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Growth performance and carcass traits as influenced by dietary supplementation of zinc in broiler chicken

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Abstract
A study was conducted to evaluate the effect of replacing inorganic zinc with organic zinc (Zn-methionine) on the performance, carcass characteristics and organ weights of commercial broiler chicken for a period of 6 weeks. A total of 150 day old chicks were selected and randomly divided into five dietary groups with three replicates containing 10 chicks in each replicate. The dietary treatments includes corn-soybean based basal diet as control (T_1) or the basal diet supplemented either with 40 or 80 mg of Zn/kg of feed from Zn oxide (T_2 and T_3) and Zn-methionine (T_4 and T_5), respectively. There was a significant performance difference exist among the treatment groups fed with zinc oxide and Zn-methionine at different levels. The result of this experiment showed that the zinc oxide and Zn-methionine had a same effect on body weight and weight gain, but zinc oxide at 40 mg/kg significantly ($p<0.05$) increased feed consumption and had better feed efficiency. Carcass traits were not influenced by the experimental supplements. Hence, it can be concluded that replacing 50% organic source of Zn was relatively economical and can be used without any negative effects either on performance or on the environment.

Keywords: Growth performance, carcass traits, supplementation, broiler chicken

Introduction
Poultry production in India has witnessed a phenomenal growth from backyard farming to scientific poultry farming involving commercial egg and meat production. India is the 5th largest producer of poultry meat in the world, producing about 2.337 million tonnes of chicken meat annually (Prabakaran, 2012) [14].

Approximately there are twenty minerals in the body of chicken that are essential for maintenance and normal functioning. Insufficient amounts of these minerals result in deficiency symptoms leading to reduced performance. Traditionally, these trace minerals are supplemented in the form of inorganic salts, such as sulfates, oxides and carbonates (Bao *et al.*, 2007) [2]. Minerals occur naturally in most feed ingredients but the amount and bioavailability varies considerably. Some researchers in mineral nutrition have shown that the availability of trace minerals can be improved by binding them to organic ligands, usually a mixture of amino acids or small peptides and hence are called organic trace minerals.

Zinc must be supplemented to meet the nutritional requirements in poultry, because of the poor availability of zinc in plant feed ingredients due to binding of zinc by phytate (Fordyce *et al.*, 1987) [5]. Zinc enzymes are involved in the synthesis and or degradation of carbohydrates, lipids, proteins and nucleic acids and encompass all known classes of enzymes (Kaim and Schwederski, 1994) [10].

The minerals can leach through soils, potentially contaminating surface and underground water supplies (Jackson *et al.*, 2003). The increased concern about potential mineral pollution has resulted in nutritionists to focus on reducing mineral excretion without any negative effect on production. Organically complexed trace minerals may provide alternative pathways for absorption, by decreasing mineral excretion (Leeson, 2003) [11]. These types of minerals are more easily absorbed compared to inorganic forms. Keeping the above points in view, there is a great need to utilize the organic source of mineral additives to reduce the gap between cost of production and benefits in successful poultry production. Hence, the current study was designed to investigate the effect of supplementation of organic zinc on commercial broiler performance.

Materials and Methods

Ethical Approval

The experiment was carried out as per the guidelines of the National Regulations on Animal Welfare and Institutional Animal Ethics Committee. An experimental study was conducted at the Department of Poultry Science, Madras Veterinary College, Chennai and the aim of the present study was to evaluate the effect of supplementing ZnO and Zn-methionine on performance and carcass traits in Commercial broiler chicken. A total of 150 straight run day-old cobb 400 broiler chicks were procured from a franchise (Swami feeds pvt. ltd, Hosur branch) of Venkateshwara Hatcheries Private Limited, Pune. Chicks were individually weighed, wing banded and randomly allotted into 5 different treatment groups, with three replicates. Each replicate had 10 chicks as such and 30 birds constituted a treatment group.

The birds were reared in brooder cum grower cages up to six weeks of age under uniform standard management. All the chicks were vaccinated against Ranikhet disease, RDVF on 7th d and LaSota on 28th days of age and Infectious Bursal Disease (Intermediate Strain) on 14th day of age.

