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Carcass Traits, Mineral Retention, Blood Biochemistry and Economics of Broiler Chicken Fed Inorganic, Organic and Nano Zinc Supplemented Diets

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ABSTRACT

The present study was planned to assess the effect of inorganic, organic and nano zinc supplemented diets on different carcass traits, haematological and serological parameters of broiler birds. One hundred and sixty one dayold broiler chicks were equally and randomly distributed into four treatment (T1, T2, T3 and T4) groups which were subdivided into four replicates having ten birds in each. Birds were reared on deep litter system up to 6 weeks of age. T1 group was kept as control and offered maize-soybean meal based diet without any source of zinc in mineral mixture. Treatment groups T2, T3 and T4 were supplemented with inorganic(92mg/kg feed), organic(92mg/kg feed) and nano zinc(46 mg/kg feed), respectively.The carcass characteristics data revealed that dressed weight and the weight of liver, gizzard and kidney significantly increased($P<0.05$)in nano zinc supplemented group (T4) in comparison to T1, T2, and T3 groups. Also the abdominal fat % was recorded lowest in T4 group among all treatment groups. Breast and thigh meat composition showed that nano zinc supplemented group (T4) had highest($P<0.05$) crude protein and lowest moisture & ether extract percentage among all other treatment groups. Zinc retention in the body was significantly higher ($P<0.05$) in T4 group followed by T3, T2 and T1 group. In haematological parameters of broiler birds a significant increase($P<0.05$) in HB, RBC and WBC was seen in nano zinc supplemented group in comparison to all other groups. Similarly in serological parameters the T4 group showed the highest reduction($P<0.05$) in cholesterol, triglyceride and LDL while highest levels of HDL in comparison to other groups. The present study thus revealed that zinc in nano form had a significant improvement in carcass traits and different blood parameters in comparison to the treatment groups supplemented zinc in organic and inorganic form.

KEYWORDS: Blood biochemistry, Broiler chicken, Carcass traits, Nano zinc

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INTRODUCTION

Trace minerals are essential feed additives in the diets of broilers to ensure better health and productivity. Zinc is the most commonly added trace mineral in poultry feeds and requires a regular supply for normal appetite, growth, skeletal developments, skin and feather integrity, reproduction, immune competence and many metabolic processes (O'Dell, 2000).

Inorganic zinc sulphate due to its dietary antagonism and excretion in faeces decrease the nutrient value of the diet and cause environment pollution.On the other hand organic zinc-methionine is stable, electrically neutral and protect zinc from chemical reactions and thus make it more bioavailable than its inorganic form, hence provides better immunity(Lim and Paik, 2003)but the use of organic zinc chelates in animal diets is limited due to its higher cost. To overcome the constraints of conventional sources of zinc Nano zinc oxide (nZnO) is a new form of mineral presentation that has been produced using concepts of nano science and technologies.Nanotechnology is concerned with materials whose structures exhibit significantly novel and improved physical, chemical, and biological properties due to their nano-scaled particle size (<100nm; Asheer et al., 2018) which have the advantage of better bioavailability, small dose rate and stable interaction in GIT.

Keeping above facts in view, the present work was carried out to investigate the comparative effects of inorganic zinc, organic zinc and nano zinc oxide particles supplementation at graded levels on carcass traits, Zn retention, hematological and serological parameters in broiler chickens.

MATERIALS AND METHODS

Ethical approval

The animal experiment was conducted in accordance with guidelines approved by the Institutional Animal Ethics Committee, 12/CPCSEA Dated 17.10.2019 in the Department of Animal Nutrition, Lala Lajpat Rai University of Veterinary & Animal Sciences, Hisar.

