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INFLUENCE OF SUPPLEMENTATION OF SOME TRACE MINERALS IN FORM OF NANOPARTICLES ON PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF RABBIT

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SUMMARY

This study was conducted to evaluate effect of adding some trace minerals (copper, zinc and selenium) in Normal form and Nano form on productive and reproductive performance of rabbit. Seven diets supplemented with Control (0), 1g Normal copper Cu, 0.5g Nano Cu, 0.8g Normal Zinc (Zn), 0.4 g Nano Zn, 0.2 Normal selenium (Se) and 0.1mg Nano- Se /100kg of diet respectively. Thirty five New Zealand White (NZW) rabbits does (5 months old) with an average weight of 2.9Kg were randomly assigned individually to seven treatments (five does in each). All diets were formulated to be iso-nitrognous, iso-caloric, and satisfy the nutrient requirements according to Agriculture Ministry Decree (1996) recommendation. Does were housed in galvanized metal rabbit battery cages (60 x 50 x 40) supplied with separated feeders. Diets were offered in pellets form *ad libtum* and fresh water was available all times from automatic nipple drinkers. All animals were kept under the same managements and hygienic conditions. Result indicated that nano form of trace element used had improved the feed efficiency significantly ($P \leq 0.05$). Concerning milk yield values which recorded during suckling period were affected significantly ($P \leq 0.05$) by different treatments. Values ranged between 5.78 - 6.52 kg vs. 5.54 kg for control diets. The best one was for diet supplemented with Nano-zinc. Also, total gain of litter (Kg)/doe, mortality % of kids and feed conversion ratio were affected significantly ($P \leq 0.05$) by different treatments. Values for diet which supplemented with Nano- Cu were very closed from values for diets supplemented Nano-Se and Nano-Zn which were better than those which supplemented normal form and control diet. Results meanwhile, indicated that there is no significant difference in dry matter digestibility and organic matter digestibility between groups. Although, the digestion coefficients of different nutrients and nutritive values of diets contained trace minerals used (Cu, Zn and Se) were better in general than control group significantly ($P \leq 0.05$). Groups supplemented with Nano- Cu, Nano- Ze and Nano- Se were the best one's in the digestion coefficients of different nutrients and nutritive values between all groups. Conclusively, adding copper, zinc and selenium in normal form and nano form with percentages used in breeding rabbit diets can be used economically without any adverse effects on rabbit reproductive performance.

Keywords: *Trace minerals, nanoparticles, rabbit, reproduction performance.*

INTRODUCTION

Rabbits are considered to be the important item for human feeding, that they are the most promising domestic species as they can provide people with a relatively inexpensive source of healthy meat. They have many advantages including high reproductive rates, rapid growth, using of non-competitive feeds, simple housing and requirements (Cheek, 1987). Traces minerals have an important role in numerous biological processes, generally in mammalian species (Rayman, 2000, 2004). Selenium is known to have important roles in reproductive functions and development, immunocompetence and ageing. The selenium is an essential trace mineral and has a profound effect on performance and immunity. Selenium and vitamin E deficiency together in poultry causes exudative diathesis, pancreatic dystrophy and nutritional muscular dystrophy. Selenium is also, an integral part of the enzyme known as glutathione peroxidase which are involved in the cell antioxidant defense mechanism and prevent the cells from free radical damage McDowell (1992).

Zinc and copper have an important role in numerous biological processes in animal and have both structural and catalytic functions in metalloenzymes (O'Dell, 1992). Also, they are essential components of many enzymes (Vallee and Auld, 1990), so it has a big effect in reproductive and productive performance. Using those trace minerals in a nano-form may be more active and have more effects in reproductive performance. That, they will have high catalytic efficiency and strong adsorbing ability (Shi *et al*., 2011), and exhibited a lower toxicity (Zhang *et al*., 2001).

However, little was known about influence of Nano-Cu, Nano-Zn and Nano-Se on reproductive performance in rabbit. The Nano-Cu used in dose of 80 mg/kg in rabbit diet improved the activities of trypsin, amylase and lipase in the small intestinal contents and maltase, sucrose and lactase of duodenum, jejunum, and ileum mucosa (Xin-Yan Han, 2012).

Thus, the objective of this study was undertaken to evaluate the effects of Nano-Cu, Nano-Zn and Nano-Se supplemented dose half in normal form on the reproductive performance indices in breeder rabbits.