The feed for birds were prepared at Central Feed Technology Unit (TANUVAS), Kattupakkam (Kancheepuram Dt. Tamil Nadu, India) were fed to chicks during the experimental period. Basal diet was formulated using corn and soyabean meal as shown in Table 1. The dietary treatments includes corn-soybean meal based basal diet as control (T_1) or the basal diet supplemented either with 40 or 80 mg of Zn/kg from Zn oxide (T_2 and T_3) and Zn-methionine (T_4 and T_5), respectively.

Table 1: Formula composition of broiler basal ration

Ingredients	PBS (0-2 weeks)	BS (3-4 weeks)	BF (5-6 weeks)
Yellow maize	518.500	542.000	573.000
Soyabean meal	407.500	364.600	318.700
Common Salt	2.800	2.800	3.300
Calcite	11.600	12.100	11.800
Dicalcium phosphate	16.300	15.200	14.600
Soya oil	20.000	-	-
Palm oil	11.700	53.100	69.000
Vitamin mixture[!]	0.500	0.500	0.500
Trace mineral[#]	1.500	1.500	1.500
Ultracil	1.000	1.000	1.000
Vetroliv	0.200	0.200	0.200
CosmoDOT[†]	0.500	0.500	0.500
Choline chloride (60%)	1.000	1.000	1.500
Lysine hydrochloride	2.200	1.500	1.300
DL-Methionine	3.100	2.500	2.300
Sodium bicarbonate	1.600	1.500	0.800
Total	1000.00	1000.00	1000.00
Calculated values			
C. Protein (%)	23.00	21.28	19.50
ME (Mcal/Kg)	2.990	3.1255	3.2500
C.Fibre	2.78	2.72	2.68
Lysine	1.44	1.27	1.14
Methionine	0.67	0.58	0.54
Calcium	0.99	0.98	0.95
Available Phosphorus	0.45	0.42	0.40

PBS: Pre-broiler starter; BS: Broiler Starter; BF: Broiler finisher; [!]Each g of vitamin mixture contains vit. A-20M IU, B2-12 mg, menadione sodium bisulphite (vit. K derivative)-6 mg, B1-4 mg, B6-8mg, B12-0.04 µg, E-100 mg, niacin-100 mg, calcium D pantothenate -60M IU and cariers Q.S.; [#]Each g of trace mineral mixture contains Fe-60.00 mg , Cu-10.00 mg, iodine as KI-1.33 mg, Mn-66.66 mg, Se-0.20 mg.[†]Anticoccidial drug; Dinitro-o-toluamide

Growth Performance

The body weight of the birds were recorded on day one and every week up to six weeks during morning before feeding by using electronic weighing balance with 0.1 g accuracy. All treatment groups were provided with *ad libitum* feeding. At the end of every week, left over feed was measured to find out the actual feed consumption of that particular period and from this data feed efficiency was calculated.

Carcass Characteristics

At the end of 6th week of age, two birds from each replicate were taken randomly for the studying the carcass characteristics such as per cent eviscerated carcass yield, ready-to-cook yield, cut up yields and organ weight. Birds were weighed and sacrificed by severing the jugular vein with a single cut and bled for 180s. After slaughter, carcass weight was determined. The weight of organs such as heart, liver and gizzard were taken and expressed as percent of live body weight.

Statistical Analysis

The data collected on various parameters were grouped and subjected for statistical analysis of variance (ANOVA) as per the procedure of statistical package for social sciences (SPSS) software package for windows as per Snedecor and Cochran 1989. All the percent values in the experiment were transformed to their arc sine roots before subjecting to statistical analysis. Results were expressed as mean ± SE and the difference were considered statistically significant at 5% and 1% level.

Results and Discussion

Body weight and weight gain

Our findings it was showed that ZnO and Zn-methionine supplementation had a non significant effect on body weight and weight gain (Table 2 and 3). From 0 to 42 d, both ZnO and Zn-methionine supplementation had improved broiler growth rate when compared with the control. Birds fed with the diets containing 80 ppm of ZnO had numerically higher weight and weight gain. Similarly, Zn-met (organic Zn) at 40 ppm fed groups showed same result as that of ZnO fed groups.

