IMPACTS OF ZINC OXIDE NANO-PARTICLES SUPPLEMENTATION IN BROILER DIETS ON GROWTH PERFORMANCE, SOME CARCASS CHARACTERISTICS AND IMMUNE ORGANS

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SUMMARY

A study was designed to investigate the effect of different levels of dietary nano zinc oxide (NZnO) on growth performance, carcass traits, digestive tract measurements, immune response and economic efficiency of broiler chicks. A total number of 192 unsexed day-old "Cobb" broiler chicks were distributed in a completely randomized design of six treatments with four replicates (8 chicks each). The control (T1) contained 100 mg inorganic zinc oxide (IZnO)/kg of diet. Treatments two to six contained 100, 80, 60, 40 and 20 mg NZnO/kg of diet, respectively. No significant differences were observed between treatments on growth parameters except for feed conversion ratio (FCR) and performance index (PI). However, birds fed 40 mg NZnO (T5) consumed less feed and recorded the highest LBW, TBWG and the best CPC and CCR compared with the other treatments. The best FCR ($P \leq 0.01$), PI ($P \leq 0.05$), economic efficiency (EE) and the relative EE were obtained by T5. The highest ($P \leq 0.05$) breast and thigh ($P \leq 0.01$) and the lowest abdominal fat percentages were observed with birds fed the control and T6 (20 mg NZnO) compared to other treatments. Thymus percentage was reduced ($P \leq 0.01$) by T5 compared with control, T3 and T4 while the bursa percentage was increased by T4 and T5 compared with the other treatments. It could be concluded that NZnO at a level of 40 mg/kg of diet had no harmful effect on health status and could be used instead of the traditional zinc sources in broiler diets.

Keywords: *Broiler, nano zinc oxide, growth performance, carcass parameters and economic efficiency.*

INTRODUCTION

Zinc (Zn) concentration in feedstuffs is too low to meet poultry requirements, so it is regularly added to poultry feeds. In addition, the readily available zinc pools stored in the animal body are limited; hence daily Zn supply via diet is vital (Bao *et al*., 2009). As an essential trace element for humans and animals; Zn is working as a co-factor in more than 300 metal enzymes and plays a prominent role in many metabolic processes, including protein synthesis (Salim *et al*., 2008). The insufficient dietary Zn adversely affects proteins and carbohydrates metabolism resulted in poor feed intake, growth rate, feed conversion ratio and reproductive performance. In addition, insufficient dietary Zn reduced immunity and can lead to skeletal and skin disorders (Navidshad *et al*., 2016).

The Nation Research Council (NRC, 1994) suggested that Zn requirement for broiler chickens, based on the quality criteria, is 40 mg/kg diet. However, for most trace minerals, these suggested values are based on the old broiler strains which may be outdated for the broiler strains currently used in commercial production (Leeson, 2005). Therefore, broiler diets are usually supplemented with inorganic trace minerals such as oxides and sulfates above the recommended levels of NRC (1994) for maximizing performance (Leeson and Caston, 2008).

In the upper gut with low pH milieu, the inorganic trace minerals tend to dissociate. Consequently, the dissociated minerals can interact with other minerals as well as other nutrients in the gastrointestinal tract, making them unavailable for absorption across the small intestine (Yan and Waldroup, 2006). In addition, feeding diets supplemented with high levels of Zn may influence the balance of other trace elements in the body and reduce the stability of vitamins and other nutrients. Furthermore, the long-term application of these diets can cause Zn residue in the animal body (Zhao *et al*., 2014) and increase Zn excretion in the feces which induce environmental pollution (Zhang *et al*., 2018).

Recently, it was found that dietary supplementation of feed additives in nano form had positive effects on poultry production (Ahmadi and Fariba, 2010). Nour and Yunus, (2010) reported that nanoparticle is a key particle that carries the property as a whole. Moreover, minerals in nanoparticles form can be used as an alternative dietary source of trace minerals (Mohapatra *et al*., 2014). Asheer *et al*. (2018) reported that replacing inorganic Zn with nano Zn in broiler diets may be improved body weight and weight gain during initial phase and reduced mortality. Also, Hafez *et al*. (2017) concluded that 40 or 80 mg nano zinc oxide (NZnO) had beneficial effects on the growth performance and was a considerable Zn source for broiler chicken. In addition, broiler chicks fed diets supplemented with 10, 20 and 40 mg NZnO/kg of diet improved performance and reduced mortality due to ascites and 40 mg NZnO was the best level (Fathi *et al*., 2016)

The present work was designed to investigate the effect of different levels of nano zinc oxide supplementation in broiler diets on growth performance, some carcass traits, digestive tract measurements, immune response and economic efficiency.

