

## **EFFECTS OF DIETARY NANO-ZINC AND NANO-SELENIUM ADDITION ON PRODUCTIVE AND PHYSIOLOGICAL PERFORMANCE OF GROWING RABBITS AT FATTENING PERIOD**

**Noha T.H. Tag-El Din**

*Animal Prod. Dept., Fac. Agric. Damietta Univ. Egypt.*

*(Received 5/2/2019, accepted 26/3/2019)*

### **SUMMARY**

**T**his study was designed to evaluate the effects of dietary Nano-zinc (Nano-Zn) and Nano-selenium (Nano-Se) supplementation on growth performance, nutrients utilization, carcass parameters and blood plasma biochemical in growing rabbits. A total of 50, six-week-old New Zealand White (NZW) rabbits of about 815 g l.b.w. were randomly distributed into five equal groups. The control group was fed on a basal diet without any supplement; the second and third groups were fed the basal diet supplemented with 30 and 60 mg Nano-Zn/kg, respectively, while the fourth and fifth groups were fed the basal diet supplemented with 0.1 and 0.3 mg Nano-Se/kg, respectively during the experimental period (6-12 wks of age). The results revealed that rabbits fed diet supplemented with different Nano-Zn or Nano-Se levels had higher ( $P>0.05$ ) live body weight at 12 wks than the control. Moreover, body weight gain, feed conversion ratio and protein efficiency ratio were insignificantly improved comparing with the control group at the whole experimental period (6-12 wks of age), rabbits fed diet supplemented with 60 mg Nano-Zn or 0.3 mg Nano-Se/kg recorded the higher value of different growth parameters. All studied nutrients digestibility and carcass traits were not significantly affected by dietary treatment. No significant differences were observed among experimental rabbit groups in studied plasma parameters by dietary Nano-Zn or Nano-Se supplementation as compared with the control group. Results generally showed that the best results in most studied traits were recorded for dietary 60 mg Nano-zinc or 0.3 mg Nano-selenium / kg diet of growing rabbits during experimental period. Therefore, the addition of 60 mg Nano-Zn or 0.3 mg Nano-Se/kg diet may be an alternative method to maximize the productivity of growing NZW rabbits without adverse effects during fattening period.

**Keywords:** *Nano-zinc, Nano-selenium, growth performance, physiological status and rabbits.*

### **INTRODUCTION**

Recently, commercial rabbit production acquired increasing interest due to their high prolificacy and rapid growth rate which is comparable to that of broiler chicken (*Gondret et al., 2005*). Rabbit meat constitutes a vital source of protein for human because of its high quality and low fat and cholesterol (*Jones, 1990*). With the rise of rabbit production, the need for animal supplements has become a necessary part of their daily diet. Trace minerals are essential for many metabolic processes and physiological functions of animals (*McDowell, 2003*). Zinc is an indispensable component of several enzymes (>300) that participate in the synthesis and degradation of proteins, lipids, carbohydrates and nucleic acids and also involved in the metabolism of other micronutrients (*Salgueiro et al., 2000*). In addition, it is necessary component of superoxide dismutase (SOD) enzyme, which has a vital role in the antioxidant defense system (*Powell, 2000*). Zinc plays an important role in polynucleotide transcription and thus in the genetic expression process. Zinc also has a vital role in the immune system and affects several aspects of humoral and cellular immunity (*Sunder et al., 2008*). Zinc can affect thymulin secretion from thymus gland, which stimulates

production of T-cell. Thus, zinc deficiency resulted in thymus malfunctioning, which severely affects normal immune function (*Mocchegiani et al., 1998*).

Selenium is an important dietary micronutrient required for the normal body functions and metabolism of animals, it plays a significant role in the catalytic processes within the enzyme system that consist of a variety of enzyme activities linked with the metabolic, endocrine, and immune systems (*Keen et al., 2004*). Selenium supplementation prevents cell damage and plays an important role in the development, fertility, and immune functions of humans and other vertebrates, including fish (*Hoffmann and Berry, 2008*). However, its deficiency causes many metabolic disorders and diseases such as calf pneumonia, white muscle disease in calves and beef cows, exudative diathesis, and infertility in fish and other vertebrates; thus, a lack of selenium exerts a negative influence on the immune function (*Muller et al., 2002*).

