blood Parameters, and Nutrient Digestibility in Lambs. Biol. Trace Elem. Res., 154:45–54.

Antunović Z.; J. Novoselec; M. Šperanda; T. Klapec; S. Ćavar; B. Mioč; Ž Klir; V. Pavić and R. Vuković (2014). Influence of dietary supplementation with selenium on blood metabolic profile and thyroid hormones activities in fattening lambs. Pak. Vet. J., 342: 224-228.

AOAC (2003): Association of official analytical chemists. Official Methods of Analysis (17^{th} ed.), Arlington, USA.

Behne D.; H. Weiler and A. Kyriakopoulos (1996). Effects of selenium deficiency on testicular morphology and function in rats. J. Repro. Fert., 106: 291–297.

Brown K.M. and J. R. Arthur (2001): Selenium, selenoproteins and human health: a review. Publ. Health Nutr., 4: 593–599.

Bunglavan, S. J.; A. K. Garg; R. S. Dass and S. Shrivastava (2014). Effect of supplementation of different levels of selenium as nanoparticles/sodium selenite on blood biochemical profile and humoral immunity in male Wistar rats. Veterinary World, *7*(12): 1075-1081.

Del Razo-Rodriguez, O.E.; J.E. Ramirez-Bribiesca; R. Lopez-Arellano; A.L. Revilla-Vazquez; S.S. Gonzalez-Munoz; M.A. Cobos-Peralta; L.M. Hernandez-Calva and L.R. McDowell (2013). Effects of dietary level of selenium and grain on digestive metabolism in lambs. Czech J. Anim. Sci., 58: 253-261.

Duncan, D.B. (1955). Multiple range test and multiple F-test. Biometrics, 11: 1-42.

Ebeid T.; H. Zeweil; M. Basyony and H. Badry (2012). The impact of incorporation of organic selenium into meat on growth performance, antioxidant status, and immune response in growing rabbits. World Rabbit Science Association, *Proceedings 10 th World Rabbit Congress-September 3 - 6, 2012– Sharm El- Sheikh –Egypt*, 861- 864.

El-Sisy, G. A.; M. A. Abdel-Razek; A. A. Younis; A. M. Ghallab and M. S. S. Abdou (2008). Effect of dietary zinc or selenium supplementation on some reproductive hormone levels in male Baladi goats. Global Vet., 2(2): 46–50.

Faixova, Z.; S. Faix; L. Leng; P.Vaczi; Z. Makova and R. Szaboova (2007). Hematological, blood and rumen chemistry changes in lambs following supplementation with se-yeast Acta. Vet. Brno, 76: 3-8.

Gammelgaard, B.; L. H. Rasmussen; C. Gabel-Jensen and B. Steffansen (2012). Estimating Intestinal absorption of inorganic and organic selenium compounds by in vitro flux and Biotransformation studies in Caco-2 cells and ICP-MS detection. Biolog. Trace Elem. Res., 145: 248-256.

Ganabadi S.; Y. Halimatun; K. L. Amelia Choong; A. Nor Jawahir and A. Mohammed Hilmi (2010). Effect of Selenium Supplementation on Spermatogenic Cells of Goats. Mal. J. Nutr., 16(1): 187 – 193.

Ganie, A. A.; R. P. S. Baghel; V. Mudgal; and G. G. Sheikh (2012). Effect of selenium supplementation on blood metabolic profile of buffalo heifers. Indian J. Anim. Res., 46: 407-409.

Goring, H.K. and P. J. Van Soest (1970). Forage fiber analysis U.S.D.A. Agricultural hand book No. 379.

Gunter, S.A.; P.A. Beck and J.M. Phillips (2003). Effects of supplementary selenium source on the performance and blood measurements in beef cows and their calves. J. Anim. Sci. 81, 856–864.

Guyot, H.; P. Spring; S. Andrieu and F. Rollin (2007). Comparative responses to sodium selenite and organic selenium supplements in Belgium Blue cows and calves. Livest. Sci., 111: 259–263.

Hall, J.A.; R.J. Van Saun; G. Bobe; W.C. Stewart and W.R. Vorachek (2011). Organic and inorganic selenium: I. Oral bioavailability in ewes. J.Anim. Sci., 90:568-576.

Hartikainen, H. (2005). Biochemistry of selenium and its impact on food chain quality and human health. Journal of Trace Elements in Medicine and Biology, 18:309-318.

Huang, Z.; A.H. Rose and P. R. Hoffmann (2012), The role of selenium in inflammation and immunity: from molecular mechanism to therapeutic opportunities. Antioxidants and Redox Signaling, 16: 705-743.

Ibrahim, E.M. (2016). The impact of dietary supplementation of iodine and selenium on nutrients digestibility and productive performance of ewes and their suckling lambs. Egyptian J. Nutrition and Feeds. 19 (2): 255-263.