MATERIALS AND METHODS

This experimental study was carried out at Noubaria Research Station, El-Behira Government, Animal Production institute, Agriculture Research Center, Egypt, Ministry of Agriculture. During January to April 2016. The Laboratory work was conducted at Laboratories of By-products Utilization Research Department, Animal Production Research Institute, Agricultural Research Center. The experiment aimed to evaluate three minerals (copper, selenium and zinc) in both normal form and nanoparticles form on rabbit reproductive performance.

Experimental diets:

Table (1) showed seven diets used in this experiment supplemented with Control (0), 1g Normal copper Cu, 0.5g nano Cu, 0.8 Normal Zinc (Zn), 0.4 g Nano-Zn, 0.2 mg Normal selenium (Se) and 0.1mg Nano- Se/100kg diet respectively. All diets were iso-nitrogenous, and iso-caloric, and satisfy the nutrient requirements according to Agriculture Ministry Decree (1996) recommendations.The experimental diets were manufactured in Noubaria research station.

Nano trace minerals prepared in National Research Centre, Center of Excellence for Advanced Sciences, Advanced Materials and Nanotechnology Group 12622 Dokki, Cairo, Egypt. Nano-Se was synthesized by reducing selenite in an environment containing bovine serum albumin (BSA), which is able to adhere to Se atoms and control the size of their aggregation according to Zhang *et al*. (2001). The nano copper and zinc were created by the artisans by adding copper and zinc salts and oxides together with vinegar, ochre and clay, on the surface of previously-glazed pottery. The object was then placed into a kiln and heated to about 600 °C in a reducing atmosphere. In the heat the glaze would soften, causing the copper and zinc ions to migrate into the outer layers of the glaze. There the reducing atmosphere reduced the ions back to metals, which then came together forming the nanoparticles according Philip (1984).

To identify the particle size and morphology of the synthesized materials, transmission electron microscope (TEM) “JEOL JEM-1230 operating at 120 kV attached to a CCD camera”, was used.

Animals and management:

A total number of 35 NZW does aged 5 months, weighing about 2.9 kg were randomly distributed individually into 7 treatments, (5 does in each group). Mating was achieved by 21 adult NZW bucks with good fertility records. Animals were housed in galvanized metal rabbit battery cages (60 x 50 x 40) supplied with separated feeders. Diets were offered in pellets form *ad libtum* and fresh water was available all times from automatic nipple drinkers. All animals were kept under the same managements and hygienic conditions. Both feed intake and live body weight were recorded weekly. Rabbits were raised in semi-closed rabbitry of 24m length and 12 width with wire-netted windows on their sides for providing natural ventilation.

Reproductive performance:

a-During gestation period.

1-Change in live body weight.

The change in live body weight was calculated by the difference between the live body weight at kindling and body weight post partum.

2-Feed intake

The amount of feed intake was calculated weekly.

3-Gestation length

Gestation length was calculated as a period between kindling and post partum.

b- During suckling period.

1- The change in live body weight

Was calculated as the difference between the live body weight at the suckling period (at weaning) and the body weight at post partum in which the kids became four weeks of age.

2- Feed intake.

Feed intake during this period was calculated weekly.

3-Feed conversion ratio.

The feed conversion ratio (FCR) value was calculated as follows:

The feed conversion ratio was calculated as a total feed intake of the does during the whole suckling period (1-28 days) and gestation period (30 days) dived by total litter gain.

$$\text{Feed conversion ratio} = \frac{\text{Total feed intake of the doe during gestation and suckling periods}}{\text{Total litter gain}}$$

4- Milk yield.

Milk yield was recorded twice weekly as the increase in kids weight, calculated by the difference between weighing the kids before and after suckling, following 12 hours deprivation of kids from suckling their mothers.

***5- Body weight and body weight gain of kids*.**

Body weight and weight gain of kids were recorded at birth and at weaning.

6- Mortality.

Mortality rate (MR) during suckling for kids was calculated as follows:

$$\text{MR of kids} = \frac{\text{Number of the live kids parturation} - \text{Number of live kids at weaning}}{\text{Number of the live kids parturation}}$$

Digestibility trail:

Digestibility trail was carried out to determine the digestion coefficients, using three bucks from each treatment. Feces were collected daily, weighed and dried at 60 ^{o} C for 48 hrs, finely ground and stored for chemical analysis. Data of quantities and chemical analysis of feed and feces were used to calculate the nutrients digestion coefficients and the nutritive values of the dietary treatments, as described by Cheeke *et al.* (1982).

Chemical analysis:

Approximate analysis of different samples (experimental diets, feces), were determined according to the methods of A.O.A.C. (2000).

