PRODUCTIVE PERFORMANCE AND SOME BIOCHEMICAL INDICES OF OSSIMI EWES AND THEIR LAMBS TO DIETARY SELENIUM SUPPLEMENTATION

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ABSTRACT

A total number of 24 Ossimi pregnant ewes were used to evaluate the effects of inorganic selenium (Se) and Nano-Se supplementation upon productive performance, nutrients digestibility, some biochemical indices and antioxidant status of Ossimi ewes and their suckling lambs. The ewes were fed on a basal diet (control) supplemented with Se at 0.3 mg as sodium selenite (T1) or Nano-Se (T2) /kg DM. The results showed that OM, CP, EE, CF and ADF digestibility were increased ($P<0.05$) for ewes fed T2 compared to those fed T1 or the control. Birth weight, FBW and ADG were improved ($P<0.05$) for lambs born to ewes fed T1 or T2 diets vs. control. Milk yield, FCM, milk fat yield and milk protein yield recorded higher ($P<0.05$) values for ewes fed T1 or T2 than the control one. Serum IgG, total protein, albumin, globulin, thyroid hormones, total antioxidant capacity and glutathione-S-transferase levels were higher ($P<0.05$) for both ewes fed T1 or T2 and their lambs than the respective control. Serum cholesterol, liver enzymes (ALT and AST) and urea concentrations showed a decrease ($P<0.05$) for ewes fed T1 or T2 and their respective lambs compared to those fed the control one

It is concluded that dietary supplementation of Nano-Se at 0.3 mg/Kg DM to Ossimi ewes, at late gestation and the suckling period, was more potent than inorganic Se to improve their nutrients digestibility, productive performance, some serum biochemical indices and antioxidant status, leading to better growth performance and health of their suckling lambs.

Keywords: *Inorganic Selenium, Nano-selenium, digestibility, productive performance, serum biochemical indices, Ossimi ewes.*

INTRODUCTION

Nutrients with antioxidants play crucial roles in immunity function and growth promoters, and their addition to feed could improve the antioxidant performance of ruminants (Tian *et al.*, 2018; Tian *et al.*, 2022). Selenium (Se) is among these nutrients which, it is a component of selenoenzyme glutathione peroxidase (GSH-Px), metabolizing hydrogen peroxide and lipid peroxide, thus neutralizing free radicals and promoting immunity functions (Silveira *et al.*, 2021; Salles *et al.*, 2022). Hence, dietary Se supplementation could affect the ruminal fluid microbial function via its antioxidant effects and the modulation of the immune function (Hendawy *et al.*, 2022; Tian *et al.*, 2022). As well, Se is a key structural component in selenocysteine, that exists in the active sites of iodothyronine deiodinase and thioredoxin reductases enzymes that are involved in thyroid hormones metabolism (Adadi *et al.*, 2019; Arshad *et al.*, 2021). So, it is believed

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that Se can influence the growth of ruminants through its regulation of thyroid hormone levels (Kieliszek and Blazejak, 2016).

It has been reviewed that Se levels in soils and plants are low in many regions worldwide, including Egypt (Abdelrazek and Fayed 2025), leading to wide spread of Se deficiency symptoms in ruminants (Wang *et al.,* 2019; Rajab *et al.,* 2023). The Se deficiency in ruminants could induce metabolic disorders, reduced productivity, health issues and even mortality resulting in financial losses for sheep producers (Hofstee *et al.,* 2020). In ewes, a specific clinical sign of Se deficiency is muscular dystrophy, particularly affecting lambs born to selenium-deficient mothers (Lee *et al.,* 2019). Additionally, Se deficiency contributes to fertility issues, abortions, retained placenta, and health problems in newborns, such as higher neonatal mortality, reduced vitality, impaired suckling reflex, and weakened immune function, making the lambs more vulnerable to infections (Milewski *et al.,* 2021; Pecoraro *et al.,* 2022). During the third trimester of pregnancy period, fetal growth accelerates, leading to an increased transfer of maternal Se to the developing fetus. Consequently, insufficient Se intake in pregnant and lactating ewes may induce Se deficiency in nursing ewes and their newborns lambs (Goof 2018; Lee *et al.,* 2019), potentially impacting their immunity and productive performance.

Nanotechnology offers an innovative approach to enhance animal health and productive performance via providing nutrients and improving the quality of animal-derived products (Malyugina *et al.,* 2021). Nanoparticles, with their unique physicochemical properties such as small size (1–100 nm), high stability, hydrophobicity, large surface area, enable efficient dispersion, cellular uptake, and interaction with biological systems (Malyugina *et al.,* 2021; Gu and Gao, 2022). Selenium nanoparticles, in particular, have gained attention for their high bioavailability, low toxicity, and superior efficacy in enhancing growth, reproduction, immunity, antioxidant enzyme activity and nutrient digestibility in ruminants, making them a sustainable and effective alternative for dietary supplementation of traditional inorganic and organic Se sources (Malyugina *et al.,* 2021; Han *et al.,* 2021; Ferrari *et al.,* 2023). Therefore, the present study aimed to evaluate the effects of inorganic Se and Nano-Se upon productive performance, nutrients digestibility and some biochemical indices as well as the antioxidant status of Ossimi ewes and their suckling lambs.