The Cobb 400 management guide establishes broiler zinc requirement during the grower period at a level of 80 mg Zn/kg diet, whereas the NRC (1994) reports that the zinc requirement of broilers during the grower period was 40 mg Zn/kg. In the present experiment, average zinc supplementation in the control diet was 20 mg Zn/kg. We hypothesized that when conventional corn-soybean meal diets were fed, the Zn content in corn-soya didn't meet out the requirement for broiler growth. It was shown that Zn supplementation did not significantly change broiler weight gain (Wedekind *et al.*, 1992) [20]. Some previous studies have documented that dietary zinc concentrations of 45 to 48 mg/kg were adequate for broilers (Huang *et al.*, 2009) [6]. However, Burrell *et al.* (2004) [3] reported that optimum weight gain was achieved with110 mg supplemental Zn/kg in conventional corn-soybean meal diets.

The present result with respect to non significant body weight and weight gain were in agreement with the results obtained by Savaram *et al.* (2013) [17] who noticed non-significant difference in body weight of Vanaraja chicks fed with reduced levels of organic trace minerals (Zn, Mn, Cu, Fe, I, Se and Cr). The present results were in disagreement with the findings of Bao *et al.* (2007) [2] who also observed increased live weight gain in Cobb broilers upto 29 days of age in group fed 4 mg of Cu and 40 mg each of Fe, Mn and Zn from organic source compared to inorganic source. The results were also in disagreement with the findings of Abbas *et al.* (2010) who also reported increased body weight gain in broilers supplemented with 50 per cent each of Zn, Mn and Cu in organic form compared to group fed with 100% of these minerals from inorganic source.

The body weight gain obtained at 42 days of experimental period with respect to inclusion of Zn-met (40 mg/kg) was in agreement with the result of Rahaman *et al.* (2008) who also observed increased body weight in the group fed Zinc methionine. The use of organic minerals can improve intestinal absorption of trace elements as they reduce interference from agents that form insoluble complexes with the ionic trace elements and thereby enhancing the body weight gain.

Table 2: Effect of dietary ZnO and Zn-methionine on body weight at sixth week of age in commercial broiler chicken (Mean ± SE)

Treatments (ppm)	Day old	1st week	2nd week	3rd week	4th week	5th week	6th week
T_1 – control	47.45±0.49	159.81^{b}±2.93	431.63^{b} ±7.79	833.53±13.49	1314.93±18.63	1804.90±18.26	2056.70±26.07
T_2 ZnO - 40	47.52±0.49	166.13^{ab}±3.41	446.86^{ab} ±9.76	844.81±15.77	1339.10±31.71	1841.76±35.24	2139.80±46.95
T_3 ZnO - 80	47.86±0.51	169.53^{a}±3.12	464.06^{a} ±9.54	873.61±15.11	1364.46±32.04	1844.06±41.35	2160.83±55.93
T_4 Znmet - 40	46.87±0.61	168.41^{ab}±2.36	461.73^{a} ±8.06	869.86±11.61	1380.53±21.88	1854.30±28.06	2124.83±40.71
T_5 Znmet - 80	47.48±0.59	167.51^{ab}±2.62	449.06^{ab} ±6.45	840.66±11.26	1306.30±20.31	1792.16±27.26	2053.93±31.65
F value	0.427	1.70	2.407	1.773	1.528	0.767	1.389
Significance	NS	*	*	NS	NS	NS	NS

Table 3: Effect of dietary ZnO and Zn-methionine on body weight gain at sixth week of age in commercial broiler chicken (Mean ± SE)

Treatments (ppm)	1st week	2nd week	3rd week	4th week	5th week	6th week
T_1 – control	112.34^{b}±2.93	384.16^{b} ±7.74	786.06±13.38	1267.46±18.60	1757.43±18.22	2009.23±26.08
T_2 ZnO - 40	118.61^{ab}±3.33	399.30^{ab} ±9.60	797.23±15.65	1291.53±31.59	1794.20±35.11	2092.23±46.73
T_3 ZnO - 80	121.67^{a}±3.08	416.23^{a} ±9.47	825.76±15.07	1316.63±31.97	1796.23±41.25	2113.00±55.83
T_4 Znmet - 40	121.52^{a}±2.16	414.86^{a} ±7.93	823.00±11.52	1333.66±21.92	1807.43±28.09	2077.96±40.77
T_5 Znmet - 80	120.02^{ab}±2.43	401.56^{ab} ±6.33	793.16±11.187	1258.80±20.24	1744.66±27.20	2006.43±31.60
F value	1.846	2.485	1.805	1.548	0.778	1.391
Significance	*	*	NS	NS	NS	NS