Economic efficiency:

The economic efficiency of the experimental diets for producing one kg body weight gain was calculated. The costs were calculated according to the price as prevailing at local market at time of experiment. Total feed cost = Average feed consumption (feed intake) kg x price per kg diet. Total revenue = weight gain x price per kg live body weight, net revenue= price of weight gain- total feed cost, and the economic efficiency = net revenue/ total feed cost.

Table (1). Composition and calculated chemical composition of doe rabbit diets.

Item	Control	Copper		Zinc		Selenium	
		normal	nano	normal	nano	normal	nano
	(0)	1g/ 100kg	0.5g/ 100kg	0.8g/ 100kg	0.4g/ 100 kg	0.2 mg/ 100kg	0.1mg/ 100 kg
Clover hay (12%CP)	20.08	20.08	20.08	20.08	20.08	20.08	20.08
Yellow corn	24.85	24.85	24.85	24.85	24.85	24.85	24.85
Soybean meal (44%CP)	21.30	21.30	21.30	21.30	21.30	21.30	21.30
Wheat bran	26.90	26.90	26.90	26.90	26.90	26.90	26.90
Molasses	3.00	3.00	3.00	3.00	3.00	3.00	3.00
DL-Methionine	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Vit..& Min. mix.*	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Limestone	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Di-Calcium. phosphate	1.91	1.91	1.91	1.91	1.91	1.91	1.91
Total	100	100	100	100	100	100	100
<u>Calculated analysis</u>: [l]							
Crude protein %	18.03	18.03	18.03	18.03	18.03	18.03	18.03
Digestible energy (Kcal/Kg)	2603	2603	2603	2603	2603	2603	2603
C/P ratio	144	144	144	144	144	144	144
Ether extract %	2.80	2.80	2.80	2.80	2.80	2.80	2.80
Crude fiber %	11.11	11.11	11.11	11.11	11.11	11.11	11.11
NDF% [m]	36.22	36.22	36.22	36.22	36.22	36.22	36.22
ADF% [n]	19.56	19.56	19.56	19.56	19.56	19.56	19.56
Hemicellulose %[o]	16.66	16.66	16.66	16.66	16.66	16.66	16.66
Calcium %	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Total Phosphorus %	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Methionine %	0.36	0.36	0.36	0.36	0.36	0.36	0.36
TSAA	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Lysine %	0.86	0.86	0.86	0.86	0.86	0.86	0.86

* *Each 1.5Kg. of Vita. Mix contained: 50,000,000 IU Vit.A; 1,000,000 IU D_3; 10,000 mg Vit. E; 1170 mg Vit. K_3;735 mg Vit.B_1; mg Vit.B_2; 15000 mg vit B_6;15 mg vit;B_{12} ; 500 mg Vit.B5 Panathonic acid; 30,000 g Nicotinic acid; 84 mg Biotin; 500 g Folic acid; 300g choline cholride. Each 1.5 Kg Min. mix contained 25 g Zn(oxid); 33.4 g Mn; 26.7 g Fe ; 2.67 g Cu; 67 mg cobalt;1mg Se and.0.334 gI;*

[l] *According to Feed Composition Tables for animal and poultry feedstuffs used in Egypt (2001) ,except the values of DDGS, which were determined (Table 2).*

[mno] *Calculated according to Cheeke (1987).*

[m] *% NDF = 28.924 + 0.657 (%CF)*

[n] *% ADF = 9.432 + 0.912 (%CF)*

[o] *Hemicellulose = %NDF - % ADF*

***Copper, Zinc and Selenium in normal or nano form were supplemented over requirements, that the requirements were covered from Vit..& Min. mixture in all diets (control diet or other diets).*

Statistical analysis:

The data were analyzed using General Linear Models (GLM) procedure of SAS Institute (2001).

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

Where:

μ= overall mean of Y_{ij}. T_i = Effect of treatment groups, I = (1,… and 7).