Experimental design

A study of 6 weeks duration was conducted on one hundred and sixty commercial broiler chicks randomly distributed into four treatment groupswith four replicates of ten birds each. The control group (T1) was offered based diet to fulfill the metabolizable energy (ME) and crude protein requirements of broilers and formulated as per BIS (2007) having mineral mixture without any source of zinc. Birds in second group (T2) were given the basal diet with mineral mixture having inorganic zinc. Third (T3) and fourth (T4) groups were offered basal diet with mineral mixture supplemented with organic and nano zinc, respectively.The ingredients and chemical composition of the basal diet as analyzed as per AOAC(2013) and presented in Table1.

The birds were housed in deep litter system from day-old to 42 days of age following standard management practices. The birds were fed pre starter, starter and finisher diets for 1 to 7, 8 to 21 and 22 to 42 days of age, respectively. Feed and water were provided *ad-lib*. All the birds were vaccinated against Ranikhet disease on 4th day and IBD on 13th day of age. At the end of the feeding trial (42 days), about 2 ml blood sample was collected from one bird per replicate via brachial wing vein puncture into vacutainer tubes containing EDTA for blood biochemistry.

Table 1. Ingredients and chemical composition (%DM Basis) of experimental diets in different growth phases of broiler chicks

Ingredients (Kg/100kg)	Pre-starter	Starter	Finisher
Maize	52	56	61
Soybean meal	36	31	27
Fish meal	6	7	6
Vegetable oil	4	4	4
Mineral mixture	2	2	2
Feed additives (g/100kg feed)			
Spectromix	10	10	10
Spectromix BE	20	20	20
Coccidiostat	65	65	65
Choline chloride	100	100	100
Lysine	30	50	-
DL-methionine	150	160	130
Antibiotic	100	100	100
Chemical composition (%DM basis)			
Moisture	11.5	11.5	11.5
Dry matter	88.4	88.4	88.5
Crude protein	22.0	22.0	20.1
Ether extract	3.32	3.32	3.61
Crude fibre	4.89	4.89	4.85
Total ash	9.11	9.11	9.22
Nitrogen free extract	49.1	49.1	50.7
Metabolizable energy(Kcal/Kg)*	3001	3013	3165

*calculated values

RESULTS AND DISCUSSION

Carcass characteristics

The dressing percentage of experimental birds under different dietary treatments ranged from 72.37 to 76.44% with highest (P<0.05) dressing percentage in treatment group supplemented with nano zinc (T4). Similarly a significant increase in the weight of liver, gizzard and kidney was observed in nano zinc supplemented group in comparison to other treatment groups (Table 2). The maximum abdominal fat reduction was also seen in group supplemented with nano zinc (T4) followed by groups supplemented with organic (T3) and inorganic zinc (T2). Supplementation of zinc oxide nano particles (40mg/kg) has been reported (Lina et al., 2009) to enhance the production and dressing performance of broilers. In another study Khah et al. (2015) indicated that dietary zinc oxide nano particles significantly improved live body weight, dressed and carcass weight.

Table 2. Live weight, Dressed weight, liver, kidney and abdominal fat (%) of the experimental birds under different dietary treatments

Treatment	Finisher live wt average (gm)	Dressing percentage	Liver %	Gizzard %	Kidneys %	Abdominal fat %
T1	1971^{a}±1.44	72.3^{a}± 0.19	2.13^{a}±0.026	2.41^{a}±0.029	0.43^{a}±0.004	1.85^{c}±0.013
T2	2004^{b}±3.93	73.7^{b}±0.17	2.20^{a}±0.027	2.52^{b}±0.033	0.44^{ab}±0.003	1.84^{c}±0.015
T3	2049^{c}±3.05	75.0^{c}±0.40	2.39^{b}±0.048	2.58^{bc}±0.033	0.45^{b}±0.003	1.77^{b}±0.01
T4	2217^{d}±3.18	76.4^{d}±0.20	2.51^{c}±0.041	2.64^{c}±0.030	0.45^{b}±0.001	1.73^{a}±0.003

^{abcd} Means bearing different superscripts in a column differ significantly (P<0.05)