Nano minerals technologies are widely used in diversified sectors including agriculture, animal, and food systems (*Thulasi et al., 2013*). Nano sized particles are having higher potential than their conventional sources and therefore cut the quantity required (*Sindhura et al., 2014*). Recent studies showed that nano particles of mineral elements have higher bioavailability, because of their novel characteristics, such as, greater specific surface area, higher surface activity, high catalytic efficiency and stronger adsorbing ability (*Albanese et al., 2012; Rajendran et al., 2013*), as well as it can be easily carried up by the gastrointestinal tract and utilized in the animal system and reached too deeper tissues by more efficient than the larger sized particles (*Liao et al., 2010*). Therefore, this study was designed to study the effects of dietary Nano-Zn and Nano-selenium on growth performance, blood plasma biochemical, nutrients utilization and carcass traits of growing New Zealand White rabbits during fattening period (6-12 wks of age).

## **MATERIALS AND METHODS**

The present study was carried out at a private rabbit farm near Mansoura city at the period from March to May 2016. The chemical and blood analysis were done at laboratory of Faculty of Agriculture, Ain shams University. A total number of 50 New Zealand White (NZW) growing rabbits at 6 weeks of age and about 815 g l.b.w. were divided into five experimental groups having nearly equal live body weight. Each group consisted of 10 individual rabbit and assigned to one of five treatments as follows: the first group served as control (C) and was fed the basal diet without any supplementation, the second and third groups were fed the basal diet supplemented with 30 and 60 mg Nano-zinc/kg (Nano-Zn<sub>30</sub> and Nano-Zn<sub>60</sub>), respectively, while the fourth and fifth groups were fed the basal diet supplemented with 0.1 and 0.3 mg Nano-selenium/kg (Nano-Se<sub>0.1</sub> and Nano-Se<sub>0.3</sub>), respectively. The rabbits were kept under the same managerial conditions. They housed individually in galvanized wire cages supplemented with feeders and stainless steel nipples. Feed and fresh water were provided *ad-libitum* during the experimental period from 6 up to 12 weeks of age. The component and chemical composition of basal experimental diet was presented in Table (1).

### ***Data collection and estimated parameters:***

***Growth performance parameters:*** Live body weight as well as feed intake was recorded on weekly basis from 6 to 12 weeks of age. Daily weight gain, daily feed intake and feed conversion ratio as g feed / g gain were calculated.

***Digestibility trial:*** At the end of the experiment (12 wks of age), three rabbits per treatment were randomly taken and kept in individual metabolic cages to conduct a digestibility trials. Diet was offered daily and water was available all the time. Consumed feed was recorded. After 5 days as a preliminary period, feces were collected quantitatively for 5 consecutive days for each rabbit. Fecal samples for each individual rabbit were stored at -20 °C immediately after collection, bulked and dried at 60°C for 24 hours, thereafter; they ground and kept for chemical analysis. Representative samples of feed offered and feces of each rabbit were chemically analysed according to AOAC (1995). Digestibility coefficient was calculated as: nutrient digested/nutrient intake x 100. Total digestible nutrient (TDN), digestible crude protein (DCP), energy efficiency utilization (EEU) and protein efficiency ratio (PER) were calculated according to Cheeke (1987).

**Slaughter test:** At 12 weeks of age, three rabbits from each treatment were randomly taken for slaughter test to determine carcass characteristics. Rabbits were fasted for 12 hours before slaughter, and then they weighed and slaughtered. After complete bleeding, they weighed, skinned and eviscerated. Carcass without head, fur, liver, kidneys and heart were immediately weighed. Total edible parts comprised empty carcass, head, liver, kidneys and heart were weighed.