MATERIALS AND METHODS

Animals:

Twenty-four Ossimi pregnant ewes averaged 38.06 ± 2.09 kg and 2.5-3 years old at 4 -6 weeks of late-gestation were used in this study, which was carried out at the Farm of Animal Production Department., Faculty of Agriculture, Minia University, El-Minia, Egypt.

Feeding and Management:

Ewes were fed on a concentrate feed mixture (CFM) to cover their nutrients requirements according to their live body weight (NRC, 2007). The ewes were randomly divided into three equal groups (8 ewes each) of similar initial body weights. The 1st group was fed on un-supplemented basal diet (control), but the 2nd and 3rd groups were fed on the basal diet supplemented with 0.3 mg Se as sodium selenite (T1) or Nano-Se (T2) /kg DM, respectively. The basal diet was consisted of CFM (40 % wheat bran, 30 % yellow corn, 17 % soybean meal, 10 % wheat straw, 2 % calcium carbonate and 1 % sodium chloride) and alfalfa hay (AH) that offered *ad libitum*.

The ewes were housed inside window stables and fed by using group feeding system. The calculated concentration of Se in the CFM was 0.19 mg/kg DM. The NRC (2007) have been recommended a dietary level of 0.30 mg Se / kg DM for sheep. The ewes were fed on supplemented diet treatments starting at 4 – 6 weeks of late-gestation and during the suckling period for three months. Feed was daily offered twice at 8 am and 2 pm and fresh water was always available to the ewes. The mean DMI, at the last week of each month, was considered in calculation of digestibility and feeding values of dietary treatments. The body weights of ewes in different experimental groups were recorded at the beginning of experiment during late-gestation and at lambing and then at every month during suckling period. Body weights of lambs born to ewes in each group were recorded within 24 hours from birth and then biweekly during suckling period for the consecutive three months and the averages of lambs' daily weight gain were calculated.

Dietary Sampling and laboratory analysis:

Dietary samples were daily collected at the last week of each month during the experimental 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 the 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 (2019). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Goring and Van Soest (1970). Daily grab fecal samples of each month were collected before feeding at 7 am and 2 pm for each ewe at the last week of each month and mixed, dried at 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 CFM, AH and total mixed ration (TMR) are presented in Table (1).

Table (1): Proximate analysis of concentrate feed mixture, alfalfa hay and total mixed ration fed to Ossimi ewes (% on DM basis).

Item	CFM	AH	TMR
DM	**88.92**	**84.20**	**87.27**
OM	**92.24**	**88.51**	**90.93**
CP	**17.88**	**14.15**	**16.58**
EE	**3.45**	**1.04**	**2.61**
CF	**10.58**	**24.98**	**15.62**
NFE	**60.32**	**48.33**	**56.12**
NDF	**26.26**	**60.20**	**38.14**
ADF	**13.89**	**48.34**	**25.95**
Ash	**7.76**	**11.49**	**9.07**

CFM: Concentrate feed mixture contained 40 % wheat bran, 30 % yellow corn, 17 % soybean meal, 10 % wheat straw, 2 % calcium carbonate and 1 % sodium chloride. AH: Alfalfa hay.TMR: Total mixed ration

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Milk sampling and analysis:

Daily milk yield was measured biweekly from each ewe starting from the fifth day of lambing till weaning. Milk yield was determined using lamb-sucking technique according to Ashmawy (1980). Lambs were separated from their mothers at 4.0 pm on the day before measuring milk yield. In the following day, lambs were weighed at 8.0 am, and left to suckle their dams till satisfied, then reweighed and kept away from their mothers. The residual milk in the udder of each dam was hand-milked and weighed. At 4.0 pm, the lambs were weighed again before and after suckling and the residual milk in the udder was also hand-milked and weighed. The amount of milk consumed by each lamb in the morning and afternoon was calculated by the differences between the weight recorded before and after suckling. The ewes' hand-milked yield, in the morning and afternoon, was added to the daily milk intake by her suckling lambs to give an estimate of 24-hr milk production. Biweekly, representative milk samples were individually collected post-lambing till weaning. Milk samples were analyzed for protein, fat, lactose and solid not fat (SNF) using infrared spectrophotometry MilkoScan (model 130 series_ type 10900 FOSS electric - Denmark). Fat corrected milk yield (FCM) was calculated by the equation:

(FCM (6%) for milk sheep) = daily milk yield × (0.428 + 0.095 × fat %) according to Economides and Louca (1981).