A significant effect of different forms of supplemented zinc was recorded on meat composition under different dietary treatments. Data presented in Table 3 shows that the highest CP % was observed in nano zinc supplemented group followed by organic, inorganic and the control group.Organic and nano zinc supplemented groups showed highest reduction in moisture content in breast and thigh muscles.The lowest EE composition values were found in nano zinc supplemented group among all treatment groups.These improvements in carcass characteristics in nano zinc supplemented group might be due to better utilization of feed, higher retention of nutrients and increased anabolic activities.These results are in accordance with the findings of Khah et al.(2015) who observed higher (P<0.05) DM and CP in meat of breast and thigh in birds supplemented with 60 mg nano ZnO/kg(T3) or 90 mg nanoZnO/kg(T4) than the control group.

Table 3.Composition of Breast and thigh meat under different dietary treatments

Treatment	Breast meat composition			Thigh meat composition		
	Moisture %	CP%	EE%	Moisture %	CP%	EE%
T1	74.5^{c}±0.120	20.4^{a}±0.239	4.79^{c}±0.019	73.9^{b}±0.164	19.2^{a}±0.065	6.70^{c}±0.013
T2	73.6^{b}±0.199	21.0^{b}±0.060	4.62^{b}±0.017	72.7^{a}±0.182	20.5^{b}±0.077	6.61^{b}±0.010
T3	73.2^{b}±0.167	21.3^{b}±0.562	4.48^{a}±0.025	72.7^{a}±0.178	20.5^{b}±0.069	6.52^{a}±0.011
T4	72.6^{a}±0.130	22.3^{c}±0.153	4.43^{a}±0.030	72.4^{a}±0.092	21.6^{c}±0.17	6.49^{a}±0.013

^{abc} Means bearing different superscripts in a column differ significantly (P<0.05)

Zinc retention

A significantly higher (P<0.05) zinc retention was observed in nano zinc supplemented group(T4) followed by T3, T2 and T1(Table 4) although the inorganic (T2) and organic (T3) zinc percent retention differed non significantly.The increased retention of zinc in T4 may be due to higher bioavailability, lesser interaction with other compounds and prolonged retention time in GIT.The bioavailability of inorganic trace minerals is variable due to dietary antagonisms, including phytic acid, fibre, Ca and P (Underwood and Suttle; 1999). This may also explain the poor retention of trace minerals in inorganic form determined for Zn in this current study in comparison to organic and nano form of zinc.

Table 4. Retention of zinc in broiler chicks under different dietary treatments

Treatment	Zinc(mg/kg)			
	Dietary intake	Zinc excreted	Zinc Retention	% Retention
T1	24.5^{a}±0.66	22.2^{a}±0.61	2.25^{c}±0.21	9.16^{a}±0.19
T2	117^{c}±0.66	105^{c}±0.55	11.6^{a}±0.25	9.91^{b}±0.11
T3	117^{c}±0.66	105^{c}±0.55	11.9^{a}±0.18	10.1^{b}±0.07
T4	70.5^{b}±0.66	62.7^{b}±0.68	7.74^{b} ±0.23	10.9^{c}±0.15

^{abc}Means bearing different superscripts in a column differ significantly (P<0.05)

Biochemical parameters

Zinc plays a major role in erythropoiesis, as it activates the synthesis of alfa-aminolevunilicdehydratase and by increasing level of iron in plasma. Thymulin, a hormone essential for maturation of T lymphocytesis also zinc dependent.Results of this study shows that hemoglobin value was increased in all zinc fed treatment groups when compared with control (Table 5). The Hb values of inorganic and organic zinc supplemented groups had non-significant (P>0.05) difference among them while nano zinc supplemented group differed significantly with all treatment groups having highest Hb value. The RBC count (x10^{6} /il) was found highest in nano zinc supplemented group differing significantly (P<0.05) from all other treatment groups.WBC count (x10^{3}/ il) was found to be significantly higher (P<0.05) in nano zinc supplemented group when compared with control and inorganic zinc supplemented group.Findings of Aksu et al. (2012) supported our results that using at much lower level organically complexed minerals (Cu, Zn and Mn) in broiler diets instead of inorganic forms has created a positive impact on hematological parameters, increased hemoglobin and packed cell volume. Also in other study of Beach et al.(1982) it was found that inadequate intracellular concentrations of zinc cause abnormal development of T-lymphocytes and lower weights of the spleen and thymus which are responsible for immunity and level of RBC & WBC in body.