**Blood plasma constituents:** During slaughtering of rabbits, blood samples were collected in heparinized tubes from each rabbit, and then centrifuged at 3000 rpm for 15 minutes to separate plasma. The obtained plasma samples were stored at -20°C until analysis. Plasma samples were analyzed for total protein, albumin, total cholesterol, HDL- cholesterol, LDL – cholesterol, triglycerides (TG), creatinine, urea, AST, ALT, Cat and ADDA calorimetrically using commercial kits.

**Statistically analysis:** The obtained data were analyzed using one-way ANOVA of GLM procedure of SAS® (SAS Institute, 2004). Significant differences between means were detected using New Duncan Multiple Range - Test (Duncan, 1955).

**Table (1): The component and chemical composition of basal experimental diet.**

Ingredient	Content (%)
Alfalfa hay	30
Wheat bran	32
Soy bean meal (44% CP)	11
Barley	21
Dicalcium phosphate	1.2
Limestone	1.0
Vitamin. & Mineral. Premix*	0.3
Common salt	0.5
Molasses	3.0
Total	100
Calculated analyses (NRC, 1977):	
Digestible energy; kcal/kg	2623
Crude protein; %	17.7
Ether extract; %	2.59
Crude fiber; %	12.75
Calcium; %	1.16
Non-phytate P; %	0.83
Lysine; %	0.87
Methionine; %	0.21
Meth.+ cyst.%;	0.51

\* Each 3 kg Vitamin. & Mineral. permix contains Vit. A, 10,000,000 IU; Vit. D<sub>3</sub>, 1,000,000 IU; Vit. E, 10 g; Vit. K<sub>3</sub>, 1.0 g; Vit. B<sub>1</sub>, 1.0 g; Vit. B<sub>2</sub>, 4.0 g; Vit. B<sub>6</sub>, 1.5 g; Nicotinic acid, 20 g; Pantothenic acid, 10 g; Vit. B<sub>12</sub>, 10 mg; Biotin, 50 mg; Folic acid, 30 g; Choline chloride, 50 g; Fe, 30 g; Mn, 40 g; Cu, 3.0 g, I, 0.45 g; Zn, 45 g and Se, 0.1 g.

## RESULTS AND DISCUSSION

### **Growth performance:**

The growth performance parameters of growing NZW rabbits fed diet supplemented with Nano-zinc and Nano-selenium are shown in Table (2). Live body weight (LBW) was insignificantly heavier for rabbits fed diet supplemented with different Nano-ZN and Nano-Se levels as compared with those fed the control diet at different ages. Rabbits LBW was increased by 2.61, 7.13, 4.01 and 6.94% by feeding supplemented with

Nano-Zn with 30 or 60 mg and Nano-Se with 0.1 or 0.3 mg/kg diet, respectively than the control group at 12 weeks of age. Moreover, daily weight gain was ( $P>0.05$ ) improved by dietary treatments than the control during all experimental period, it was improved by 12.97 and 10.76% for rabbits fed diet supplemented with 60 mg Nano-Zn/kg and 0.3 mg Nano-Se/kg, respectively as compared with those fed the control diet. Daily feed intake was approximately similar for treated rabbits groups when compared with the control during different experimental periods, it was decreased by 4.76 and 7.62% for rabbits fed 0.1 and 0.3 mg Nano-Se/kg diet than the control during the whole experimental period. Feed conversion ratio of rabbits was almost better by feeding Nano-Zn or Nano-Se diet than the control during varying experimental periods, it was improved ( $P>0.05$ ) by values ranged between 7.53 and 16.56% for treated groups than the control at the period of 6-12 weeks of age.

**Table (2): Effect of Nano-zinc and Nano-selenium addition to New Zealand White rabbit's diet on growth parameters and feed conversion at fattening period.**