Serum bio-chemical indices analysis:

Non-heparinized blood samples were collected from the jugular vein of the experimental ewes and their suckling lambs every two weeks before feeding and drinking. Blood samples were left to clot at room temperature for at least 4 h, then the clots were removed and sera were cleared by centrifugation at 1500×g for 20 min and stored at -20 ºC for later assay. Serum total protein, albumin, glucose, cholesterol, aspartate transaminase (AST), alanine aminotransferase (ALT) and urea were determined colorimetrically using Bio-diagnostic product kits (Egypt). Serum globulin concentrations were calculated by difference between total protein and albumin concentrations. Levels of immunoglobulin G (IgG) were quantified three times at 12-, 24- and 48-hours post-lambing using bovine IgG ELISA kits (Alpha Diagnostic international, Texas, USA and Kamiya Biomedical Company, Seattle, Washington, USA, respectively). Serum triiodothyronine (T_3) and thyroxin (T_4) concentrations were determined by ELISA (Enzyme-Linked Immune-Sorbent Assay) technique using EIA kits (Prechek Bio, Inc., Atlaslink technology, California-USA). The T_3 / T_4 ratio was calculated. Serum total antioxidant capacity (TAC) and glutathione-S-transferase (GST) levels were analyzed colorimetrically by STAT-LAB SZSL60-SPECTRUM, using Bio-diagnostic kits (Bio-diagnostic Company, Egypt).

Statistical analysis:

Data were analyzed by least square means analysis of variance using General Linear Model procedure of the statistical analysis system (SAS, 2012). The model used to analyze the different traits studied for ewes or lambs was as follows:

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

Where: Y_{ij}: observation, μ: General mean; T_i: Effect of i^{th} treatments and e_{ij}: random error. Duncan's Multiple Range test was used to detect differences between means of the experimental groups (Duncan, 1955).

RESULTS AND DISSCUSION

Nutrients digestibility and feeding values of the experimental diets:

The results presented in Table (2) have shown the effect of inorganic Se (Sodium selenite, T1) or Nano-Se (T2) dietary supplementation on nutrients digestibility and nutritive values of the experimental diets. The data revealed that DM and NDF digestibility were increased (P <0.05) for ewes fed T1 or T2 compared to that of control ration. Meanwhile, values of OM, CP, EE, CF and ADF digestibility were greater (P<0.05) for ewes fed T2 than those fed T1 or control with significant (P < 0.05) differences among ewes fed T1 and T2. As far as nutritive values are concerned, values of DCP were increased (P<0.05) for ewes fed T2 compared to T1 or control with a significant (P < 0.05) difference among ewes fed T1 and T2. Meanwhile, values of TDN were higher (P<0.05) for ewes fed T1 or T2 compared to control with insignificant differences between the two supplements. These findings related to nutrients digestibility and nutritive values are in agreement with other studies (Zhang *et al.*, 2020 and Pan *et al.*, 2021), confirming that Se supplementation can improve nutrients digestibility in ruminants, and this may be ascribed to the increase in rumen microbial counts and enzyme activity (Liu *et al.*, 2019; Cui *et al.*, 2021). In the same way, when Se was added at 0.3 mg to the basal diet in any form (inorganic, organic and Nano) resulted in a significant (P< 0.05) increase in the digestion coefficients of DM, OM, CP, EE, CF, NDF, ADF and NFE compared to those of control (Vajpeyee *et al.*, 2024). In another study, the digestibility of DM, OM, CP, NDF and ADF were also increased (p<0.05) with Nano-Se supplemented diet in dairy cows, suggesting that adding Nano-Se at a moderate dose (0.3 mg Se /kg DM) was beneficial for nutrients digestion (Liu *et al.*, 2024). Taken together, dietary Se supplementation, in ruminants, can positively impacted the fermentation in multiple ways: modifying the microbial structure of the rumen promoting the growth of bacteria that obtain more selenium, digest fiber better, having probiotic/antioxidant effects; producing more VFA, favorable pH levels can be achieved, rumen resistance to pathogens can be increased, inflammatory and oxidative stress signaling cascades can be modulated; and finally Se as an antioxidant/anti-inflammatory, along with production of VFA and promoting beneficial bacteria growth, may be corrected the oxidative stress and inflammation in the digestive tract, leading to optimal gastrointestinal functioning (Hendawy *et al.*, 2022). This ongoing discussion could explain the improvement in nutrients digestibility and feeding values that were observed in the present study, especially in response to dietary Nano-Se supplementation.

Productive performance of ewes and their suckling lambs:

The results presented in Table (3) indicated that there were no significant differences in IBW, FBW and DMI among ewes fed T1 (Sodium selenite), T2 (Nano-Se) or control. Meanwhile, values of DCPI and TDNI were increased (P<0.05) for ewes fed T1 or T2 when compared to control. Accordingly, DM, OM and CP intakes were found to be similar among the control and Se-supplemented groups (Kumar *et al.*, 2022). This may indicate that supplementation of different sources of Se at 0.3 ppm level had no effect on palatability and feed intake. In the same way, Liu *et al.*, (2024) noticed that dietary Nano-Se supplementation in dairy cows had no effect on DMI. The present results are in the same line with previous works, which indicated that either levels or sources of Se did not influence FBW or DMI in Awassi ewes (Kasim *et al.*, 2023; Kareem *et al.*, 2024).