MATERIALS AND METHODS

Birds and management:

This study was conducted at the Poultry Research Farm, Department of Animal Production, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt. One hundred and ninety-two, unsexed "Cobb" broiler chicks, one-day-old, were obtained from a commercial hatchery (Ismailia Misr Poultry Company, Ismailia, Egypt). Chicks were wing-banded, individually weighed and randomly distributed into 24 groups of eight chicks each. The average of the one-day live body weight of birds for each group was comparable with an overall mean of 54.51 ± 0.20 g. Six treatments, four replicates each, were used. Chicks were raised in an open house and caged in brooder batteries with wire mesh floors. Feed and water were supplied *ad-libitum*. The artificial light was provided daily for 23 hr and one hr of darkness. The ambient temperature was 34-35°C during the first week of the experiment and gradually decreased 2-3°C per week. Ventilation was provided by electric fans. All chicks were kept under the same management, hygienic and environmental conditions during the experimental period which lasted for 6 weeks. Chicks were vaccinated at the 8th days of age with Hitchner and at 22th and 35th with Lasota while the vaccination at the 14th and the 28th days of age was by Gumboro. Birds were observed daily for mortality and the number of dead birds was recorded.

Treatments and the experimental diets:

Six treatments in a completely randomized design were applied. The first treatment (control) contained 100 mg ZnO/kg of diet in inorganic form (IZnO; as recommended by the manual of Cobb, 2015). Treatments two to six were supplemented with nano-zinc oxide (NZnO) at 100, 80, 60, 40 and 20 mg /kg of diet, respectively. Chicks were fed three types of diets in mash form and were formulated to be iso-caloric and iso-nitrogenous. Starter diet (0 to 3 weeks of age; contained 22% CP and 3000 Kcal ME/kg diet), grower diet (4 to 5 weeks of age; contained 20% CP and 3100 Kcal ME/kg diet) and finisher diet (6th week of age; contained 18% CP and 3200 Kcal ME/kg diet). The preparation of ZnO in nano form particles was processed in Nanotechnology and Advanced Materials Central Lab Agriculture Research Center, Giza, Egypt, according to Kumar *et al*. (2013). Chemical analysis of the experimental samples and diets were performed in the laboratories of Animal Production Department, Faculty of Agriculture, and Suez Canal University according to the procedures outlined by A.O.A.C (1990). The experimental diets composition (starter, grower and finisher) and chemical analysis (calculated and determined) are shown in Table (1).

Growth parameters:

Individual live body weight (LBW) and feed intake (FI) per replicate were recorded weekly. Average daily gain (ADG), average daily feed intake (ADFI) per chick, feed conversion ratio (FCR), crude protein conversion (CPC) and caloric conversion ratio (CCR) were calculated. Also, the performance index (PI%) was calculated on the basis of (North, 1981):-

$$PI\,\% = \frac{Live\ weight\ in\ Kg}{Feed\ conversion} \times 100$$

Table (1): Formulation and chemical analysis (determined and calculated) of the experimental basal diets.

Ingredients (%)	Starter (0-3wk)	Grower (3-5wk)	Finisher (6^{th} wk)
Yellow corn	57.00	60.60	64.90
Soybean meal (44%CP)	30.00	27.00	24.31
Corn gluten meal (60%CP)	6.70	5.00	3.00
Veget.oil (Soybean +sun flower)	1.82	3.01	3.92
Limestone	1.24	1.07	1.00
Di-calcium phosphate	1.68	1.57	1.40
Mineral premix (Zn free)[1]	0.25	0.25	0.25
Vitamin premix[2]	0.25	0.30	0.25
Sodium chloride	0.40	0.50	0.37
DL- Methionine	0.23	0.21	0.28
L-Lysine	0.33	0.29	0.22
Choline chloride	0.10	0.20	0.10
Total	100.00	100.00	100.00
Chemical determined analysis %			
Dry matter	91.34	91.03	91.05
Crude protein	21.65	19.87	17.58
Crude fiber	3.65	3.44	3.15
Ether extract	4.97	5.71	6.76
Crude ash	5.60	5.61	4.91
Nitrogen free extract	55.47	56.40	58.65
Chemical calculated values % (according to NRC, 1994)			
Metabolizable energy (Kcal/kg)	3000.64	3100.80	3200.26
Crude protein (CP)	22.07	20.02	18.02
Lysine	1.321	1.196	1.052
Methionine	0.610	0.553	0.582
Methionine + Cystine	0.984	0.896	0.822
Calcium	0.939	0.842	0.771
A. Phosphorous	0.450	0.422	0.384
Zinc (ppm)	26.15	24.91	23.79

1) Each 1 kg of vitamin mixture contained: 10.000.000 IU vit. A, 5.000.000 IU vit. D3, 80.000 mg vit. E, 3.000 mg vit. K3, 3.000 mg vit. B1, 9.000 mg vit. B2, 4.000 mg vit. B6, 20 mg vit. B12, 15.000 mg pantothenic acid, 60.000 mg Nicotinic acid, 2.000 mg Folic acid and 150 mg Biotin.

2) Each 2 kg of minerals mixture contained: 500.000 mg choline chloride, 150.000 mg Cu, 1.000 mg I; 40.000 mg Fe, 100.000 mg Mn. and 350 mg Se.

