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Influence of dietary different levels of zinc oxide nano particles on the yield and quality carcass of broiler chickens during starter stage

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ABSTRACT

The aim of the present study was to evaluate the effect of dietary different levels of zinc oxide nanoparticles (Zno-NPs) on the yield and quality carcass of broiler chickens during starter stage (from 1 to 21 day). One-day mail broilers (300) were distributed in a completely randomized design (CRD) in 5 treatment groups, each having 4 replicates and 15 birds in each experimental pen. The experimental diets were: T1 control (basal diet); T2, T3, T4 and T5 diets, supplemented with 30, 60, 90 and 120 mg Zno-NPs/kg of diet, respectively. Birds had access to feed and water throughout time of research. On d 21 birds (4;1 bird/replicate) were randomly selected, slaughtered and then carcass yield, breast and thigh composition were evaluated. The results indicated that live body weight, dressing and percentage of breast and thigh meat were higher in the T3 and T4 groups than control and other groups. Dry matter (DM), and crude protein (CP) of breast and thigh meats were higher in T3 (60 mg Zno-NPs/kg) and T4 (90 mg Zno-NPs/kg) bird groups as compared to control and other treatments. Ether extract in breast and thigh meat reduced in comparison with control treatment. In conclusion, results of present trial suggested that dietary no-NPs with 60 and/or 90 mg/kg Zno-NPs had significantly improved broiler quality and quantity of carcass broiler during starter period.

Key words: Broiler, Carcass, Nanoparticles, Zinc oxide

Zinc plays a vital role in numerous biological processes as essential component of different enzymes (Vallee and Auld 2006). Zinc is a portion of the metalloenzymes such as alkaline transferase (ALP), supper oxide dismutase (SOD); also it is essential for function of growth hormone, skeletal development and immune competence (Brandeo-Neto *et al*. 1995, Collins and Mot 1999). Zinc participates as a cofactor or component of 250 to 300 enzymes that being important for protein and carbohydrate metabolism, growth, and reproduction (Kidd *et al*. 1996, McDowell 2003). In poultry, Zn deficiency causes reduction in weight gain; therefore, Zn is often supplemented in practical poultry diets to elicit a positive response in broiler chickens, particularly during early age (Blamberg *et al*. 1960). Tissue uptake of Zn in chicks is linearly related to Zn levels in the diet (Sandoval *et al*. 1997). Hudson *et al*. (2004) and Rossi *et al*. (2007) have indicated that growth performance and meat yields were unaffected when dietary Zn concentrations were provided in excess of the NRC (1994) recommendations of 40 mg/kg of supplemented Zn.

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Recently, researchers had applied nanoparticle products in veterinary, medicine, food packaging and agriculture (Bartlett and Smith 2003).

Recently, animal nutritionist had investigated the effect of different elements nanoparticles such as silver nanoparticles, nanoselenium, nanogold, and zinc oxide nanoparticles on the economic performance traits, immune system, and quality carcass in broiler, rat and pigs (Hudson *et al*. 2004). Therefore, present research was conducted to evaluate the effect of different levels of zinc oxide nanoparticles (Zno-NPs) on the several carcass traits of broilers from 1 to 21 d.

MATERIALS AND METHODS

Birds and experimental diets: One-day-old male broiler chicks (300) were fed in concrete floor pens with 2.0 m × 1.5 m × 0.75 m dimensions by repeat pens that contained wood shavings as bedding. Each pen was equipped with a cylindrical hand feeder and an automatic water supply system so the birds had *ad lib.* access to feed and water throughout the study. The temperature and other feeding conditions in the pens were controlled according to the recommendations for commercial broiler chickens. Lighting was provided on a 23L: 1D regime basis. For the control group, a basal diet was provided that consisted of corn and soybean meal and fully met the nutrient requirements of

Table 1. Ingredient and chemical composition of the basal diets (As fed) from 1 to 21 days of broiler age

Feed ingredients	(%)
Corn grain	60.36
Soybean meal (44%)	34.00
Soybean oil	3.20
DL-methionine	0.20
L-lysine, HCl	0.30
Limestone	0.35
Dicalcium phosphate	1.83
Salt (NaCl)	0.26
Mineral and Vitamin premix[1]	0.50
Calculated analysis	100
ME (kcal/kg)	3,000
CP (%)	21.34
Total P (%)	0.66
Available P (%)	0.44
Ca (%)	1.02
Lys (%)	1.21
Met (%)	0.49
Met + Cys (%)	0.86
Zinc (mg/kg)	36.29