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Table 2 . Effects of inorganic Se or Nano-Se dietary supplementation on nutrients digestibility and nutritive values of experimental diets (Mean ± SEM).

Parameters	Treatments			± SEM
	Control	T1	T2	
Nutrients digestibility (%):				
DM	77.47 [b]	80.38 [a]	81.11 [a]	0.30
OM	78.98 [c]	80.78 [b]	81.69 [a]	0.17
CP	70.21 [c]	73.49 [b]	78.44 [a]	0.16
EE	71.37 [b]	72.42 [b]	76.09 [a]	0.21
CF	68.07 [c]	70.59 [b]	73.94 [a]	0.15
NDF	54.24 [b]	56.57 [a]	57.73 [a]	0.52
ADF	42.47 [c]	44.79 [b]	50.24 [a]	0.32
Nutritive values (%):				
DCP	11.64 [c]	12.18 [b]	13.01 [a]	0.03
TDN	67.51 [b]	70.41 [a]	71.55 [a]	0.36

[a,b,c] means within the same row having different superscripts significantly different ($P<0.05$).
T1: Inorganic Se (0.3 mg/kg DM), T2: Nano-Se (0.3 mg/kg DM).

In case of lambs, Table (3) showed that values of BW, FBW and ADG were improved significantly ($P<0.05$) by 14.25 and 31.84; 10.05 and 25.32; 8.97 and 23.74 % for lambs born to ewes fed T1 or T2 diets vs. control, respectively. Also, the differences in BW, FBW and ADG between lambs born to ewes fed T1 and T2 was significant ($P<0.05$) in favor of T2. This improvement may be explained as Se may affect growth performance via activating the conversion of tetraiodothyronine (T_4) into the more active triiodothyronine (T_3), a process mediated by the enzyme 5-iodothyronine deiodinase, which is a Se-dependent selenoprotein, and it is also the last selenoprotein whose activity is affected in the case of Se deficiency (Li *et al.,* 2022). Furthermore, the improvement in growth performance could be ascribed to the involvement of Se in regulating several enzymatic systems that interfere with energetic metabolism (Saleh and Ebeid, 2019). Besides, sodium selenite and Nano-Se were shown to increase serum T_3 concentration and participated in modulating mRNA expression of IGF-I and insulin receptors, thus consequently promoting growth performance traits (Aghwan *et al*. 2013). As well, Se is transmitted through the placenta to the fetus, milk and colostrum to the newborn, resulting in improved immunity and growth (Chen *et al.*, 2019). These findings are supported by previous studies (Yaghmaie *et al*. 2017; Ibrahim and Mohamed, 2018; Salam *et al.*, 2021; Vajpeyee *et al.*, 2024). On the other hand, some studies showed that Nano-Se supplementation had no significant effect on growth performance of Moghani lambs (Ghaderzadeh, 2016) or Barbari bucks (Kumar *et al.,* 2022).

Table 3: Effects of inorganic Se or Nano-Se dietary supplementation on growth performance of ewes and their sucking lambs (Mean ± SEM).

Parameters	Treatments			± SEM
	Control	`T1	T2	
Ewes:				
IBW (late-gestation), kg	36.92	38.67	38.58	2.09
FBW (kg/day)	38.50	39.50	39.67	1.68
AHI (kg/day)	0.49	0.51	0.51	0.02
CFMI (kg/day)	0.91	0.94	0.94	0.04
DMI (kg/day)	1.40	1.45	1.45	0.07
DCPI (g/head/day)	162.96 [c]	176.61 [b]	188.65 [a]	0.58
TDNI (g/head/day)	945.14 [b]	1020.95 [a]	1037.48 [a]	5.32
Suckling lambs:				
Birth weight (kg)	3.58 [c]	4.09 [b]	4.72 [a]	0.09
FBW (kg)	17.42 [c]	19.17 [b]	21.83 [a]	0.39
ADG (g/day)	184.45 [c]	201.00 [b]	228.23 [a]	5.42

[a,b,c] means within the same row having different superscripts significantly different (P<0.05).
T1: Inorganic Se (0.3 mg/kg DM), T2: Nano-Se (0.3 mg/kg DM).