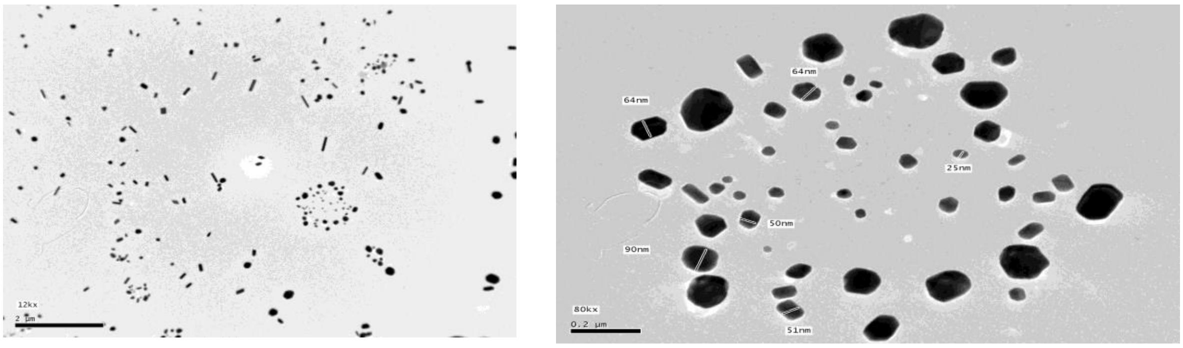
e_{ij} = Experimental error

Variables having a significant F-test were compared using Duncan's Multiple Rang Test (Duncan, 1955).

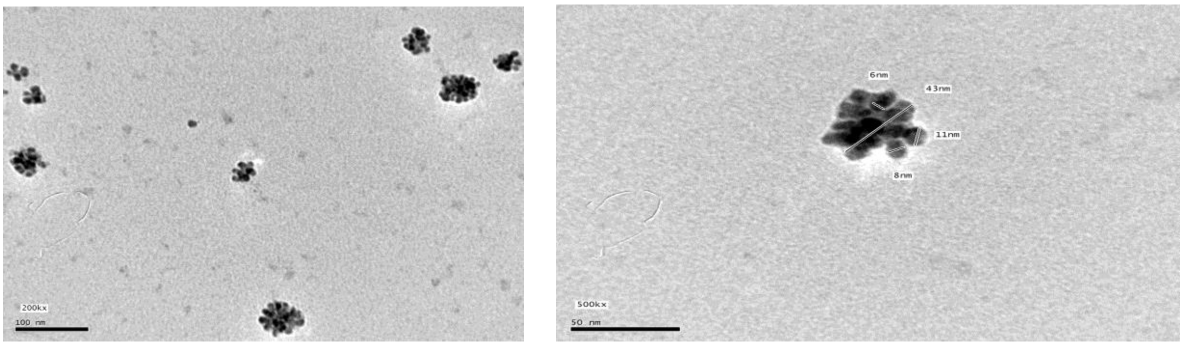
RESULTS AND DISCUSSIN

Physical structure of nano trace elements used:

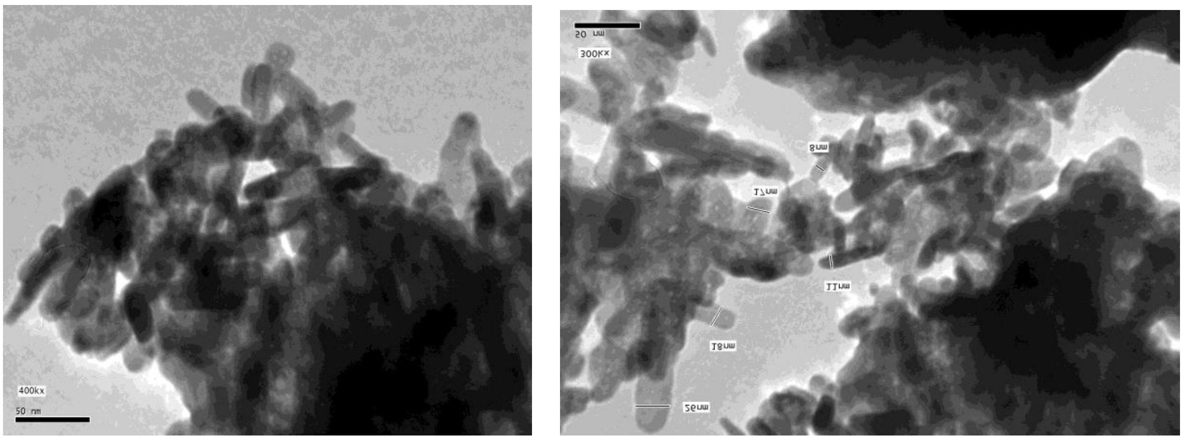
Images of prepared copper (a), zinc (b), and selenium (c) Nanoparticles at two different magnifications. It is indicated that the selenium exhibits agglomerated rod-like particles with homogeneous particles having length of about 50 nm and width ranging between 8 and 26 nm. Well-dispersed copper nano particles with different morphologies i.e. rods, cuboids and cubes, are appeared (Fig. 1c). Their sizes are ranging between 25-90nm. On the other hand, agglomerated flower shape zinc nanoparticles are detected (Fig. 1b). These agglomerates consist of several cube nanoparticles with size ranging between 6-11 nm.