Table 5. Mean values of haematlological and serological parameters of broiler birds under different dietary Treatments

Treatment	Hb (g/dl)	RBC (x106 /µl)	WBC (x103/ µl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)	HDL (mg/dl)	LDL (mg/dl)
T1	8.97^{a}±0.11	2.10^{a}±0.04	27.12^{a}±0.12	145.15^{c}±0.56	94.57^{d}±0.39	89.50^{a}±0.47	36.50^{c}±0.40
T2	9.60^{b}±0.091	2.55^{b}±0.06	27.50^{ab}±0.22	143.10^{b}±0.30	91.07^{c}±0.72	92.25^{b}±0.47	34.50^{b}±0.64
T3	10.07^{b}±0.10	2.62^{b}±0.08	27.87^{bc}±0.17	142.55^{b}±0.41	88.00^{b}±0.17	94.75^{c}±1.10	33.00^{a}±0.40
T4	10.6^{c}±0.27	2.82^{c}±0.04	28.3^{c}±0.19	139.4^{a}±0.52	86.0^{a}±0.33	96.5^{c}±0.64	32.7^{a}±0.40

^{abcd} Means bearing different superscripts in a column differ significantly (P<0.05)

The cholesterol level of groups ranged from 139.45 to 145.15 mg/dl. The nano zinc(T4) group having lowest cholesterol values differed significantly (P<0.05) from T3, T2 and T1 but T2 and T3 differed non-significantly with each other. A significant reduction in triglyceride value was observed in zinc fed diets when compared with control. The highest reduction in triglyceride value was observed in T4 followed by T3 and T2 when compared with control. The HDL values (mg/dl) were increased significantly (P<0.05) in zinc fed groups with highest increment in nano zinc (T4) group. However the organic and nano zinc supplemented groups showed no-significant difference in HDL values.A significant reduction was observed in LDL values of broilers in zinc supplemented groups when compared with control. The lowest values were recorded in nano zinc (T4) supplemented group as per data shown in Table 5.The result of present study are in line with the findings of Fathi et al.(2016), that addition of 20 mg/kg nano zinc oxide to the broiler diet reduced serum concentration of cholesterol and malondialdehyde. Similarly in an another study conducted by Ibrahim et al. (2017)the results indicated that the serum total cholesterol, triglyceride and very low-density lipoprotein were significantly decreased (P<0.05) in groups supplemented with organic Zn and/or nano Zn. Improved haematological parameters in treatment group supplemented with nano zinc shows better immune response than other treatment groups. Similarly, serum parameters showed highest hypocholestermic and hypolipidemic effects in group supplemented with nano zinc. These better effects of nano zinc oxide particle and organic zinc can be attributed to higher bioavailability of zinc in these forms in comparison to inorganic zinc.

Economics

The cost of feeding per chick (Rs) was highest in the treatment T4 (131.18) supplemented with nano zinc while lowest in T1 (116.28) control group. The total production cost was maximum in treatment T4 (Rs. 158.18) and minimum in T1 treatment (Rs. 143.28). The highest profit per bird (Rs.) was obtained in organic zinc (T3) supplemented group (Rs. 110.98) and lowest in control group T1 (Rs. 84.72). Economics data(Table 6) revealed that nano zinc proved to be costly in comparison to organic zinc but on large scale broiler production cost benefit ratio can further decrease for nano zinc.