Data presented in Table (4) indicated that milk yield, FCM, fat and protein yields recorded higher (P<0.05) values for ewes fed T1 or T2 than those of control one. Meanwhile, feed efficiency as FCM/DMI and lactose yield were increased (P<0.05) for ewes fed T2 compared to those fed T1 or control. The observed positive effect of Se supplementation on milk production could be associated with the improvement that noticed in nutrients digestibility (Table 2), serum metabolites (Table 6) and antioxidant status (Table7) of ewes in the present study. The increment that occurred in milk production could be explained in the way that Se or Nano-Se is necessary for ewes to enhance their immune functions (Tian *et al.*, 2022), acting as a scavenger of oxygen-free radicals (Silveira *et al.*, 2021) and improving intestinal absorption (Gangadoo *et al.*, 2020) reflecting on optimizing milk production in small ruminants (Hashem and EL –Zarkouny, 2016). In addition, this improvement may be associated with improved fiber digestion (Table, 2) because Se supplementation improves the activity of fibrolytic bacteria in the rumen and absorption in the intestine (Rabee *et al.*, 2023). As well, this improvement in milk production following Se supplementation could result from increased energy availability rather than solely from reducing oxidative stress or sustaining redox balance. This is because generating antioxidant defenses and repairing cellular damage caused by free radicals demand significant energy expenditure. By ensuring adequate Se levels in plasma to stabilize redox homeostasis, this energy can be preserved and redirected toward productive processes such as milk synthesis. Furthermore, the increase in milk yield might also stem from reduced free radical damage in mammary gland tissue, enhancing the efficiency of milk synthesis by supporting healthier gland function (Arshad *et al.*, 2021). These results are reinforced with previous reports which indicated that either levels or sources of supplemental Se increased milk yield, milk fat yield and milk protein yield in dairy cows (Ullah *et al.*, 2019; Zhang *et al.*, 2020; Liu *et al.*, 2024); Zaraibi goats (Gaafar *et al.*, 2021).

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Table 4: Effects of inorganic Se or Nano-Se dietary supplementation on milk production and its composition of Ossimi ewes.

Parameters	Treatments			±SEM
	Control	T1	T2	
Milk yield (g/head/day)	359.79 ^{c}	405.67 ^{b}	474.50 ^{a}	4.47
FCM (g/head/day)	361.76 ^{c}	408.52 ^{b}	480.43 ^{a}	5.27
DMI (kg/day)	1.40	1.45	1.45	0.07
FCM/DMI	0.26 ^{b}	0.28 ^{b}	0.33 ^{a}	0.01
Milk composition (g/kg)				
Fat	6.08	6.09	6.15	0.10
Protein	4.31	4.68	4.74	0.14
Lactose	4.11	4.14	4.18	0.20
Solid not fat	9.14	9.55	9.71	0.24
Ash	0.72	0.74	0.79	0.03
Total solids	15.22	15.66	15.87	0.28
Milk constituents yield (g/d)				
Fat	21.87 ^{c}	24.73 ^{b}	29.19 ^{a}	0.45
Protein	15.50 ^{c}	19.00 ^{b}	22.51 ^{a}	0.56
Lactose	14.77 ^{b}	16.81 ^{b}	19.81 ^{a}	0.76

^{a,b,c} means within the same row having different superscripts significantly different ($P<0.05$).
T1: Inorganic Se (0.3 mg/kg DM), T2: Nano-Se (0.3 mg/kg DM).

As shown in Table (4), no significant changes were noticed in milk composition (g/kg) among ewes fed T1 or T2 when compared to control. in this regard some studies have shown that Se supplementation had no effect on milk components (Bagnicka *et al.,* 2017; Vasil *et al.,* 2017; Han *et al.,* 2021; Barcelos *et al.,* 2023; Liu *et al.,* 2024).

Serum biochemical indices of ewes and their suckling lambs:

The data presented in Table (5) showed the concentrations of serum IgG (µg/ml) for Ossimi ewes and their lambs at 12, 24 and 48 hrs. post lambing. The results indicated that serum IgG concentrations for ewes fed T1 (Sodium selenite) or T2 (Nano-Se) and their respective lambs were increased ($P<0.05$) at 12, 24 and 48 hrs. post-lambing compared to those of control diet. It was clear to notice that serum IgG concentrations of the ewes fed T2 and their suckling lambs were higher ($P<0.05$) than those fed T1 or control at all examined times post-lambing. These findings could be explained as Se is crucial for modulating immune function, in particular non-specific immune response and its deficiency has been associated with impaired immune system performance (Milewski *et al.,* 2021; Pecoraro *et al.,* 2022; Tian *et al.,* 2022). According to Hall *et al.,* (2013), Se supplementation may improve the lymphocytes proliferation, which may signify the increase in IgG concentration in the present study. Similar results were documented with Nano-Se supplementation in suckling lambs (Salam *et al.,* 2021) and in suckling Friesian calves (Shams *et al.,* 2020).

Table 5 : Effects of inorganic Se or Nano-Se dietary supplementation on serum immuno-globulin G (IgG, mg/ml) concentrations of Ossimi ewes and their lambs (Mean ± SEM).