Slaughtered parameters:

Two birds were chosen, close to the average body weight, from each replicate (eight birds per treatment) at the end of the experimental period (6 weeks of age). Birds were kept overnight fasted of food with free access to water. After the birds individually weighed, slaughtered and bleed for 3-5 minutes, each bird was feathered. The head was cut off close to the skull and feet with shanks were removed at the hock joint. The carcass evisceration was accomplished by a posterior ventral cut to remove the visceral organs. The inedible parts (blood, feather, head, legs and viscera) and eviscerated carcass were calculated via difference. Dressing (carcass plus giblets), giblets (liver, gizzard and, heart), immune organs (spleen, thymus gland and, bursa of fabricius) and abdominal fat were weighed for each bird. Proventriculus, and the intestine were individually weighed. Each eviscerated carcass was portioned into two halves then the right side was portioned into breast and thigh. The measurements mentioned above were expressed as a percentage of live body weight.

Economic efficiency (EEf):

The amount of feed intake during the experimental period for each treatment was multiplied by the price of one kg of each experimental diet (estimation based on the local current prices at the experimental time). The net revenue was calculated by subtracting the total feed cost from the price of one Kg broiler. The EEf was calculated by dividing the net revenue by the total feed cost.

Statistical analysis:

Data were subjected to analysis for significance by a one-way ANOVA model (as a completely randomized design) using the General Linear Models (GLM) procedures of SPSS (2018), IBM SPSS statistics, version 22, USA. The following mathematic model was used: $\mathbf{Y_{ij} = \mu + t_i + e_{ij}}$ where: $\mathbf{Y_{ij}}$ = the observation on the j^{th} individual from the i^{th} treatment; $\boldsymbol{\mu}$ = the overall mean; $\mathbf{t_i}$ = the fixed effect of the i^{th} treatment; $\mathbf{e_{ij}}$ = the random error associated with the individual ij.

Treatments differences were considered significant at P≤0.05 and P≤0.01 for all measurements. Means comparisons were performed using Duncan's multiple range tests (Duncan, 1955).

RESULTS AND DISCUSSION:

Growth performance and economic efficiency:

The effect of dietary Zn supplementation on broiler chickens performance and economic efficiency are shown in Tables (2 and 3). No significant differences were observed between treatment groups in average values of final LBW, TBWG, CCR and CPC, whereas significant differences were detected for FCR (P≤0.01) and PI (P≤0.05). Numerically, the highest mean value of TBWG was observed with the 40 mg NZnO treatment in comparison with other treatments with lowest TBWG values obtained from birds fed the control diet (Table 2).

Table (2): Growth performance and feed efficiency parameters of broiler chickens as affected by different levels of dietary nano zinc oxide (mean±SE).

	Zinc source and supplementation level (mg/Kg diet)						
	Inorganic zinc oxide	Nano zinc oxide					
Parameters	100 (T1)	100 (T2)	80 (T3)	60 (T4)	40 (T5)	20 (T6)	Sig.
Initial body weight (g/chick)	54.75 ±0.41	54.23 ±0.45	54.38 ±0.55	54.26 ±0.53	54.59 ±0.39	54.84 ±0.59	NS
Final body weight (g/chick)	2607.40 ±57.88	2654.50 ±50.36	2651.54 ±55.93	2634.72 ±63.54	2727.39 ±60.48	2651.27 ±58.89	NS
Total gain (g/chick)	2552.69 ±57.71	2600.41 ±50.35	2597.16 ±55.99	2580.31 ±63.60	2672.75 60.53±	2595.88 ±58.72	NS
Total Feed intake(g/chick)	3826.92 ±91.32	3799.42 ±79.49	3620.61 ±59.07	3718.44 ±67.89	3550.04 ±51.37	3898.44 ±63.14	NS
FCR	1.483[a] ±0.017	1.451[ab] ±0.022	1.393[bc] ±0.013	1.383[bc] ±0.038	1.369[c] ±0.026	1.388[bc] ±0.016	**
CCR	4.761 ±0.107	4.602 ±0.174	4.393 ±0.162	4.486 ±0.132	4.306 ±0.016	4.691 ±0.403	NS
CPC	0.305 ±0.007	0.296 ±0.011	0.285 ±0.005	0.285 ±0.013	0.279 ±0.003	0.303 ±0.028	NS
PI %	174.25[b] ±7.69	178.03[ab] ±7.79	185.98[ab] ±5.05	174.70[b] ±9.57	201.025[a] ±8.20	188.76[ab] ±2.56	*

*[a-c] means within each raw followed by different letters differ significantly , * = P≤0.05 ,*
*** = P≤0.01 and NS =Non significant.*