Item	Control	Nano-Zn mg/kg		Nano- Se mg/kg	
		30	60	0.1	0.3
Live body weight (LBW), g					
6 wks	817.0±52.7	806.0±59.1	802.0±53.2	834.0±52.4	826.0±45.8
8 wks	1238.0±50.2	1271.0±63.3	1265.0±52.3	1287.0±52.4	1304.0±45.3
10 wks	1690.0±48.8	1755.0±48.8	1781.0±53.7	1746.0±59.8	1796.0±43.1
12 wks	2146.0±52.3	2202.0±62.2	2299.0±54.1	2232.0±48.1	2295.0±45.2
Daily weight gain (DWG), g					
6-8 wks	30.0±0.35	33.0±0.71	33.0±0.71	32.0±0.01	34.0±0.01
8-10 wks	32.0±1.06	35.0±1.41	37.0±1.41	33.0±1.06	35.0±1.06
10-12 wks	32.9±1.02	32.4±1.39	37.0±1.19	34.7±1.31	35.7±0.93
6-12 wks	31.6±0.35	33.5±0.51	35.7±0.37	33.2±0.38	35.0±0.05
Daily feed intake (DFI), g					
6-8 wks	75.0±2.2	79.0±2.8	80.0±2.6	79.0±2.8	77.0±3.0
8-10 wks	117.0±5.6	109.0±8.1	117.0±5.7	104.0±7.4	99.0±5.7
10-12 wks	124.0±5.3	121.0±7.8	125.0±6.0	118.0±5.7	115.0±6.4
6-12 wks	105.0±4.2	103.0±6.0	107.0±4.6	100.0±4.9	97.0±4.9
Feed conversion ratio (g feed : g BWG)					
6-8 wks	2.50±0.07	2.39±0.11	2.42±0.11	2.47±0.11	2.26±0.11
8-10 wks	3.66±0.25	3.11±0.35	3.16±0.21	3.15±0.35	2.83±0.18
10-12 wks	3.77±0.35	3.73±0.35	3.38±0.00	3.40±0.35	3.22±0.35
6-12 wks	3.32±0.14	3.07±0.18	3.00±0.14	3.01±0.18	2.77±0.14
Protein efficiency ratio (PER)					
6-12 wks	1.80±0.11	1.90±0.14	1.9±0.11	2.0±0.11	2.1±0.11
Efficiency of energy utilization (EEU)					
6-12 wks	9.0±0.40	8.0±0.47	8.0±0.35	8.0±0.42	7.0±0.37

Moreover, protein efficiency ratio (PER) was improved by dietary treatment than the control during the overall experimental period; rabbits fed Nano-Se diets recorded the best PER value than other treatments. Also, efficiency of energy utilization (EEU) was decreased by the addition of both Nano-Zn and Nano-Se than the control during the whole experimental period.

Improvement in growth performance parameters in this study by dietary nano-Se for growing NZW rabbits during growing period, especially high dose of them may be due to nano-Se has biological characteristics of high oxidation resistance, high immune regulating, high biological activity, and low toxicity (Huang *et al.* 2015).Se- nano particles had high antioxidant activity because it have an increased ability to trap free radicals with greater antioxidant effect (Torres *et al.*, 2012), 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.*, 2004). Additionally, nano-Se can act as a chemopreventive agent when administered at a

smaller particle size (Peng *et al.*, 2007). Also, Se plays a major role as an antioxidant which could protect intestinal mucosa against oxidative damage and pathogens and limit peristaltic activity in digestive disorders preventing diarrhea (Kermauner and Laurenčić, 2008) as well as it has immunomodulating properties (Surai, 2002). These findings are agreement with Dokoupilová *et al.* (2007) and Marounek *et al.* (2009) who found that Se supplementation improved ( $P>0.05$ ) body weight gain, feed intake and feed conversion of growing rabbits. Ebeid *et al.* (2012) reported that feeding male California rabbits on diets supplemented with organic Se (0.15 or 0.30 ppm) resulted in an increase ( $P>0.05$ ) in live body weight and daily weight gain compared with their control counterparts. Also, Mohapatra *et al.* (2014) found that feeding diets enriched with nano-Se up to 0.30 mg/kg from 9 to 20 weeks of age improved in live body weight of pullets. El-Deep *et al.* (2016) reported that dietary nano-Se supplementation by 0.3 mg/kg diet might enhance growth performance by improving antioxidative or immune properties in broilers.