Cu (a)



Zn (b)



Se (c)

Fig. (1). Physical structure of nano trace elements used (a, b and c)

Performance of rabbit does during gestation period.

Table (2) indicated that the gestation length and change in body weight of the does were not affected significantly (P≤ 0.05) by different treatments. Whereas, values of total feed intake Kg/doe was affected significantly (P≤ 0.05) by different treatments, values of total feed intake Kg/doe ranged between 4.22-4.50 kg vs., 4.77 kg for control diet. Also, average daily feed intake was affected significantly (P≤ 0.05) by different treatments. Daily feed intake (g) value ranged between 140.83-150g vs. 158.97 for control one. The best diet for change in weight (g) was for Nano-Zn supplemented diet and the highest total feed intake was for control diet.

Table (2). Performance traits of rabbit does (Means±SE) as affected by different treatments, during gestation period.

Treatment	Gestation length days	Total feed intake Kg/doe	Average daily feed intake (g)	Change in weight (g)
Control	30±0.20	4.77^{a}±0.05	158.97^{a}±1.72	+114.00±39.03
Normal-Cu	30±0.20	4.50^{b}±0.04	150.00^{b}±1.21	+116.00±49.15
Nano-Cu	30±0.20	4.43^{cd}±0.03	144.69^{cd}±1.11	+121.00±28.83
Normal-Zn	30±0.20	4.39^{c}±0.04	146.28^{c}±1.55	+165.00±39.24
Nano-Zn	30±0.20	4.40^{cb}±0.03	146.76^{bc}±0.86	+144.00±38.29
Normal-Se	30±0.20	4.22^{e}±0.03	140.83^{e}±0.88	+130.00±15.49
Nano-Se	30±0.20	4.26^{ed}±0.01	141.93^{e}±0.37	+114.00±37.36

a, b, c, d and e means on the same column with different superscripts are significantly different (P ≤ 0.05).

Performance of rabbit does during suckling period.

Table (3) showed that feed intake and total milk yield of does were affected significantly (P≤ 0.05) by different treatments. Change in body weight of does was not affected significantly (P≤ 0.05) by different treatments. Values of total feed intake in supplemented groups ranged between 6.18- 6.62 kg vs 6.67 kg for control one.

Concerning milk yield values there were significantly (P≤ 0.05) difference between treatments. Total milk yield ranged between 5.78 - 6.52 kg for supplemented does vs. 5.54kg for control one. Diet supplemented with Nano-zinc increased milk production up to 6.41 kg/doe.

Diets supplemented with normal and nano forms of traces minerals increased milk yield compared with control diet. Nano mineral diets increased does milk production compared with normal mineral ones.

Table (3). Performance traits of rabbit does (Means±SE) as affected by different treatments, during suckling period.

Treatment	Total feed intake (kg)/doe	Average feed intake (g)/doe/day	Total milk yield (kg)/doe	Change in weight (g)
Control	6.67^{a}±0.05	229.93^{a}±1.90	5.54^{c}±0.12	-112.00±18.21
Normal-Cu	6.44^{b}±0.04	222.07^{b}±1.37	5.78^{bc}±0.08	-98.00±13.19
Nano-Cu	6.62^{a}±0.01	228.21^{a}±0.43	6.37^{a}±0.09	-116.00±20.64
Normal-Zn	6.28^{c}±0.08	216.41^{c}±0.46	6.41^{a}±0.10	-112.00±19.85
Nano-Zn	6.43^{b}±0.01	221.66^{b}±0.38	6.52^{a}±0.08	-102.00±19.08
Normal-Se	6.18^{c}±0.06	213.03^{c}±2.01	5.80^{bc}±0.20	-98.00±19.08
Nano-Se	6.21^{c}±0.01	214.07^{c}±0.40	6.21^{ab}±0.25	102.00±25.77

a, b and c means on the same column with different superscripts are significantly different (P≤0.05).

Productive traits of kids.

Productive traits of kids as affected by different treatments are presented in table (4). Litter size at birth, kids weight at birth , kids weight at weaning and kids weight gains at weaning were not affected significantly (P≤0.05) by different treatments. Litter size at weaning, total gain of litter (Kg), kids mortality rate and feed conversion ratio were affected significantly (P≤0.05) by different treatments.

Values of litter size at weaning ranged between 4.40-5.80 vs 4.40 for control diet. Total gain of litter (Kg) values ranged between 2.25 - 2.80 vs. 2.17 for control diet. Kids Mortality % values ranged between 9.71 -20.71vs for 36.19 for control diet. Feed conversion ratio values ranged between 3.74-4.74 for supplemented does vs. 5.27 for control diet.