Data of Table (2) showed that feeding NZnO at different levels did not alter birds' feed intake. The lowest feed intake (P>0.05) and the best FCR value (P≤0.01) were observed by 40 mg NZnO/kg diet (T5) while the worst FCR value was recorded by the control group. Besides, the same group (40 mg NZnO/kg diet) significantly improved ($P \leq 0.05$) PI value, however, CPC and CCR values were numerically improved compared with the control group (Table 2). The total mortality was within normal limits and did not exceed 3%. Similarly, Asheer *et al.* (2018) found that no significant differences between treatments on final LBW, cumulative FI and cumulative FCR at the 6^{th} week of age when broiler chicks' diets were supplemented with 0.0, 25, 50, 75 or 100% of NZnO. Besides, these results agree with El-Katcha *et al.* (2017) who showed that 60, 45 or 30 ppm NZnO/kg of broilers diet improved growth performance and feed efficiency parameters; however, 15 ppm NZnO significantly worsen performance. In addition, a reduction in total FI was reported as a result of feeding on NZnO. Furthermore, supplementation of NZnO, Zn methionine (organic Zn) and mix of organic Zn and NZnO at 50 mg/kg to broiler diet contained inorganic ZnO significantly increased broiler BWG and enhanced protein efficiency and FCR in comparison with the inorganic ZnO (Ibrahim *et al.,* 2017). Parallel with the data here, Hafez *et al.* (2017) reported that ZnO nanoparticles at 40 or 80 mg/kg of diet is a considerable source of Zn for broiler chicken which had beneficial effects on the growth performance but no significant difference in FI. Additionally, ZnO at 20 or 40 mg/kg of diet (Fathi, 2016) or 60 mg/kg of diet (Pathak *et al.*, 2016) improved the growth performance of broiler chicks and reduced mortality due to ascites.

In general, the results of most former studies confirmed that ZnO nanoparticles at 20 to 60 mg/kg of diet could be appropriate levels to enhance BWG and achieve a better FCR of broiler chickens (Lina *et al.*, 2009; Zhao, *et al.*, 2014 and Swain *et al.* 2015) and this was matched with the present work. The improvements resulted from supplementing broilers diets with NZnO as the only source of Zn (the current study) or to a basal diet with inorganic Zn (some previous studies) indicated that Zn nanoparticles were more available and effective to induce the positive effects on performance parameters. Also, this might be related to the role of Zn as an integral part of more than 300 enzyme systems involved in energy nucleic acids and protein metabolism (Tabatabaie *et al.*, 2007). Ibrahim *et al.* (2017) found that ZnO nanoparticles improved Zn retention, enzymes antioxidant activity and metabolism of broiler chickens which resulted in a better performance. In the contrarily, Mohammadi *et al.* (2015) revealed that NZn-sulphate (80 mg/kg of diet) decreased BWG of broilers during the period from 1–42 day of age. The conflicting results of different research studies could be related to the differences in the physical and chemical features of different sources of Zn studied.

Data in Table (3) showed that 40 mg NZnO/kg of diet (T5) observed the best values of the economic efficiency (1.73) and relative efficiency (112.81). Although the process of producing zinc nanoparticles is expensive (1.3 L.E. per gram of NZnO) compared to the traditional form (0.3 L.E. per gram of inorganic ZnO); the economic return of T5 was the highest. This could be due to the lower amount used of NZnO compared with that of IZnO (40 vs. 100). The lowest FI, highest BWG and the best FCR obtained from T5 in comparison with the rest of the treatments and control. A like with the current results, Badawi *et al.* (2017) confirmed that a 40 ppm NZnO/kg of diet gave the highest return and net profit values in spite of the high cost of NZnO feed additive. Additionally, Swain *et al.* (2015) reported that NZnO has been provided economic benefits in poultry. On the other hand, the cost of production and net profit of NZnO at different levels (0.0, 25, 50, 75 and 100%) of broiler chicken diets were very similar (Asheer *et al.*, 2018).

Carcass characteristics:

Data in Table (4) showed that different levels of NZnO had no significant effect on carcass characteristics except for giblet, breast and thigh percentages and this effect was varied and inconsistent. The highest ($P \leq 0.05$) breast percentage was observed with birds fed diets supplemented with 80 mg NZnO (T3) followed by 20 mg (T6) and then IZnO 100 mg (control, T1) compared to the other treatments. However, the higher thigh ($P \leq 0.01$) and the lowest abdominal fat percentages ($P > 0.05$) were resulted with birds fed T1 followed by T6. Also, birds fed T3 and T6 had the higher ($P \leq 0.05$) giblets percentages in comparison with other treatments. Carcass and dressed percentages ($P > 0.05$) were the highest by T2 (100 mg NZnO/kg of diet) followed by T5 (40 mg NZnO/kg of diet) and T6, however, the highest ($P > 0.05$) inedible parts percentage was observed by T3.

Table (3): Economic efficiency of broiler chicks as affected by different levels of dietary nano zinc oxide (NZnO).