In the present study, it was found that appropriate levels of nano-ZnO (30 and 60 mg/kg) could promote body weight gain and achieve a better feed conversion ratio compared with the control. These results may be due to Zn is essential for body's proper physiological functions like, normal growth (Case and Carlson, 2002), DNA synthesis, cell division and gene expression (Prasad, 1991), augmenting the immune system of the body (Zhao *et al.*, 2014) through energy production, protein synthesis, protection of membranes from bacterial endotoxins and lymphocyte replication and antibody production (Nockels, 1994). Also, Zn is a component of the free radicals scavengers which are produced during different physiological processes (Zhao *et al.*, 2014), and is required for the normal condition of epidermis, epithelium, skin and hooves (Kruczynska, 2004). These results are in the same line with Zhao *et al.* (2014); Siddhartha *et al.* (2016) who stated that birds fed diet supplemented with 60 nano-Zn/kg had greater weight gains and better feed conversion ratio than the control. Hassan *et al.* (2017) found that rabbits fed diet supplemented with nano-zinc (30 and 60 mg/kg) had the heaviest live body weight, highest DWG, FCR and the lowest mortality rate in comparison with those fed the control. Also, El-Katcha *et al.* (2017) found that final body weight, BWG, FCR, PER, EEU and performance index of broiler chicken were improved by nano-zinc supplementation (30,45 and 60 mg/kg) than the control.

#### **Nutrients utilization:**

Results in Table (3) showed non-significant differences among experimental treatments in all studied nutrients digestibility coefficients and feeding value due to Nano-zinc and Nano-selenium addition to rabbit's diet at 12 weeks of age. Dry matter digestibility (%) was improved by 0.43 and 2.32% for rabbits fed diet supplemented with 0.1 and 0.3 mg Nano-Se/kg, while it was decreased by 7.25 and 3.77 % for rabbits fed 30 and 60 mg Nano-Zn/kg, respectively than those fed the control diet. Digestibility coefficients of CP, CF, EE and NFE were approximately similar for those of the control group. Feeding values (TDN& DCP) were slightly decreased by dietary treatments comparing with the control group. The rabbits fed diet supplemented with Nano-Se by 0.3 mg/kg recorded the best value of TDN and DCP compared to other treated groups.

The present data of nutrients digestibility are in contrast with MacDonald (2000) who reported that Zn positively affected feed utilization through participating in the metabolism of carbohydrates, lipids and proteins. Also, Saleh *et al.* (2018) found that Zn has a protective role on pancreatic tissue against oxidative damage, it might help the pancreas to function properly including secretions of digestive enzymes, thus improving digestibility of nutrients. Also, Zn is required for the activity of over 300 enzymes and participates in many enzymatic and metabolic functions in the body (Prasad and Kucuk, 2002).

#### **Carcass traits:**

No significant differences were observed among experimental treatments in the studied carcass traits by feeding diet supplemented with both Nano-Zn and Nano-Se of growing NAW rabbits at 12 weeks of age (Table 4). Relative weights of kidneys, heart, liver and head were numerically similar for treated groups as compared with the control group. Also, relative total edible parts weight was almost identical among all experimental groups. The absence of significant differences in carcass parameters of the experimental rabbits agrees with the findings of Dokoupilova *et al.* (2007) who noted that added Se did not affect dressing-out

percentage of growing rabbits. These results agree with *El-Katcha et al. (2017)* who reported that carcass parts are numerically similar ( $P \geq 0.05$ ) by dietary organic or nano- zinc supplementation than the control of broiler chicks. In disagreement with the present results, *Ebeid et al. (2012)* reported that feeding male California rabbits on diets supplemented with organic Se (0.15 or 0.30 ppm) led to an improvement in both carcass weight and dressing percentage compared with their control counterparts.