[1]Per kilogram of starter diet from 1 to 21 d contained: Ca, 210 g; P, 85.7 g; Fe, 1,250 mg; Cu, 250 mg; I, 15 mg; Se, 8.2 mg; vitamin A, 250,000 IU; vitamin D3, 50,000 IU; vitamin E, 275 mg; vitamin K3, 42.5 mg; vitamin B1, 45 mg; vitamin B2, 150 mg; vitamin B6, 62.5 mg; vitamin B12, 300 mcg; niacin, 1,000 mg; folic acid, 27 mg; pantothenic acid, 400 mg; choline, 12.5 g; biotin, 2mg; Met, 45 g and Zn, 36.29 mg/kg.

the broilers based on the feeding standards (NRC 1994).The basal diet fed to broilers had all nutrient levels including crude protein (CP) and metabolizable (ME) energy the same during the experiment (Table 1).

Experimental design: All experimental procedures, including those dealing with animals, were conducted in accordance to the Institutional Animal Care and Use Committee of Animal Production, Veterinary Organization, Iran. Experimental diets were following: (T1) Control (basal diet), and T2, T3, T4 and T5 basal diets were supplemented with 30, 60, 90 or 120 mg Zno-NPs/kg (Table 2). The feed was manufactured every week and supplied in mash form. The level of zinc in basal diet after digestion of diet sample, was determined by atomic absorption spectrophotometerical method.

Carcass sampling and analysis: On d 21, four birds (1 bird/replicate) from each treatment group with closest weight to treatment mean were killed by cervical cutting to measure dressing weight, percentage, and wing, breast and thigh meat weights, fat pad (abdominal fat plus surrounded gizzard fat). The weight and percentage of every part of birds expressed as g/ kg of live weight or percentage (%). Also, to determine several parameters as dry matter (DM), crude protein (CP), and ether extract (EE) in the breast and thigh meat, about 100 g sample from different sections of breast and thigh meat removed. After prepared samples from breast and thigh meats from the bird's carcass were analyzed

Table 2. Concentration of Zn and ZnO-NPs in the experimental diets[1] (by analysis)

Experimental diets	Level of Zinc oxide in Experimental diets (mg/kg)[2]	
	Zinc (mg/kg)	Zinc oxide nanoparticles
T1-Control	36.29	0
T2	36.29	36.29+30mg
T3	36.29	36.29+60mg
T4	36.29	36.29+90mg
T5	36.29	36.29+120mg

[1]Zinc source was zinc oxide (Purity = 72%) and zinc oxide nanoparticles (Purity= 99/99%). [2] Zinc basal diet contain calculated based on NRC (1994) nutrient information.

and qualitative parameters were expressed in % of the total mass of each carcass.

The samples were completely mixed and then a part (50 g) of sample was used to analyse DM, moisture, CP and ether extract (EE). Dry mater (oven, 120° C for 12 h), crude protein, and ether extract content in breast and thigh samples measured according to standard procedures of AOAC (No. 995.6).

Statistical analysis: Data were analyzed at a completely randomized design using the general linear model (GLM) procedure of SAS for Windows version 9.1 (SAS 2003). When a significant difference was found, means were separated using Duncan's multiple range tests (Duncan 1955). Differences were considered to be significant if $P < 0.05$.

RESULTS AND DISCUSSION

Carcass yield: Results related to the effect of zinc oxide nanoparticles on carcass yield (Table 3) indicated that dietary zinc oxide nanoparticles significantly increased live body weight, dressing and carcass weight ($P > 0.05$). Also, the weight of breast and thigh in birds that were fed diet with were zinc oxide nanoparticles were higher than ($P > 0.05$) control treatment. The highest live body weight, carcass, breast and thigh were observed in birds fed diet consisting of 60 (T3) or 90 (T4) mg zinc oxide nanoparticles. Relative weight of wing and fat pad was not affected ($P < 0.05$) by using zinc oxide nanoparticles in broiler, although observed a decreasing trend attributed to relative fat pad weight as compared to control. Results of current study is in agreement with Wojciech *et al*. (2007) as they had reported that different source of zinc (organic form of zinc) resulted in a 4.15% increase of the dressing percentage of the birds compared to the dressing percentage of the birds from the treatment that fed diet inclusion of zinc-oxide. Also, the same researcher indicated that the birds receiving an amino-acid chelate of zinc exhibited a higher share of breast and leg meats. Yogesh *et al.* (2013) reported that different levels and sources of zinc did not significantly affect carcass yield parameters in broiler chickens. Results of present research were in disagreement with report of