Time post lambing	Treatments			±SEM
	Control	T1	T2	
Ewes:				
12 hrs.	7.37 [c]	8.66 [b]	9.43 [a]	0.07
24 hrs.	8.78 [c]	10.07 [b]	11.51 [a]	0.15
48 hrs.	8.34 [c]	9.73 [b]	10.69 [a]	0.12
Suckling Lambs:				
12 hrs.	8.25 [c]	9.50 [b]	10.20 [a]	0.13
24 hrs.	9.77 [c]	11.00 [b]	11.91 [a]	0.21
48 hrs.	9.47 [c]	10.70 [b]	11.48 [a]	0.16

[a,b,c] means within the same row having different superscripts significantly different (P<0.05).
T1: Inorganic Se (0.3 mg/kg DM), T2: Nano-Se (0.3 mg/kg DM).

The data presented in Table (6) summarized the effects of Se supplementation on some serum biochemical indices for the ewes and their lambs. Most of the determined biochemical indicators were within the normal reference values (Kaneko *et al.,* 2008) indicating proper nutrition and normal metabolic processes. The results showed that serum concentrations of total protein, albumin and globulin were increased (P<0.05) for ewes fed T1 or T2 and their respective lambs compared to those fed control. In this regard, it has been suggested that Nano-Se supplementation may promote the efficiency of protein utilization, improve ruminal fermentation and nutrients digestibility (Shi *et al.,* 2011 and Wang *et al.,* 2019), thus could lead to the increment that occurred in serum metabolites observed in the presented study. In the same way, Liu *et al.,* (2024) reported that adding Nano-Se to dairy cows' diets at 0.1, 0.2 and 0.3 mg/kg DM had increased (P<0.05) blood metabolites concentrations compared to a control diet.

No significant changes were observed in serum glucose concentrations among ewes fed T1 or T2 and their respective lambs compared to those fed control (Table, 6). These results are supported by some works which indicated that dietary Se supplementation exhibited no effects on serum glucose of male buffalo calves (Mudgal *et al.,* 2008); ewe lambs (Mousaie *et al.,* 2014) and dairy goats and their respective kids (Barcelos *et al.,* 2022)

As shown in Table (6), serum cholesterol concentrations were decreased (P<0.05) for ewes fed T1 or T2 as well as their suckling lambs compared to their respective control with no significant differences between T1 and T2. The decline in total cholesterol levels could point out the positive effect of dietary Nano-Se supplementation on energy metabolism and lipid profile (Ibrahim and Mohamed, 2018). The physiological status of animals may also affect their levels of total cholesterol, and the lower levels are related to an increased energy requirement (Halawa *et al.,* 2023a). The present results are in the same line with previous works which indicated that Nano-Se supplementation decreased serum cholesterol levels in Karadi lambs (Bolshakova and Aljaf 2022) and Dorper Sheep (Budak, 2024).

As shown in Table (6), the levels of AST and ALT showed a significant decrease (P<0.05) for ewes fed T1 or T2 rations, and their suckling lambs compared to their respective control. They also decreased

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($P<0.05$) for ewes fed T2 and their lambs more than those fed T1. The decreased activity of these enzymes observed in this study, however such levels were within the normal values (Lepherd *et al.,* 2009) and may indicate that Se supplementation had no adverse effect on liver health status (Alahmadi *et al.,* 2020). In this regard, earlier studies showed that serum AST and ALT activities significantly increased in case of liver necrosis incidence or other diseases that damaged liver tissue (Alimohamady *et al.,* 2013; Mousaie *et al.,* 2014). Moreover, these decreases in AST and ALT activities, observed in the current study, could be attributed to the role of Se in removing hydrogen peroxide via the action of the glutathione peroxide enzyme (Haenlein and Anke 2011; Abdel Ghfar *et al.,* 2022). These results are reinforced by previous reports which indicated that Nano-Se supplementation decreased AST and ALT activities in Ossimi ewes (Halawa *et al.,* 2023a); male lambs (Aljaf and Bolshakova, 2023) and Dorper sheep (Budak, 2024).

The data in Table (6) showed that urea concentrations were decreased ($P<0.05$) for ewes fed T1 or T2 and their suckling lambs compared to their respective controls. They also decreased ($P<0.05$) for ewes fed T2 and their lambs more than those fed T1. The significant decrease in urea concentrations noticed for ewes receiving treatments, in particular Nano-Se, as compared to the control may signify an improvement in normal kidney functions. In this respect, Ucar *et al.,* (2010) found that Se, as an antioxidant, helps the body to get rid of urea damaging effects. This could account for the decreased urea levels observed in the presented study, suggesting a protective role of Nano-Se against kidney dysfunctions. In this respect, similar results were documented on different animal species treated with Nano-Se (Qin *et al.,* 2016; Halawa *et al.,* 2023b; Liu *et al.,* 2024).