Item	Zinc source and supplementation level (mg/Kg diet)					
	100 [7]IZnO (T1)	100 [8]NZnO (T2)	80 NZnO (T3)	60 NZnO (T4)	40 NZnO (T5)	20 NZnO (T6)
Average feed intake (Kg/bird) Starter = a^1	1.108	1.113	1.070	1.012	1.122	1.095
[1] Price / Kg starter feed (L.E.) =b^1	6.530	6.579	6.566	6.553	6.540	6.527
Average feed intake (Kg/bird) Grower =a^2	1.705	1.715	1.699	1.743	1.654	1.623
[2] Price / Kg grower feed (L.E.) =b^2	6.427	6.495	6.477	6.459	6.441	6.422
Average feed intake (Kg/bird) Finisher =a^3	0.878	0.883	0.787	0.803	0.799	0.875
[3] Price / Kg finisher feed (L.E.) =b^3	6.269	6.318	6.305	6.292	6.279	6.266
Total feed cost (L.E.) = $(a^1 \times b^1)+(a^2 \times b^2)+(a^3 \times b^3)$ =c	23.699	24.045	22.990	22.934	23.008	23.047
Average LBW (Kg) = d	2.607	2.655	2.651	2.634	2.727	2.651
[4] Price /kg LBW (L.E.) = e	23.00	23.00	23.00	23.00	23.00	23.00
Total revenue (L.E.) =d × e = f	59.97	61.05	60.97	60.58	62.72	60.97
[5] Net revenue (L.E.) = f - c = g	36.27	37.01	37.98	37.65	39.71	37.93
Economical Efficiency = (g/c)	1.53	1.54	1.65	1.64	1.73	1.65
[6] Relative Efficiency	100	100.60	107.98	107.30	112.81	107.56

[1,2 and 3]Based on average price of starter, grower and finisher diets, respectively during the experimental time.
[4] According to the local market price at the experimental time.
[5] Net revenue per unit feed cost.
[6] Assuming that the economical efficiency of control diet equal 100.
[7] IZnO =Inorganic zinc oxide. [8] NZnO= Nano zinc oxide.

Table (4): Carcass characteristics (% of live body weight) of broiler chicks as affected by different levels of dietary nano zinc oxide (mean±SE).

Parameters %	Zinc source and supplementation levels (mg/Kg diet)						Sig.
	Inorganic zinc oxide		Nano zinc oxide				
	100 (T1)	100 (T2)	80 (T3)	60 (T4)	40 (T5)	20 (T6)	
Carcass	77.49 ±0.41	78.75 ±0.51	77.05 ±0.53	77.49 ±1.05	78.04 ±0.39	77.98 ±0.61	NS
Inedible parts	22.51 ±0.41	21.25 ±0.51	22.95 ±0.53	22.51 ±1.05	21.96 ±0.39	22.03 ±0.61	NS
Giblet	3.49^{ab} ±0.11	3.50^{ab} ±0.09	3.58^{a} ±0.11	3.25^{b} ±0.05	3.23^{b} ±0.07	3.59^{a} ±0.10	*
Dressed	80.99 ±0.38	82.23 ±0.47	80.64 ±0.56	80.73 ±1.08	81.26 ±0.38	81.61 ±0.54	NS
Breast	26.16^{a} ±1.56	21.86^{b} ±0.97	26.39^{a} ±1.05	22.36^{b} ±0.78	23.69^{ab} ±0.97	26.25^{a} ±1.28	*
Thigh	17.73^{a} ±0.56	15.04^{b} ±0.45	15.54^{b} ±0.54	15.34^{b} ±0.36	15.45^{b} ±0.49	17.03^{a} ±0.63	**
Abdominal fat	0.93 ±0.07	1.20 ±0.08	1.19 ±0.13	1.17 ±0.14	1.02 ±0.12	0.96 ±0.10	NS

*[a-b]means within each row followed by different letters differ significantly, * = $P \leq 0.05$,*
*** = $P \leq 0.01$ and NS =Non significant.*

Comparable to the data here El-Katcha *et al.* (2017) stated that dressing percentage was significantly improved and abdominal fat weight and its relative weight were decreased by replacing dietary inorganic Zn with lower levels of organic or NZn. However, Mohammadi *et al.* (2015) reported that NZn-sulphate and control groups (without added Zn) dramatically reduced carcass yield (%) and increased abdominal fat (%)

at 42 day of age when broilers fed basal diet (without Zn) and basal diet supplemented with Zn-sulphate, Zn-methionine, NZn-sulphate, NZn-methionine and NZn-max. at a concentration of 80 mg/kg of diet. While, Sahoo *et al.* (2016) reported no significant differences between Zn source (inorganic, organic, nano-Zn) and levels (0, 15 ppm ZnSO4, 15 ppm Zn-Met., 7.5 ppm Zn-Met., 0.3 ppm NZnO, 0.06 ppm NZnO and 0.03 ppm NZnO) on carcass weight and percentages of dressing, breast and thigh of broiler chicken.