Kamdev S. I.; R. S. Dass; A. K. Garg; S. Sahu and S. Gogoi (2015). Effect of different selenium sources (Selenium yeast and Sodium selenite) on haematology, blood chemistry and thyroid hormones in male goats (*Capra hircus*) Indian J. Anim. Res., 49 (6) 788-792.

Kumar, M.; A. K. Garg; R.S. Dass; V.K. Chaturvedi; V. Mudgal and V.P. Varshney (2009). Selenium supplementation influences growth performance, antioxidant status and immuneresponse in lambs. Anim. Feed Sci. Technol., 153: 77–87.

Lu, J. and A. Holmgren (2009). Selenoproteins. J. Biol. Chem., 284: 723-727.

Mahima, A.; K. Verma; A. Kumar; A. Rahal; V. Kumar and D. Roy (2012). Inorganic versus organic selenium supplementation. Pakistan Journal of Biological Sciences, 15:418-425.

McDonald, P.; R. A. Edwards and J. F. D. Greenhalgh (1994). Factors affecting the utilization of metabolisable energy. In: Animal nutrition. 4th ed. Longman, England.

Mehdi Y; J. Hornick; L. Istasse and I. Dufranse (2013). Selenium in the environment, metabolism and involvement in body functions. Molecules, 18: 3292-331.

Mohapatra, P.; R. K. Swain; S. K. Mishra; T. Behera; P. Swain; S. S. Mishra; N. C. Behura; S. C. Sabat; K. Sethy; K. Dhama; and P. Jayasankar (2014). Effects of dietary nano-selenium on tissue selenium deposition, antioxidant status and immune functions in layer chicks. Int. J. Pharmacol., 10: 160-167.

Mudgal, V.; A. K. Garg; R. S. Dass and V. P. Varshney (2008). Effect of selenium and copper supplementation on blood metabolic profile in male buffalo (*Bubalus bubalis*) calves. Biol.Trace Elem. Res., 121(1): 31-38.

Murakoshi, M.S; S. Osamura; P.D. Yoshimura and K. Watanabe (1983). Immunocytochemical localization of glutathione (GSH-Px) in the rat testis. Acta Histochemica et Cytochemica, 16:335-345.

NRC (2007): Nutrient requirements of small ruminants sheep, goats, cervids, and new world camelids. National Academies Press: Washington, DC, USA.

Palvlata, L.; L. Misurova; A. Pechova and R. Dvorak (2011). The effect of inorganic and organically bound forms of selenium on glutathione peroxidase activity in the blood of goats. Veterinarian Med., 56:75-81.

Panev, A.; K. Hauptmanova; L. Pavlata; A. Pechova; J. Filipek and R Dvorak (2013). Effect of supplementation of various selenium forms and doses on selected parameters of ruminal fluid and blood in sheep. Czech J. Anim. Sci., 58: 37-46.

Payne, R. L. and L. L. Southern (2005). Comparison of inorganic and organic in broilers. Poult. Sci. 84, 898–902.

Pechova, A.; L. Sevcikova; L. Pavlata and R. Dvorak (2012). The effect of various forms of selenium supplied to pregnant goats on selected blood parameters and on the concentration of Se in urine and blood of kids at the time of weaning. Veterinarni Medicina, 57, 8: 394–403.

Rock M. J.; R. L. Kincaid and G. E. Carstens (2001). Effects of prenatal source and level of dietary selenium on passive immunity and thermo metabolism of newborn lambs. Small Rum. Res., 40:129–138.

SAS (2000): SAS/STAT Guide for personal computers, SAS Inst., Cary. N.C., USA

Serra, A.; K. Nakamura; T. Matsui; T. Harumoto and T. Fujihara (1994). Inorganic selenium for sheep I. Selenium balance and selenium levels in the different ruminal fluid fractions. Asian J. Anim. Sci., 7**:** 83-89.

Sgoifo Rossi, C.A.; R. Compiani; G. Baldi; C.E.M. Bernardi; M. Muraro; J.-P. Marden and V. Dell'Orto (2015). The effect of different selenium sources during the finishing phase on beef quality. Journal of Animal and Feed Sciences, 24:93–99.

Shalini, S. and M. P. Bansal (2007). Alterations in selenium status influences reproductive potential of male mice by modulation of transcription factor NFkB. Biometals, 20: 49–59.

Shi, L.; W. Xun; W. Yue; C. Zhang and Y. Ren (2011b). Effect of sodium selenite, Se-yeast and nano-elemental selenium on growth performance, Se concentration and antioxidant status in growing male goats. Small Ruminant Res., 96: 49-52.

Shi, L.; W. Xun; W. Yue; C. Zhang; Y. Ren; Q. Liu; Q. Wang and L. Shi (2011a). Effect of elemental nano-selenium on feed digestibility, rumen fermentation, and purine derivatives in sheep. Anim Feed Sci. Technol., 163:136–142.