**Table (3): Effect of nano-zinc and nano-selenium addition to New Zealand White rabbit's diet on nutrient digestibility coefficient and nutritive value at 12 wks of age.**

Parameter	Control	Nano-Zn mg/kg		Nano- Se mg/kg	
		30	60	0.1	0.3
Nutrient digestibility coefficient, %					
Dry matter (DM)	68.9±0.40	63.9±3.64	66.3±1.27	69.2±0.92	70.5±1.33
Crude protein(CP)	71.6±0.35	69.3±0.87	70.0±1.73	69.4±1.79	71.3±1.21
Crude fiber(CF)	52.5±1.22	50.3±1.65	48.8±0.35	49.8±1.93	49.1±1.80
Ether extract (EE)	83.2±0.29	81.0±1.27	82.6±0.58	85.5±0.64	81.6±0.92
Nitrogen free extract (NFE)	74.1±0.40	72.8±0.75	71.9±0.87	71.0±0.64	73.4±0.92
Feeding value					
Total digestible nutrients (TDN)	61.4±0.35	59.9±0.75	59.5±0.69	59.3±0.69	60.4±0.92
Digestible crude protein (DCP)	12.3±0.06	11.9±0.17	12.0±0.29	11.90±0.29	12.2±0.23

**Table (4): Effect of nano-zinc and nano-selenium addition to New Zealand White rabbit's diet on carcass traits at 12 wks of age.**

Parameter	Control	Nano-Zn, mg/kg		Nano- Se, mg/kg	
		30	60	0.1	0.3
Fasted wt., g	2232.0±13.9	2250.3±39.6	2303.3±27.4	2396.7±21.4	2175.0±33.3
Blood, %	4.0±0.02	4.0±0.02	3.6±0.06	3.9±0.02	4.0±0.02
Kidneys, %	0.7±0.02	0.8±0.00	0.8±0.02	0.8±0.02	0.8±0.02
Heart, %	0.4±0.02	0.4±0.02	0.4±0.00	0.4±0.00	0.4±0.02
Liver, %	3.7±0.08	3.8±0.06	3.8±0.08	3.8±0.08	3.8±0.02
Head, %	5.9±0.06	5.9±0.04	5.7±0.04	5.8±0.02	6.3±0.04
Total edible parts, %	61.4±0.10	60.8±0.16	60.7±0.24	60.9±0.27	61.0±.10
Fur, %	11.8±0.06	10.9±0.12	11.8±0.04	11.7±0.06	12.0±0.06

**Blood plasma constituents:**

The effects of Nano- zinc and Nano-selenium supplementation to growing NZW rabbit's diet on blood plasma constituents are shown in Table (5). Plasma total protein, albumin and globulin constituent were not significantly affected by dietary treatments comparing to the control. An increase of total protein by nano-Se (0.3 mg/kg) diet may be due to Se can improve plasma lipoproteins i.e. decline the LDL-, cholesterol and plasma triglycerides, and increase HDL- cholesterol (*Iizuka et al., 2001*). This finding is similar to those obtained by *Fawzy et al. (2015)* who observed that protein profile recorded an elevation in total proteins, albumin, and globulin levels in broiler chicks fed diet supplemented with selenium. *Selim et al. (2015)* found that plasma total proteins, albumin, globulins and albumin/globulins ratio didn't significantly affect due to nano-selenium supplementation to broiler diet. Also, *Shunyi et al. (2016)* reported that blood total protein was not significantly affected by nano-selenium or sodium selenite supplementation to growing rabbit's diet. *Ahmadi et al. (2018)* stated that total protein concentrations in blood plasma of broiler chickens were not significantly different by dietary nano-Se supplementation than the control.

Plasma triglycerides level was ( $P > 0.01$ ) decreased by 10.20 and 5.21% for rabbits fed diet supplemented with 30 mg Nano-Zn and 0.1 mg Nano-Se/kg, respectively than those fed the control diet, while it increased by high level addition of these supplements. Plasma total cholesterol constituent was insignificantly

decreased by 9.50, 3.64, 11.75 and 3.21% for rabbits fed diet supplemented with Nano-Zn by 30 and 60 and Nano-Se by 0.1 and 0.3 mg/kg, respectively than the control, whereas, HDL cholesterol was ( $P>0.01$ ) increased by 9.34, 5.61 and 7.01% for those fed 60 mg Nano-Zn and 0.1 or 0.3 mg Nano-Se /kg, respectively. Increased level of HDL is probably due to improvement in calories and fat intake after zinc supplementation (Wu and Sun, 2004). Change of triglycerides and total cholesterol levels in blood plasma may be due to the zinc's role in enzyme action which an integral part of several enzymes (metalloenzymes) that are severed in lipid digestion and absorption (Hazim et al., 2011). These finding are similar with El-Katcha et al. (2017) who reported that dietary nano-zinc supplementation non significantly reduced blood serum triglycerides while increased HDL than the control of broiler chicks. In addition, Shunyi et al. (2016) reported that blood biochemistry of rabbits, including concentrations of cholesterol, HDL and triglyceride were not significantly affected by supplementation of nano-selenium or sodium selenite.