Digestive tract parameters and immune organs:

Dietary levels of nano-zinc had significant effects on chicks' digestive tract parameters and immune organs except for spleen (Table 5). Data revealed that the relative weight of proventriculus at 40 and 100 mg NZnO/kg of diet were significantly ($P \leq 0.05$) the lower compared with those of the control group. The relative weight of the intestine was decreased by lowering the NZnO levels with significant differences ($P \leq 0.05$) at 40 and 20 mg/kg of diet compared with the control. Also, dietary NZnO reduced ($P \leq 0.01$) the relative weight of thymus (at 100, 40, and 20 mg/kg of diet) and improved ($P \leq 0.01$) the relative weight of bursa of fabricius (60 and 40 mg/kg of diet) in comparison with the control.

Table (5): Digestive tract measurements and immune organs (% of live body weight) of broiler chicks as affected by different levels of dietary nano zinc oxide (mean±SE).

	Zinc source and supplementation levels (mg/Kg diet)						
	Inorganic zinc oxide	Nano zinc oxide					
Parameters %	100 (T1)	100 (T2)	80 (T3)	60 (T4)	40 (T5)	20 (T6)	Sig.
Digestive tract measurements							
Proventriculus	0.29^{a} ±0.02	0.25^{b} ±0.01	0.28^{ab} ±0.02	0.26^{ab} ±0.01	0.24^{b} ±0.01	0.25^{b} ±0.01	*
Intestine	3.01^{a} ±0.10	2.98^{ab} ±0.13	2.84^{abc} ±0.10	2.80^{abc} ±0.09	2.64^{c} ±0.06	2.69^{bc} ±0.11	*
Immune organs							
Spleen	0.08 ±0.01	0.08 ±0.01	0.08 ±0.01	0.10 ±0.01	0.08 ±0.01	0.08 ±0.01	NS
Thymus	0.47^{a} ±0.04	0.30^{b} ±0.04	0.39^{ab} ±0.03	0.40^{ab} ±0.04	0.32^{b} ±0.03	0.32^{b} ±0.03	**
Bursa of Fabricius	0.04^{bc} ±0.00	0.04^{bc} ±0.00	0.03^{bc} ±0.00	0.05^{a} ±0.01	0.04^{ab} ±0.01	0.03^{c} ±0.00	**

*$^{a-c}$ means within each row followed by different letters differ significantly , * = $P \leq 0.05$, ** = $P \leq 0.01$ and NS =Non significant.*

The bursa of fabricius is the main lymphoid organ in poultry that has an important function in B lymphocyte differentiation (Schat and Skinner, 2014). In addition, Sahoo *et al.* (2014) studied the effect of supplementing inorganic zinc (15 ppm $ZnSO_4$), organic Zn (15 and 7.5 ppm Zn-Met) and NZn (0.3, 0.06 and 0.03 ppm NZnO) to unsupplemented basal diet (contained 30 ppm Zn) on the immune organs of broiler chicks. They concluded that 15 ppm Zn-Met and 0.06 ppm NZnO significantly improved relative weights of the spleen, bursa and thymus in comparison with the rest of the treatments. On the contrary, El-Katcha *et al.* (2017) found that the replacement of dietary inorganic ZnO with lower levels of organic Zn or Zn nanoparticles significantly improved the thymus and spleen weight and percentages and significantly reduced weight and relative weight of bursa. However, increasing the level of organic Zn (Zn-polysaccharide complex) increased bursa weight in comparison with those fed a basal diet supplemented with inorganic Zn. This could be explained by that supplementation diets with organic or nano zinc increased thymulin activity; thus, enhancing the immune response through increased maturation of T-lymphocyte and activation of B lymphocytes by T-helper cells (Hudson *et al.*, 2004). Furthermore, Mohammadi *et al.* (2015) showed that spleen and bursa of fabricius (%) of broiler chicks were significantly higher when the diet was supplemented with 80 mg Zn/kg (inorganic or nano) compared with the unsupplemented control. Whereas, Ahmadi *et al.* (2013) reported that NZnO (30, 60, 90 or 120 mg/kg of diet) had no significant effect on digestive and visceral organs of broiler chicks (1-21 day of age) compared with the unsupplemented control.

In conclusion, results of this study indicated that NZnO at the level of 40 mg/kg of diet is a considerable Zn source for broiler chicken with beneficial effects on the growth performance economic efficiency. Moreover, supplementation of Zn as nano particles to the diets had no harmful effect on birds' health status and reducing the amount of Zn in the diets resulted in a positive outcome on the environment.

REFERENCES

Ahmadi, F. and R. Fariba (2010). The effect of different levels of nano silver on performance and retention silver in edible tissue of broilers. World Applied Sci. J., 12: 1-4.

Ahmadi, F.; Y. Ebrahimnezhad; N. Naser and J. G. Ghalehkandi (2013). The effects of zinc oxide nanoparticles on performance, digestive organs and serum lipid concentrations in broiler chickens during starter period. Int. J. Biosci., 3: 23-29.

AOAC (1990). Association of Official Analytical Chemists. Official Methods of Analysis, 15th Edition. Washington, DC, USA.