Thyroid hormones and antioxidant status of ewes and their suckling lambs:

Profiles of serum thyroid hormone concentrations and antioxidant status of the ewes and their respective lambs are illustrated in Table (7). The data showed that serum thyroid hormone concentrations (T_3 and T_4) were higher ($P<0.05$) for both ewes fed T1 (Sodium selenite) or T2 (Nano-Se) and their lambs when compared to their respective control. The levels of T_3 and T_4 hormones were also noticed to be increased ($P<0.05$) for ewes fed T2 and their suckling lambs compared to those fed T1. Meanwhile, the values of the T_3/T_4 ratio did not change among treatments. These findings were consistent with those of Salam *et al.,* (2021) who reported that giving pregnant ewes Nano-Se at 0.1 and 0.2 mg / kg DM increased T_3 and T_4 of their suckling lambs by 36.25 and 45.31; 2.08 and 9.4 %, respectively based on the control. A similar trend of increasing T_3 levels, but not for T_4 or T_4/T_3 ratio, due to vitamin E plus Se supplement was detected in suckling lambs (Ibrahim, 2017). The enhancement in thyroid hormones levels could be explained by the fact that Se serving as a critical structural element in selenocysteine, which exists in the active sites of iodothyronine deiodinase and thioredoxin reductases enzymes, which are involved in thyroid hormones metabolism (Adadi *et al.,* 2019; Arshad *et al.,* 2021).

Table 6: Effects of inorganic Se or Nano-Se dietary supplementation on some serum biochemical indices of Ossimi ewes and their lambs (Mean ± SEM).

Parameters	Treatments			± SEM
	Control	`T1	T2	
Ewes:				
Total protein (g/dl)	6.37 [b]	7.31 [a]	7.61 [a]	0.28
Albumin (g/dl)	4.12 [b]	4.53 [a]	4.68 [a]	0.18
Globulin (g/dl)	2.25 [b]	2.78 [a]	2.93 [a]	0.17
A/ G ratio	1.83	1.63	1.58	0.08
Glucose (mg/dl)	78.54	79.17	79.39	1.58
Cholesterol (mg/dl)	100.20 [a]	93.81 [b]	90.73 [b]	1.84
AST (U/L)	54.67 [a]	46.50 [b]	30.17 [c]	1.93
ALT (U/L)	28.66 [a]	26.50 [b]	22.33 [c]	0.62
Urea (mg/dl)	67.74 [a]	61.25 [b]	45.59 [c]	1.62
Suckling lambs:				
Total protein (g/dl)	6.13 [b]	7.09 [a]	7.61 [a]	0.12
Albumin (g/dl)	3.26 [b]	3.74 [a]	4.68 [a]	0.07
Globulin (g/dl)	2.88 [b]	3.35 [a]	2.93 [a]	0.07
A/ G ratio	1.14	1.12	1.58	0.03
Glucose (mg/dl)	75.53	76.65	79.39	5.06
Cholesterol (mg/dl)	97.72 [a]	90.12 [b]	90.73 [b]	1.83
AST (U/L)	45.67 [a]	42.83 [b]	30.17 [c]	1.59
ALT (U/L)	26.22 [a]	22.06 [b]	22.33 [c]	1.45
Urea (mg/dl)	76.94 [a]	59.17 [b]	45.59 [c]	3.38

[a,b,c,] means within the same row having different superscripts significantly different (* $P<0.05$),
Cont.: control, T1: Sodium selenite (0.3 mg / kg DM), T2: Nano selenium (0.3 mg /kg DM)
AST = aspartate transaminase
ALT = alanine transaminase

Therefore, the current findings suggest that dietary Nano Se supplementation may have enhanced metabolic functions in Ossimi ewes and their suckling lambs, potentially explaining the observed increases in nutrients digestibility and overall production efficiency.

Additionally, other data in Table (7) showed that serum total antioxidant capacity (TAC) and glutathione-S-transferase (GST) levels were higher ($P<0.05$) for ewes fed T1 or T2 and their respective lambs when compared to control. It was observed that the values of TAC and GST concentrations increased ($P<0.05$) for ewes fed T2 and their lambs compared to those fed T1. This increase in antioxidant levels could be explained by the ability of nano particles to trap free radicals with a greater antioxidant effect and have an increased adsorptive ability due to interactions between the nanoparticles and NH, C=O, COO-, and C-N functional groups of proteins (Zhang *et al*. 2007; Vajpeyee *et al.*, 2024). The significant increase of GST and TAC concentrations may indicate that maternal Se supplementation at late pregnancy and the suckling period could enhance the antioxidant

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status of Ossimi ewes and their respective lambs. These findings are in the same line with the previous findings which indicated that Se supplementation increased TAC concentrations (Sushma *et al.* 2015; Shi *et al*. 2018; Abdel-Raheem *et al.*, 2019; Vajpeyee *et al.*, 2024), and GST in small ruminant (Mohamed *et al.*, 2017; Szeligowska *et al.*, 2022).

Table 7: Effects of inorganic Se or Nano-Se dietary supplementation on thyroid hormone concentrations and serum antioxidant status of Ossimi -9ewes and their lambs (Mean ± SEM).