Table 3. Effect of dietary zinc oxide nanoparticles on carcass yield of broiler chickens at the starter period[1]

Treatment	LBW (g)	Dressing weight (g)	Net carcass weight (g)	Breast weight (g)	Thigh weight (g)	Wing (g)	Abdominal fat (%)
T1-Control	709.2b	553.3c	491.0c	241.5	207.4	54.7	1.35
T2-30 mg/kg diet	701.0b	579.7b	508.3b	243.3	212.7	53.2	1.31
T3-60 mg/kg diet	753.2a	631.0a	573.9a	254.9	213.8	52.4	1.27
T4-90 mg/kg diet	776.0a	635.2a	590.1a	260.7	219.7	54.0	1.27
T5-120 mg/kg diet	696.0b	551.4bc	508.4b	238.1	218.8	53.9	1.34
SEM	9.7	11.06	7.1	5.8	8.8	2.1	0.037
P-value	0.0219	0.036	0.047	0.139	0.341	0.306	0.172

[1]Means with different superscripts in the same column differ (P <0.05); LBW, live body weight; dressing weight consisted of: carcass plus liver and heart. Net carcass weight consists of: carcass without liver and heart. Fat pad consisted of abdominal fat plus surrounded gizzard fat.

Table 4. Effect of dietary zinc oxide nanoparticles on carcass quality parameters of broiler at the starter period[1]

Treatments	DM (%)		CP (%)		EE (%)	
	Breast	Thigh	Breast	Thigh	Breast	Thigh
T1-Control	22.71c	18.08b	22.15c	17.42b	15.13	19.81
T2-30 mg/kg diet	23.01b	18.12b	23.98b	17.61a	15.12	19.25
T3-60 mg/kg diet	24.40a	19.09a	24.67a	18.75a	15.08	18.75
T4-90 mg/kg diet	24.95a	19.95a	24.71a	18.91a	15.01	18.51
T5-120 mg/kg diet	22.52c	18.02b	21.07cd	16.74b	15.81	18.68
SEM	0.21	0.90	1.71	0.51	0.09	0.07
P-value	0.0103	0.026	0.013	0.0491	0.409	0.806

[1]Means with different superscripts in the same column differ (P < 0.05).

mentioned researchers. Bonomi *et al.* (1993) in their experiment using amino-acid chelates of Zn, Cu, Mn and Fe as supplement in broiler chickens and turkey broiler diet, reported that dressing percentage of the carcass and percentage of meat increased compared to the control group of birds. The result of present research was in agreement with mentioned researchers report.

Some of the reasons to explain incoherence may be attributed to type, form, exposing time, dose of zinc oxide nanoparticles etc. It is well demonstrated that the form of material nanoparticles with regards to bulk form had achieved some of the new physico-chemical traits such as size particles, shape particles, surface/volume ratio particles and etc. (Hudson *et al.* 2004). Johnson (1998) demonstrated the positive effects of Zn-methionine, Zn-lysine complex and an amino-acid zinc complex on the percentage of breast meats in the carcass of broiler chickens. The results with regard to thigh meat weight, wing and abdominal fat showed that inclusion of zinc oxide nanoparticles had not significantly affected these compared to control treatment.

The effect of dietary zinc oxide nanoparticles on the carcass traits such as dry matter (DM), crude protein (CP) and ether extract (EE) are shown in Table 4. DM (P<0.05) and CP (P<0.05) in the meat of breast and thigh were higher in birds fed T3 (60 mg Zno-NPs/kg) or T4 (90 mg Zno-NPs/kg) experimental diets than control and other treatments. The ether extract in the meat of breast and thigh was not significantly (P> 0.05) affected by adding zinc oxide nanoparticles to the basal diet, but observed decreasing trend in concentration of EE concurrent with increasing dietary Zno-NPs (P>0.05).

Richards and Dibner (2005) and Bou *et al*. (2005) indicated that carcass and different parts (thighs, fillets, tenders and total breast) weights and yields were not affected (P >0.05) by the dietary treatments. This report is contrary with our finding. Saenmahayak *et al.* (2010) and Rossi *et al.* (2007) reported that the birds fed with diet inclusion of further Zn than NRC (1994) recommendation had higher breast fillet and total breast (fillet and tender) yields as compared to control treatment.

In conclusion, our results suggested that dietary Zno-NPs @ 60 or 90 mg/kg had significantly improved broiler quality and quantity of carcass broiler during starter stage (1–21d). In addition, to undersland the effects of adding Zno-NPs to the basal diet of broilers, further research is required to clearly explain the functional mechanism, absorption, translocation, and interaction with other element or nutrients.

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