Asheer, M.; S.J. Manwar; M.A. Gole; S. Sirsat; M.R. Wade; K.K. Khose and S. Sajid Ali. (2018). Effect of dietary nano zinc oxide supplementation on performance and zinc bioavailability in broilers. Indian J. of Poult. Sci., 53: 70-75.

Badawi, M.; M. Ali and A. Behairy (2017). Effects of zinc sources supplementation on performance of broiler chickens. J. of American Sci., 13: 35-43.

Bao, Y.M.; M. Choct; P.A. Iji and K. Bruerton (2009). Optimal dietary inclusion of organically complexed zinc for broiler chickens. Br. Poult. Sci., 50:95-102.

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

El-Katcha, M.; A. Mosad Soltan and M. El-badry (2017). Effect of dietary replacement of inorganic zinc by organic or nano particles sources on growth performance, immune response and intestinal histopathology of broiler chicken. Alexandria J. of Vet. Sci., 55: 129-145.

Fathi. M. (2016). Effects of zinc oxide nanoparticles supplementation on mortality due to ascites and performance growth in broiler chickens. Iranian J. Appl. Anim. Sci., 6: 389-394.

Fathi, M.; M., Hydari and T. Tanha (2016). Effect of zinc oxide nanoparticles on antioxidant status, serum enzyme activities, biochemical parameters and performance in broiler chicken. J. Livestock Sci. and Technol., 4: 07-13.

Hafez, A.; S.M. Hegazi; A.A. Bakr and H. El- Shishtawy (2017). Effect of zinc oxide nanoparticles on growth performance and absorptive capacity of the intestinal villi in broiler chickens. Life Sci, J. 14:125–129.

Hudson, B.P.; W. A. Dozier; J.L. Wilson; J.E. Sander and T.L. Ward (2004). Reproductive performance and immune status of caged broiler breeder hens provided diets supplemented with either inorganic or organic sources of zinc from hatchery to 65 wk of Age. J. Appl. Poult. Sci., 13: 49-59.

Ibrahim, D.; A. H. Ali and A.M. Shefaa El-Mandrawy (2017). Effects of different zinc sources on performance, bio distribution of minerals and expression of genes related to metabolism of broiler chickens. Zagazig Vet. J., 45: 292-304.

Kumar, S.S.; P. Venkateswarlu; V.R. Rao and G.N. Rao (2013). Synthesis, characterization and optical properties of zinc oxide nanoparticles. International Nano Letters. 3: 1-6.

Leeson, S. (2005). Trace mineral requirements of poultry validity of the NRC recommendations. In: Re-defining mineral Nutrition. LA Tucker, and JA Taylor-Pickard, Nottingham university press, Nottingham, UK. 107– 117.

Leeson, S. and L. Caston (2008). Using minimal supplements of trace minerals as a method of reducing trace mineral content of poultry manure. Anim. Feed Sci. Tech. 142:339–347.

Lina, T., Zhu, F., Ren ,H., Jiang, J.Y. and Li, W. (2009). Effects of nano-zinc oxide on antioxidant function in broilers. Chinese J. Anim. Nut., 21: 534-539.

Mohammadi, V.; S. Ghazanfari; A. Mohammadi-Sangcheshmeh and M.H. Nazaran (2015). Comparative effects of zinc-nano complexes, zinc-sulphate and zinc-methionine on performance in broiler chickens. Br Poult Sci, 56:486-493.

Mohapatra, P.; R.K. Swain; S. K. Mishra; T. Behera; P. Swain; N. C. Behura; G. Sahoo; K. Sethy; B. P. Bhol and K. Dhama (2014). Effects of dietary nano-selenium supplementation on the performance of layer grower birds, Asian J. Animal and Veterinary Advances, 9: 641-652.

Navidshad, B.; S. Jabbari and F. Mirzaei Aghjeh Gheshlagh (2016). The New Progresses in Zn Requirements of Poultry. Iranian Journal of Applied Animal Science (IJAS). 6: 763-767.

North, M.O. (1981). Commercial chicken. Production Annual. 2nd Edition, AV., publishing company I.N.C., West post Connecticut, USA.

Nour, A.H. and R.M. Yunus (2010). Demulsification of water-in-oil emulsions by microwave heating technology. World. Acad. Sci. Eng. Tech., 38:188-193.

NRC (1994). Nutrient Requirements of Poultry, 9th Rev. Ed. National Academy Press, Washington, DC., USA.

Pathak, S. S.; K. V. Reddy and S. Prasoon (2016). Influence of different sources of zinc on growth performance of dual purpose chicken, J. Bio. Innov 5: 663-672.

Sahoo, A.; R. K. Swain and S. K. Mishra (2014). Effect of inorganic, organic and nano zinc supplemented diets on bioavailability and immunity status of broilers. Int. J. Adv. Res., 2:828-837.