All diets supplemented with normal and nano forms of traces minerals used were improved kids performance than control diet, that's may be due to an important role of those trace minerals in numerous biological processes and have both structural and catalytic functions in metalloenzymes , (O'Dell, 1992).

Diets supplemented with nano form of used trace minerals were improved animals performance in total milk yield and feed conversion ratio than those which supplemented normal form and control diet. The best diet was the one which supplemented with Nano-Se in a feed conversion ratio and the best one for a milk yield was the one which supplemented with Nano-Zn.

Total gain of litter (Kg)/doe and mortality % of kids were affected significantly ($P \leq 0.05$) by different treatments. Values for diet which supplemented with Nano- Cu were very closed from values for diets supplemented Nano-Se and Nano-Zn which were better than those which supplemented normal form and control diet.

These results may be related to more active for a biological processes in body, which resulting from great specific surface area, high surface activity, a lot of surface active centers, high catalytic efficiency and strong adsorbing ability of minerals in a Nano form (Zhang *et al*., 2005, 2008; and Wang and Yu, 2007).

Digestion coefficients of nutrients and nutritive values:

The results presented in Table (5), showed a significant differences between groups in the most of the digestion coefficients of different nutrients and nutritive values. There is no significant difference in both dry matter and organic matter digestibility between groups. Whereas the digestion coefficients of different nutrients and nutritive values of diets contained trace minerals used (Cu, Zn and Se) were better in general than control group significantly ($P \leq 0.05$). Groups supplemented with Nano- Cu, Nano- Ze and Nano- Se recorded the highest values for digestion coefficients of different nutrients and nutritive values between all groups.

Results indicated that nano form of trace element groups were more improving the digestion coefficients of different nutrients and nutritive values, that's may be related to more active for a biological processes and great specific surface area, high surface activity and strong adsorbing ability of elements in a nano form rats (Zhang *et al*., 2005, 2008; and Wang and Yu, 2007). That's improving soluble fiber has high water holding capacity, readily forms gel, increases luminal viscosity, and is easily degraded by micro- flora in the large bowel. On the contrarily, insoluble fiber has little water holding capacity, decreases transit time, is only partially degraded by micro- flora, and increases fecal bulk (Swanson *et al*., 2001).

Also, results agree with Shi *et al*. (2011) who indicated that fraction of CP was quadratically ($P<0.01$) increased with increasing Nano-Se supplementation and Xin-Yan Han (2012) who reported that the Nano-Cu used in dose 80 mg/kg in rabbit diet improved the activities of trypsin, amylase and lipase in the small intestinal contents and maltase, sucrose and lactase of duodenum, jejunum, and ileum mucosa.

Effect of experimental diets on the economical efficiency:

The economic efficiency of the experimental diets as affected by different experimental diets is shown in table (6).The economic efficiency of the present study was calculated based upon input-output analysis of the total feeding cost/doe and the prevailing selling price of the litter/doe at weaning. Values for economic efficiency ranged between 1.58- 2.34 for supplemented groups vs 1.41 for control diet.

The results indicated that diets supplemented with nano form of used trace minerals were more profit than those which supplemented normal form and control diet. The best value was for diet supplement with Nano-Se followed by diet supplement with Nano-Cu. .

This result may be related to that the Nano form of trace minerals used has more improving the profit from feed intake, milk yield and total gain of litter. These results were in agreement with (Hu *et al*., 2012) who reported that using selenium in nano form was more economically than control one.

Table (4). Productive traits of kids as affected by different treatments.

Supplementation level (%)	Litter size at birth	Litter size at weaning	Litter weight (g) at birth	Litter weight (g) at weaning	Total gain of litter (Kg)/doe	Kids weight(g) at birth	Kids weight at weaning	Kids weight gain Daily	Kids weight gain Total	Mortality % Of kids (from birth till weaning)	FCR* (feed/ gain)
Control	7.00	4.40[b]	349.00	2518.00	2.17[b]	50.06	576.60	18.81	526.54	36.19[a]	5.27[a]
Normal- Cu	6.80	5.60[ab]	356.00	2894.00	2.54[ab]	52.66	519.33	16.67	466.67	16.43[b]	4.31[abc]
Nano-Cu	7.00	5.80[a]	366.00	3114.00	2.75[ab]	52.51	541.22	17.45	488.71	16.91[b]	4.02[bc]
Normal -Zn	5.80	4.40[b]	322.60	2572.00	2.25[ab]	70.01	635.00	20.18	564.99	20.71[ab]	4.74[ab]
Nano-Zn	6.20	5.20[ab]	374.00	2974.00	2.60[ab]	61.62	566.13	18.02	504.52	11.33[b]	4.17[abc]
Normal-Se	5.80	5.20[ab]	320.00	2205.00	2.71[ab]	56.40	582.77	18.80	526.37	9.71[b]	3.84[bc]
Nano-Se	6.60	5.60[ab]	359.00	3156.00	2.80[a]	55.71	573.20	18.84	517.49	15.55[b]	3.74[c]