Shi, L.; R. Yang and W. Yue (2009). Comparison of nano-selenium and methionine-selenium on Growth and selenium content in blood and tissue of Boer goats lamb (Chinese). J. Domest. Anim. Ecol., 19: 33-39.

Skalickova S.; V. Milosavljevic; K. Cihalova; P. Horky; L. Richtera and V. Adam (2016). Perspective of selenium nanoparticles as a nutrition supplement, Nutrition. doi: 10.1016/ j.nut.2016.05.001.

Van Keulen, J. and B. A. Young (1977). Evaluation of acid insoluble ash as a natural marker in ruminant digestibility studies. J. Anim. Sci., 44:282.

Vignola, G.; L. Lambertini; G. Mazzone; M. Giammarco; M. Tassinari; G. Martelli and G. Bertin (2009). Effects of selenium source and level of Supplementation on the performance and meat quality of lambs. Meat Sci., 81: 678–685.

Vinu, M. N.; P. Gangadevi; A. D. Mercy; K. S. Anil and K. Shyama (2012). Effect of dietary supplementation of organic selenium on growth performance and nutrient utilization in crossbred calves. J. Vet. Anim. Sci., 43:36-40.

Wang, L. S. A. (2011). Recent advances of nano-selenium in animal nutrition (Chinese). Zhongguo Xu Mu Shou Yi; 4:14-21.

Wang, C.; Q. Liu; W. Z. Yang; Q. Dong; X. M. Yang; D. C. He; P. Zhang; K. H. Dong and Y. X. Huang (2009). Effects of selenium yeast on rumen fermentation, lactation performance and feed digestibilties in lactating dairy cows. Live Sci., 126:239–244.

Wang, H, J. Zhang, and H. Yu (2007). Elemental selenium at nano size possesses lower toxicity without compromising the fundamental effect on selenoenzymes: Comparison with selenomethionine in mice. Free Radic. Biol. Med., 42, 10:1524-1533.

Wang, Y. B. and B. H., Xu (2008). Effect of different selenium source (sodium selenite and selenium yeast) on broiler chickens. Anim. Feed Sci. Technol., 144: 306-314.

Weiss, W. P. (2005). Selenium sources for dairy cattle. Proceedings of Tri–State Dairy Nutrition Conference. Fort Wayne, Indiana, USA.

Xu, B. H.; Z. R. Xu and M. S. Xia (2003). Effect of nano red elemental selenium on gpx activity of broiler chick kidney cells in vitro. Wuhan Univ. J. Nat. Sci., 8: 1167–1172.

Xun W.; L. Shi; W. Yue; C. Zhang; Y. Ren and Qiang (2012). Effect of High-Dose Nano-selenium and Selenium-Yeast on Feed Digestibility, Rumen Fe mentation, and Purine Derivatives in Sheep. Liu Biol. Trace Elem. Res., 150:130–136.

Yaghmaie, P.; A. Ramin; S. Asri-Rezaei and A. Zamani (2017). Evaluation of glutathion peroxidase activity, trace minerals and weight gain following administration of selenium compounds in lambs. Veterinary Research Forum, 8, 2: 133 – 137.

Yatoo, M. I.; A. Saxena; P. M. Deepa; B. P. Habeab; S. Devi; R. S. Jatav and U. Dimri (2013). Role of Trace elements in animals: A Review. Vet. World, 6: 963-967.

Yue, W. B.; C. X., Zhang; L. G. Shi; Y. S. Ren; Y. S. Jiang and D. O. Kleemann (2009). Effect of supplemental selenomethionine on growth performance and serum antioxidant status in Taihang black goats. Asian-Aust. J. Anim. Sci., 22: 365–370.

Zhang, J. S.; X. Y. Gao; L. D. Zhang and Y. P. Bao (2001). Biological effects of a nano red elemental selenium. Biofactors, 15: 27–38.

Zhang, J. S.; X. F. Wang and T. W. Xu (2008). Elemental selenium at nano size (Nano-Se) as a potential chemopreventive agent with reduced risk of selenium toxicity: comparison with Se-methylselenocysteine in mice. Toxicol. Sci., 101, 22–31.

Zohreh T.; S. Karimi; H. Mehrban and A. Moharrery (2016). Supplementation of different selenium sources during early lactation of native goats and their effects on nutrient digestibility, nitrogen and energy status. Journal of Applied Animal Research, DOI: 10.1080/09712119.2016.1259625.

تأثيرالإمداد الغذائى بمصادر مختلفة من السلينيوم على معاملات الهضم، الأداء الإنتاجى وبعض مؤشرات السيرم البيوكيميائية فى الأغنام

عمادالدين محمد إبراهيم[1] و محمود ياسين محمد[2]

[1]قسم الإنتاج الحيوانى - كلية الزراعة - جامعة المنيا – المنيا - مصر.