**Table (5): Effect of Nano-zinc and Nano-selenium addition to New Zealand White rabbits diet on blood plasma constituents at 12 wks of age.**

Parameter	Control	Nano-Znmg/kg		Nano- Semg/kg	
		30	60	0.1	0.3
Total protein , g/dl	5.9±0.04	5.8±0.02	5.9±0.06	5.9±0.02	6.0±0.04
Albumin, g/dl	3.1±0.02	3.1±0.02	3.2±0.04	3.0±0.02	3.2±0.02
Globulin , g/dl	2.71±0.03	2.74±0.02	2.72±0.03	2.85±0.03	2.78±0.02
Triglycerides, mg/dl	46.1±0.50	41.4±0.74	48.0±0.61	43.7±0.64	49.0±0.92
Cholesterol, mg/dl	69.5±0.83	62.9±1.16	66.97±0.77	61.33±0.64	67.27±1.14
HDL-choL., mg/dl	21.4±0.27	19.3±0.64	23.4±0.35	22.6±0.18	22.9±0.59
AST, U/dl	44.3±0.80	44.4±0.55	46.9±0.81	43.4±0.84	41.4±0.92
ALT, U/dl	15.0±0.33	15.0±0.13	15.3±0.27	14.7±0.23	13.1±0.31
Catalase, U/g	22.4±1.10	22.1±0.49	24.9±0.28	27.7±0.53	29.7±0.57
Creatinine, mg/dl	1.3±0.02	1.2±0.02	1.3±0.02	1.2±0.0	1.3±0.02
Urea , mg/dl	13.3±0.20	12.3±0.33	13.6±0.10	11.9±0.24	12.4±0.37
ADDA	31.5±0.80	24.5±0.39	29.4±0.95	28.4±0.99	25.9±0.39

In addition, liver enzymes (ALT and AST) were not significantly influenced by different dietary treatments when compared with the control. However, plasma catalase content was slightly elevated by supplementing the high dose of nano-Zn (30 mg/kg) and both doses of nano-Se (0.1 & 0.3 mg/kg) than the control group. Moreover, plasma creatinine and urea contents were numerically similar by dietary treatment as compared with the control group, while plasma ADDA content was decreased ( $P>0.05$ ) by treatments.

These results indicate that nano-zinc had no adverse effect on kidney function and slightly increase liver enzyme. These data are in contrast with Fathi (2016) who reported that nano-zinc increase broiler chickens blood serum creatinine kinase activity which reflect on higher creatinine concentration. Also, the finding of the current study is adverse with Fazilati (2013) who observed that zinc oxide nano particles (25-200 mg) had significantly increased ( $P<0.05$ ) activity of ALT and AST enzymes in serum of male rats. Possible reason for these differences is probably related to using doses and time of animal exposed, as, it has been reported that, level above 50 mg/kg of nano-ZnO induce the oxidative stress and increase the plasma level of ALT and AST (Sharma et al., 2009).The present data are in harmony with Ahmadi et al. (2014) who reported that nano-ZnO had no significant effects on ALT and AST activities in serum of broilers.

Moreover, Mohapatra et al. (2014) found that liver enzymes were insignificantly influenced by nano-Se (0.15, 0.30 and 0.60 ppm) supplementation comparing with the control. Shunyi et al. (2016) reported that blood biochemistry of rabbits, including concentrations of alanine amino transferase (ALT) and aspartate amino transferase (AST) were not significantly affected by supplementation of nano-selenium or sodium selenite. El-Deep et al. (2017) found that the birds fed diet supplemented with nano-Se recorded lower value of AST enzyme compared with control group. Also, Selim et al. (2015) found that increasing supplemental

nano-Se level from 0.15 to 0.30 ppm in broiler diets resulted in an increase in plasma creatinine level compared with the control group without any significant differences.