Sahoo, A.; R.K. Swain; S.K. Mishra; N.C. Behura; S.S. Berura; C. Sahoo; A. Das; A. Mishra and B. Jena (2016). Growth, feed conversion efficiency and carcass characteristics of broiler chicks fed on inorganic, organic and nano zinc supplemented diets. Anim. Sci. Rep.10: 10-18.

Salim, H.M.; C. Jo and B.E. Lee (2008). Zinc in broiler feeding and nutrition. Avian Biol. Res. 1:5-18.

Schat, K.A. and M.A. Skinner (2014). Avian Immunosuppressive Diseases and Immune Evasion. In : Schat KA, Kaspers B, Kaiser P, editors. Avian Immunology. San Diego :Elsevier Ltd. Publishing; 275-297.

SPSS (2018). User's guide: statistics. Version 22. SPSS. Inc. Chicago, IL, USA.

Swain, P.S; D. Rajendran; S.B.N. Rao and G. Dominic (2015). Preparation and effects of nano mineral particle feeding in livestock: a review. Vet World 8: 888–891.

Tabatabaie, M.M; H. Aliarabi; A.A. Saki; A. Ahmadi and S.A. Hosseini Siyar (2007). Effect of different sources and levels of zinc on egg quality and laying hen performance. Pakistan. J. Biol. Sci.; 10: 3476-3478.

Yan, F. and W.P. Waldroup (2006). Evaluation of Mintrex^{R} manganese as a source of manganese for young broilers. Int. J. Poult. Sci. 5:708–713.

Zhang, T.Y.; J.L. Liu; J.L. Zhang; N. Zhang; X. Yang; H.X. Qu; L. Xi and J.C. Han (2018). Effects of dietary zinc levels on the growth performance, organ zinc content, and zinc retention in broiler chickens. Braz J Poult Sci 20:127–132.

Zhao, C.Y; S. X. Tan; X.Y. Xiao; X.S. Qiu; J.Q. Pan and Z.X. Tang (2014). Effects of dietary zinc oxide nanoparticles on growth performance and antioxidative status in broilers. Biol Trace Elem Res 160:361–367.

تأثيرات إضافة الأجزاء النانوية لأكسيد الزنك في علائق بداري التسمين على أداء النمو وبعض خصائص الذبيحة وأعضاء المناعة

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صُممت هذه الدراسة لمعرفة تأثير المستويات المختلفة لأكسيد الزنك النانو الغذائي على أداء النمو وصفات الذبيحة وقياسات الجهاز الهضمي والاستجابة المناعية والكفاءة الاقتصادية لكتاكيت التسمين.

تم استخدام 192 كتكوت تسمين من نوع "Cobb" غير المجنس في عمر يوم قسمت بشكل عشوائي إلى ستة معاملات ، بكل معاملة أربع مكررات بمعدل 8 كتاكيت في كل مكررة.

تم تغذية الطيور علي العليقة القاعدية كعليقة مقارنة (معاملة 1) والتي تحتوي علي 100 مجم من أكسيد الزنك الغير عضوي/كجم من العليقة. بينما المعاملات من الثانية إلي السادسة وتحتوي كل منها علي 100، 80، 60، 40 و 20 مجم /كجم عليقة علي التوالي في صورة أكسيد النانو زنك.

واتضح من النتائج انه لا يوجد فروق معنوية بين المعاملات بالنسبة لمقاييس كفاءة النمو باستثناء كفاءة التحويل الغذائي (FCR) ومؤشر الآداء (PI).

ومع ذلك ، فإن الطيور التي غذيت على الغذاء المحتوي 40 ملجم من NZnO (T5) استهلكت غذاء أقل وسجلت أعلى وزن حي للجسم وكذلك أعلي زيادة مكتسبة في وزن الجسم وأفضل كفاءة تحويلية لكل من البروتين والطاقة وأفضل كفاءة تحويل غذائي ($P\leq0.01$)، وأفضل مؤشر آداء PI ($P\leq0.05$) و أفضل كفاءة اقتصادية (EE) وكفاءة اقتصادية نسبية (REE) بواسطة T5. وقد لوحظ أن أعلى وزن للصدر ($P\leq0.05$) والفخذ ($P\leq0.01$) وأدنى نسب غير معنوية للدهون في البطن مع الطيور التي غذيت عليقة الكنترول والعليقة السادسة والتي تحتوي20 مجم من NZnO مقارنة مع المعاملات الأخرى.

انخفضت النسب المئوية للغدة الثيموسية معنويا ($P\leq0.01$) بالنسبة للمعاملة الخامسة مقارنة بالمعاملات الكنترول والثالثة والرابعة بينما ازدادت النسب المئوية لغدة فابريشيوس للمعاملات الرابعة والخامسة بالمقارنة بالمعاملات الأخري.

نستنتج من هذه الدراسة أن NZnO بمستوي 40 مجم /كجم غذاء ليس له أي تأثير ضار على الحالة الصحية ويمكن استخدامه بدلاً من مصادر الزنك التقليدية في علائق التسمين.