a, b and c means on the same column with different superscripts are significantly different ($P \leq 0.05$).

$$\text{*FCR, feed conversion ratio} = \frac{\text{Total feed intake of the doe during gestation and suckling periods}}{\text{Total litter gain}}$$

Table (5). Digestion coefficients of nutrients and nutritive values as affected by the experimental diets.

Treatments	Digestibility (%)						Nutritive values [k]	
	DM	OM	CP	CF	EE	NFE	TDN	DCP
(Control)	64.53 ±0.96	59.21 ±2.19	71.68 [c] ±0.19	46.57 [c] ±0.99	77.65 [b] ±1.29	67.61 [b] ±1.63	52.36 [b] ± 1.68	13.56 [c] ±0.04
Normal-Cu	64.55 ±0.53	64.55 ±0.48	76.03 [b] ±0.68	55.11 [ab] ±1.48	82.22 [a] ±1.71	70.31 [b] ±1.96	60.10 [b] ±1.42	14.41 [b] ±0.13
Nano-Cu	64.57 ± 0.34	59.86 ±0 .80	75.01 [b] ±0 .89	55.54 [ab] ±1.18	82.81 [a] ±0.59	68.70 [b] ± 0.55	57.38 [b] ±1.13	14.20 [b] ±0.17
Normal-Zn	64.18 ±1.64	59.70 ±2.37	75.76 [b] ±1.51	52.73 [b] ±2.43	82.33 [a] ±1.28	68.27 [b] ±2.76	57.42 [b] ±2.53	14.32 [b] ±0.29
Nano-Zn	64.95 ±1.21	60.74 ±1,28	75.26 [b] ± 1.18	55.30 [ab] ± 2.49	83.27 [a] ±0.55	69.03 [b] ± 0.37	58.02 [b] ±1.23	14.28 [b] ±0.23
Normal-Se	62.44 ±0.19	57.78 ±0.49	75.22 [b] ±0.15	50.02 [bc] ±0.49	76.96 [b] ±0.67	67.35 [b] ±0.70	56.53 [bc] ±0.60	14.20 [b] ±0.03
Nano-Se	64.36 ±1.11	62.37 ±4.99	79.53 [a] ±0.87	59.74 [a] ±2.22	85.59 [a] ±0.24	76.76 [b] ±0.16	64.62 [a] ±0.60	15.15 [a] ±0.16

a, b and c means on the same column with different superscripts are significantly different (P≤0.05).

[K] Calculated according to Cheeke et al. (1982).

Table (6). Input /output analysis and economic efficiency of the experimental diets of does as affected by different treatments[1].

Item	Control	Supplementation					
		Normal-Cu	Nano-Cu	Normal-Zn	Nano-Zn	Normal-Se	Nano-Se
Price / kg diet during experiment period (p.t)	275.00	275.95	275.44	275.80	276.20	275.25	275.84
Total feed intake/doe/G period (Kg)	4.61	4.35	4.20	4.24	4.25	4.08	4.11
Total feed intake/doe/S period (Kg)	6.67	6.44	6.62	6.28	6.43	6.18	6.21
Total feed cost/doe during G. period (LE)	12.68	12.00	11.57	11.69	11.74	11.23	11.34
Total feed cost/doe during S. period (LE)	18.34	17.77	18.23	17.32	17.76	17.01	17.13
Total feed cost /doe(LE)	31.02	29.77	29.80	29.01	29.50	28.24	28.47
Litter size at weaning	4.40	5.60	5.80	4.40	5.20	5.20	5.60
Total revenue/litter at weaning (LE)[2]	74.80	95.20	98.60	74.80	88.40	88.40	95.20
Net revenue/doe (LE)[3]	43.78	65.43	68.80	45.79	58.90	60.16	66.73
Economical efficiency(EE)	1.41	2.20	2.31	1.58	2.00	2.13	2.34
Relative EE%	100.00	156.03	163.83	112.06	141.84	151.06	165.96

[1] Based on prices in the Egyptian market during the experimental period (2016).