## CONCLUSION

The best results in most studied traits were recorded for dietary 60 mg Nano-zinc or 0.3 mg Nano-selenium / kg diet of growing rabbits during experimental period. So, it could be advised that the addition of 60 mg NZn or 0.3 mg NSe/kg diet may be an alternative method to maximize the productivity and profitability of growing NZW rabbits with no adverse effects during fattening period.

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## تأثير إضافة النانو زنك والنانو سيلينيوم للعليقة على الأداء الإنتاجي والفيولوجي للأرانب النامية خلال فترة التسمين

نها تاج الدين حسن تاج الدين

قسم الانتاج الحيواني - كلية الزراعة - جامعة دمياط - مصر.

إستخدم في هذه الدراسة عدد 50 أرنب (نيوزيلاندى أبيض) عمر ستة أسابيع بمتوسط وزن حوالى 815 جم وذلك لدراسة تأثير إضافة نانو زنك (30 ، 60 ملجم / كجم) وكذلك نانو سيلينيوم (0.1 ، 0.3 ملجم /كجم) للعليقة خلال فترة التسمين (6-12 أسبوع من العمر) على أداء النمو والاستفادة من العليقة وبعض محتويات بلازما الدم فضلا عن صفات الذبيحة. تم وزن وتقسيم الأرانب إلى خمسة مجموعات تجريبية (بكل منها 10 أرانب) وتم ترتيبها على النحو التالى : المجموعة الأولى تغذت على العليقة الأساسية بدون أى إضافات (مجموعة مقارنة) والمجموعتين الثانية والثالثة غذيت على العليقة الأساسية مضاف لها 30.0 ، 60.0 ملجم نانو زنك لكل كجم عليقة على التوالى ، بينما تغذت المجموعة الرابعة والخامسة على العليقة الأساسية مضاف لها 0.20 ، 0.30 ملجم نانو سيلينيوم لكل كجم عليقة على التوالى خلال فترة التجربة (6-12 أسبوع). تم تسجيل الوزن و كمية العليقة المأكولة ، كما تم أخذ عينات دم لتقدير بعض محتويات البلازما ، كما تم إجراء تجربة هضم لتقدير معاملات هضم العناصر الغذائية وكذلك تجربة ذبح لتقدير بعض قياسات الذبيحة. وأوضحت النتائج ما يلي :- لوحظ تحسنا غير معنويا في وزن الجسم للأرانب التى تغذت على العلائق المضاف لها النانو زنك والنانوسيلينيوم عند نهاية التجربة (12 أسبوع من العمر) بالمقارنة بمجموعة المقارنة ، كما لوحظ تحسنا غير معنويا فى معدل الزيادة الوزنية المكتسبة ومعدل التحويل الغذائى ونسبة الاستفادة من البروتين خلال الفترة الكلية للتجربة (6-12 أسبوع). كما لم تتأثر معاملات هضم العناصر الغذائية المدروسة معنويا بالمعاملات الغذائية مقارنة بمجموعة المقارنة، كما لم تتأثر محتويات بلازما الدم وصفات الذبيحة المدروسة معنويا بالمعاملات الغذائية. وأوضحت النتائج أن إضافة 60 ملجم نانو زنك أو 0.30 ملجم نانو سيلينيوم لكل كجم عليقة كانت الأفضل تأثيرا على صفات النمو المدروسة والحالة الفسيولوجية للأرانب.

لذا خلصت الدراسة إلى إمكانية إضافة 60 ملجم نانو زنك أو 0.30 ملجم نانو سيلينيوم / كجم من عليقة الأرانب النامية لتحسين أداء النمو والحالة الفسيولوجية للجسم بدون أى تأثير سلبي خلال فترة التسمين (6-12 أسبوع من العمر) تحت الظروف المصرية.