[2]معهد بحوث إنتاج الحيواني - وزارة الزراعة - الدقي – الجيزة – مصر.

استخدم فى هذه الدراسة عدد إثنان وثلاثون من الحملان الأوسيمى بمتوسط وزن 29.25 ± 2.02 كجم ، 4 شهور من العمر لمقارنة تأثير الإمداد الغذائى بالسيلنيوم الغير عضوي ، السلينيوم العضوي و النانو سلينيوم على معاملات الهضم، القيمه الغذائية ، الأداء الإنتاجى و بعض مؤشرات السيرم البيوكيميائية للحملان. تم توزيع الحملان إلى أربعة مجموعات متساوية (8 حملان لكل منها). غذيت حملان مجموعة المقارنة على عليقة أساسية تحتوى على 0.17 ملجم سلينيوم/ كجم مادة جافة. بينما غذيت حملان المجموعات الثلاثه الأخرى على نفس العليقة الأساسية (الكنترول) مضافاً إليها 0.3 ملجم سلينيوم / كجم مادة جافة في صورة سلينات صوديوم (SS) ، خميرة السلينيوم (SY) و النانو سلينيوم (NS) .

أظهرت النتائج أن معاملات هضم الماده الجافة كانت أعلى معنوياً (P<0.05) للحملان التى غذيت على المعاملات الثلاثة (**SS،SY، NS**) بالمقارنة بالكنترول. كما زادت معنوياً (P<0.05) معاملات هضم الماده العضوية، البروتين الخام، الألياف الخام، المستخلص الأثيري، الكربوهيدرات الذائبة و القيمة الغذائية (البروتين المهضوم و المركبات الغذائية المهضومة) للحملان المغذاه على معاملات **SY** ، **NS** مقارنة بالحملان المغذاه على معاملة **SS** أو الكنترول. كما زادت متوسطات وزن الجسم النهائى للحملان المغذاه على معاملات **SY** ، **NS** مقارنة بالحملان المغذاه على معاملة **SS** أو الكنترول. زادت متوسطات وزن الجسم النهائى للحملان المغذاه على معاملة **NS** مقارنة بالحملان المغذاه على معاملة **SY**. كما ارتفع معدل الزيادة اليومية فى الوزن معنويا (P<0.05) للحملان المغذاه على المعاملات **SS ،SY** ، **NS** بالمقارنة بتلك المغذاه على الكنترول مع وجود فروق معنوية (P<0.05) بين المعاملات. لم تلاحظ أية فروق معنوية في متوسطات المأكول من البرسيم ، المأكول من الماده الجافه و المأكول الكلي من الماده الجافه بينما كان المأكول من البروتين المهضوم والمركبات الغذائية المهضومه أعلى معنوياً (P<0.05) للحملان التى غذيت على المعاملات **SS** ، **SY** ، **NS** بالمقارنة بالكنترول مع وجود فروق معنوية بين المعاملات. كما حدث تحسين (P<0.05) في معدلات التحويل الغذائي للماده الجافه ، البروتين المهضوم والمركبات الغذائيه الكليه المهضومه للحملان التى غذيت على المعاملات **SS** ، **SY** ، **NS** مقارنة بالكنترول و لوحظ أيضا ارتفاع في قيم الأداء الإنتاجي (وزن الجسم النهائي، معدل الزياده اليومية، المأكول من البروتين المهضوم، المأكول من المركبات الغذائية المهضومة، معدل التحويل الغذائي للبروتين المهضوم ومعدل التحويل الغذائي للمركبات الغذائية الكلية المهضومه) للحملان التى غذيت على معاملة **NS** يليها معاملات **SY** ثم **SS** والكنترول. وقد حدث ارتفاع معنوي (P < 0.05) في تركيزات السيرم من القدره الكلية المضاده للأكسده (TAC) ونشاط إنزيم GSH-Px ومستوي هرمون التستيستيرون للحملان التى غذيت على المعاملات **SS** ، **SY** ، **NS** مقارنة بالكنترول. كما لوحظ ارتفاع مستويات القدره الكلية المضاده للأكسده (TAC) ونشاط إنزيم GSH-Px و مستوي هرمون التستيستيرون للحملان التى غذيت على معاملة **NS** مقارنة بتلك التي غذيت على معاملات **SS** ، SY.

يمكن أن نستخلص من هذه الدراسه أن الإمداد الغذائي بالنانو سلينيوم كان أكثر فاعلية من سلينات الصوديوم أو خميرة السلينيوم في تحسين معاملات الهضم الغذائية، القيمه الغذائية، معدل النمو، بعض مؤشرات السيرم البيوكيميائية، حالة مضادات الأكسده و الكفاءة التناسلية لذكور الحملان.