[2]Litter size x17 ,assuming that the selling price of each rabbit at weaning was LE (17).

3Net revenue /rabbit doe (LE) = Total revenue / rabbit doe (LE)-Total feed cost/rabbit doe (LE).

Economic efficiency = Net revenue /rabbit doe (LE)/ Total feed cost/ rabbit (LE).

CONCLUSION

From previous results, it could be concluded that the Copper, Zinc and selenium supplementation in nano form in even a half of amount in rabbit diets can be used economically without any adverse effects on rabbit reproductive performance.

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تأثير أضافة بعض العناصر النادرة في صورة جسيمات النانو علي الاداء التناسلي للأرانب

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تهدف هذه الدراسة لتقيم اثر اضافة بعض العناصر النادرة (النحاس- السلنيوم- الزنك) في علائق الارانب .حيث استخدم خمسة وثلاثون أ م أرنب سلالة نيوزيلندي أبيض (عمر 5شهور) بمتوسط وزن 2.9 كجم قسمت عشوائيا إلي 7 مجموعات تجريبية بحيث احتوت كل مجموعة منها على 5 أرانب . احتوت العليقة الضابطة علي كسب فول الصويا كمصدر بروتيني رئيسي حيث اضيف عنصر النحاس المعدني بنسبة 1جم/100كجم عليقة واضيف بنسبة 5,جم/ 100جم في صورة النانو واضيف عنصر الزنك المعدني بنسبة 8,جم/ 100جم واضيف بنسبة 4, جم/ 100جم في صورة النانو واضيف عنصر السلنيوم المعدني بنسبة 4, مجم/ 100جم واضيف بنسبة 2, مجم/ 100جم في صورة النانو . كانت الاحتياجات الغذائية طبقا لتوصيات القرار الوزاري لسنة 1996 وقد كانت العلائق متساوية في محتواها من الطاقة والبروتين .

وقد تم تسكين الامهات في بطاريات معدنية مجلفنة بمقاس(60x 50x 40) مزودة بمعالف منفصلة وكانت تقدم العلائق في صورة مصبعات متاحة حتى الشبع والمياة كانت متوفرة من خلال نبل اتوماتيكى وكانت كل الحيوانات تحت نفس الظروف البيئية .

وقد أظهرت النتائج أن استخدام العناصر في صورة النانو كان اكثر معدل استفادة من المأكول من العليقة معنويا . وقد تأثرت كمية اللبن معنويا باستخدام العلائق المختلفة بحيث تروامحت قيمتها من بين 78و5-52و6 بالمقارنة 54و5 –كجم لعليقة الكنترول وكانت أفضل عليقة هي العليقة التي اضيف عليها النانو زنك.

وقد تأثرت معنويا قيم كلا من معدل النفوق للخلفات لكل ام لهم ومعدل التحويل الغذائي لكل العلائق . كما كانت القيم للعليقة التي اضيف الها النانو نحاس قريبة جدا من تلك التي كانت للعلائق التي اضيف الها النانو سلنيوم والنانو زنك والتي كانت افضل منها في العلائق التي اضيفت اليها هذه العناصر في الصورة العادية والعليقة الكنترول

كما أوضحت النتائج ايضا أنه لم يوجد اختلاف معنوي في معامل هضم المادة الجافة والمادة العضوية الا انه كان هناك اختلاف معنوي في معاملات هضم بقية المركبات الغذائية وكانت معاملات هضم المجاميع التي اضيف اليها النحاس والزنك والسلنيوم افضل معنويا من مجموعة الكنترول .وبالنسبة للمجاميع التي اضيف اليها هذه العناصر في صورة النانو كانت افضل مجموعة هي المجموعة التى اضيف اليها النانو سلنيوم في كل معاملات الهضم . كما أوضحت النتائج أن أضافة النحاس والزنك و السلنيوم في الصورة العادية أو في صورة النانو حتي لو استخدمت بنصف الكمية كانت أفضل من الناحية الاقتصادية ولم يكن لها أي تأثير سلبي علي الاداء التناسلي للارانب عند استخدم النسب التي تم استخدامها.

التوصية : يستخلص من هذه الدراسة أنه يمكن اقتصاديا استخدام النحاس والزنك والسلنيوم في الصورة العادية في حدود النسب المستخدمة وفي صورة النانو بنصف النسب فى علائق الارانب دون حدوث تأثيرات عكسية علي الاداء التناسلي في الآرانب وذات تأثير ايجابي من الناحية الاقتصادية.