Table 6. Economics of broiler production under different dietary treatments

Treatments	Cost of chick (Rs.)	Feed intake (kg)	Total cost of feeding (Rs.)	Weight of bird (kg)	Market price/kg live wt (Rs.)	Gross return/bird (Rs.)	Total production cost/bird (Rs.)	Profit/ bird (Rs.)	Cost benefit ratio
T1	27.0	3.57	116.2	1.90	120.0	228.0	143.2	84.7	1.69
T2	27.0	3.60	117.0	2.00	120.0	240.0	144.0	95.9	1.50
T3	27.0	3.61	118.8	2.14	120.0	256.8	145.8	110.9	1.31
T4	27.0	3.80	131.1	2.21	120.0	265.2	158.1	107.0	1.47

Conclusion

In this experimental study nano zinc supplementation had the overall best carcass traits and blood parameters showing best quality broiler meat production with lowest cholesterol levels which is preferable by consumers. This can be attributed tothe advantage of better bioavailability, small dose rate and stable interaction of nano zinc particles with other compounds. Thus it can be concluded that use of nano zinc oxide particles even at the half dose rate can be a better alternative for the conventional zinc sources.

REFERENCES

AOAC. 1995. Official Methods of Analysis. Association of Official Analytical Chemists.16th Edn. USA.

Aksu, D.S, Taylan A, and Bülent Ö. 2010.The effects of lower supplementation levels of organically complexed minerals (zinc, copper and manganese) versus inorganic forms on hematological and biochemical parameters in broilers. Kafkas Univ Vet Fak Derg.16(4):553-559

Asheer, M., Manwar, S.J., Gole, M.A., Sirsat, S., Wade, M.R.,Khose, K.K., and Ali, S. Sajid. 2018. Effect of dietary nano zinc oxide supplementation on performance and zinc bioavailability in broilers. Indian Journal of Poultry Science.53(1): 70-75

Beach, R. S., Gershwin, M. E., and Hurley, L. S. 1982.Reversibility of developmental retardation following murine fetal 'zinc' deprivation.The Journal of Nutrition112: 1169–1181.

BIS. 2007. Nutrient Requirements for Poultry IS:9883 Bureau of Indian Standards, New Delhi, India.

Fathi, M., Haydari, M., and Tanha, T. 2016.Effects of zinc oxide nanoparticles on antioxidant status, serum enzymes activities, biochemical parameters and performance in broiler chickens.Journal of Livestock Science and Technologies.4 (2):07–13.

Ibrahim, D., H. A. Ali., and S. A. 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 Veterinary Journal.45:292–304.

Khah, Mohammadi, M., Ahmadi, F., and Amanlou, H. 2015.Influence of dietary different levels of zinc oxide nano particles on the yield and quality carcass of broiler chickens during starter stage. Indian Journal of Animal Sciences.85 (3): 287-290.

Lim, H.S. and Paik, I.K. 2003.Effects of supplementary mineral methionine chelates (Zn, Cu, Mn) on the performance and egg shell quality of laying hens. Asian-Australasian Journal of Animal Sciences.16(12), pp.1804-1808.

Lina, T., Fenghua, Z., Huiying, R., Jianyang, J. andWenli, L. 2009.Effects of nano-zinc oxide on production and dressing performance of broiler.Chinese Agricultural Science Bulletin. 2(003):318

O'Dell, B.L.1992.Zinc plays both structural and catalytic roles in metallo proteins. Nutrition Reviews.50:539-452.

Saleh, A. A., Ragab, M. M., Ahmed, E. A. M., Abudabos, A. M. and Ebeid, T A. 2018.Effect of dietary 'zinc'-methionine supplementation on growth performance, nutrient utilization, antioxidative properties and immune response in broiler chickens under high ambient temperature. Journal of Applied Animal Research.46:(1), 820-827.

Underwood, E. J. and Suttle, N. F. 1999.The mineral nutrition of livestock.3rd edn.CABI Publishing, New York.