Parameters	Treatments			± SEM
	Control	`T1	T2	
Ewes:				
T_3 (nmol/l)	1.98 [c]	2.33 [b]	2.75 [a]	0.04
T_4 (nmol/l)	38.95 [c]	45.85 [b]	55.61 [a]	1.27
T_3/T_4	0.05	0.05	0.05	0.01
TAC (mM/L)	1.58 [c]	2.14 [b]	2.73 [a]	0.06
GST (U/ml)	90.31 [c]	127.01 [b]	148.47 [a]	3.26
Suckling lambs:				
T_3 (nmol/l)	2.02 [c]	2.49 [b]	3.06 [a]	0.06
T_4 (nmol/l)	46.68 [c]	60.21 [b]	75.42 [a]	1.98
T_3/T_4	0.043	0.041	0.041	0.01
TAC (mM/L)	1.95 [c]	2.73 [b]	3.36 [a]	0.07
GST (U/ml)	58.84 [c]	105.62 [b]	144.20 [a]	3.18

[a,b,c,] means within the same row having different superscripts significantly different (* P<0.05),
Cont.: control, T1: Sodium selenite (0.3 mg / kg DM), T2: Nano selenium (0.3 mg /kg DM)
TAC = total antioxidant capacity
GST = glutathione-S- transferase

Conclusion

Based on the present study, it could be concluded that dietary supplementation of Nano-Se at 0.3 mg/Kg DM to Ossimi ewes, at late gestation stage and the suckling period, was more potent than inorganic Se (sodium selenite) to improve their nutrients digestibility, productive performance, some serum biochemical indices and antioxidant status, leading to better growth performance and health of their suckling lambs.

Ethics statement

All animal procedures were approved by the Animal Care and Use Committee of Faculty of Agriculture, Minia University and were in accordance with the university's guidelines for animal research (MU FA 0311123).

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الملخص العربى

الأداء الإنتاجي وبعض المؤشرات البيوكيميائية للنعاج الأوسيمي وحملانها للإمداد الغذائي بالسلينيوم

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استخدم فى هذه الدراسة عدد أربعة وعشرون من النعاج الأوسيمى العشار لتقييم تأثير الإمداد الغذائى بالسيلنيوم الغير عضوي والنانو سلينيوم على الأداء الإنتاجى، معاملات الهضم الغذائية، بعض مؤشرات السيرم البيوكيميائية و حالة مضادات الأكسده للنعاج الأوسيمي وحملانها الرضيعة. غذيت النعاج على العليقة الأساسية (الكنترول) مضافاً إليها ٠.٣ ملجم سلينيوم / كجم مادة جافة في صورة سلينات صوديوم (T1) أو نانو سلينيوم (T2) .

أظهرت النتائج أن قيم معاملات هضم كلا من الماده العضوية، البروتين الخام، المستخلص الأثيري، الألياف الخام و الألياف المستخلصه بالمحاليل الحامضية ارتفعت معنوياً (P<0.05) للنعاج المغذاه على المعامله (T2) مقارنة بتلك المغذاه على الكنترول أو المعاملة (T1). زادت متوسطات وزن الميلاد، وزن الجسم النهائي ومعدل النمو اليومي معنوياً (P<0.05) للحملان المولودة للنعاج المغذاه على المعاملات (T1) أو (T2) مقارنة بالكنترول على الترتيب. سجلت النعاج التى غذيت على المعاملات (T1) أو (T2) قيما أعلى معنوياً (P<0.05) في إنتاج اللبن، محصول اللبن المعدل لنسبة الدهن، محصول دهن اللبن ومحصول بروتين اللبن مقارنة بتلك المغذاة على الكنترول. كان تركيز السيرم من الأمينوجلوبيولين، البروتينات الكلية، الألبيومين، الجلوبيولين، هرمونات الغدة الدرقية، القدره الكلية المضاده للأكسده وكذلك إنزيم الجلوتاثيون – إس- ترانسفيريز أعلى معنويا (P<0.05) لكلا من النعاج المغذاه على المعاملات (T1) أو (T2) وحملانها الرضيعة مقارنة بتلك المغذاه على الكنترول. وقد حدث انخفاض معنويا (P <0.05) في تركيزات السيرم من الكولستيرول، نشاط انزيمات الكبد (AST ،ALT) وتركيز اليوريا لكلا من النعاج المغذاه على المعاملات (T1) أو (T2) وتوابعها من الحملان مقارنة بتلك المغذاه على العليقة الكنترول.

نستخلص من هذه الدراسة أن الإمداد الغذائي بالنانو سلينيوم بتركيز ٠.٣ ملجم / كجم مادة جافة ،خلال الفترة الأخيرة من الحمل وفترة الرضاعة، كان أكثر فاعلية من السلينيوم غير العضوي (سلينات الصوديوم) في تحسين معاملات الهضم الغذائية، الأداء الإنتاجي وبعض مؤشرات السيرم البيوكيميائية وكذلك حالة مضادات الأكسده للنعاج الأوسيمي مؤديا إلى أداء نمو وحالة صحية أفضل لحملانها الرضيعة.

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