Mean bearing different superscripts within the sane coloum differ significantly ($p<0.05$)

Feed Consumption

Supplementation of either inorganic or organic Fe and Zn showed a significant difference in feed consumption among different dietary treatments as shown in table 4. However, during sixth week of the experimental period there was a significant difference in feed consumption among different source and level of Zn fed groups. During sixth week, significantly ($P<0.05$) highest feed consumption was observed in group fed with 80 mg/kg of ZnO (T_3) followed by T_4 (40 mg/kg Zn-met) when compared to control.

The results obtained in the present study was in agreement with the findings of Rahaman *et al.* (2008) who reported that Ross broilers fed with zinc- methionine (40, 80 and 120 mg/kg) showed significantly higher feed intake compared to inorganic source fed groups. Rossi *et al.* (2007) [16] reported that diets with low zinc levels lead to depressed appetite, resulting in reduced feed intake and weight gain.

However, the present findings were in disagreement with Hudson *et al.* (2005) [7] who revealed that broiler fed with diets having added Zn from either inorganic or organic source had no significant effect on feed intake. Similarly, Iqbal *et al.* (2011) [8] who reported that feed intake of broiler chickens were not influenced significantly by supplementation of Zn from inorganic and organic sources and at different concentration of 40 and 80 mg/kg.

Table 4: Effect of dietary ZnO and Zn-methionine on feed consumption at sixth week of age in commercial broiler chicken (Mean ± SE)

Treatments (ppm)	1st week	2nd week	3rd week	4th week	5th week	6th week
T_1 – control	158.50±0.86	543.50^{a} ±3.75	1106.16^{a} ±5.18	1838.16^{a}±8.29	2767.16^{ab}±13.35	3330.83^{c}±10.91
T_2 ZnO - 40	151.66±3.52	531.33^{ab} ±2.72	1080.33^{b} ±7.62	1787.66^{b}±9.06	2724.33^{c}±13.11	3277.33^{d}±15.71
T_3 ZnO - 80	153.33±2.33	535.33^{ab} ±2.33	1091.00^{ab} ±3.05	1828.33^{a}±3.52	2774.33^{bc}±6.96	3414.66^{a}±8.95
T_4 Znmet - 40	159.33±2.02	536.83^{ab} ±2.89	1085.50^{b} ±2.75	1794.63^{b}±5.86	2737.96^{a} ±2.58	3371.96^{b}±7.62
T_5 Znmet - 80	154.66±4.63	528.33^{b} ±4.05	1075.33^{b} ±5.66	1792.33^{b}±2.40	2737.00^{bc} ±5.50	3356.00^{bc}±12.89
F value	1.238	3.225	5.126	13.270	5.238	19.278
Significance	NS	*	*	**	*	**

Mean bearing different superscripts within the sane coloum differ significantly ($p<0.05$)

Feed efficiency

The present results showed a significant difference in FCR among different dietary treatment groups as indicated in Table 5. The group fed with 40 mg/kg ZnO showed significantly ($p<0.05$) better feed efficiency followed by organic Zn-met fed groups when compared with control. The present result was in agreement with the findings of Nollet *et al.* (2007) [13] who observed improved FCR in broilers fed low levels of organic minerals Mn, Zn and Fe (all at 10 ppm) and Cu at 2.5 ppm compared to group fed with inorganic Mn, Zn, Fe and Cu sulphates at levels of 70, 37, 45 and 12 ppm, respectively. However, the present result was in disagreement with the findings of Iqbal *et al.* (2011) [8] who reported that FCR of broiler chicken was not influenced by supplementation of Zn inorganic and organic sources and different concentration of 40 and 80 mg/kg combined with Cu.

Table 5: Effect of dietary ZnO and Zn-methionine on feed efficiency at sixth week of age in commercial broiler chicken (Mean ± SE)

Treatments (ppm)	1st week	2nd week	3rd week	4th week	5th week	6th week
T_1 – control	$1.412^{b}\pm0.032$	$1.415^{b}\pm0.019$	$1.407^{b}\pm0.004$	$1.450^{c}\pm0.001$	1.575 ± 0.017	$1.657^{b}\pm0.013$
T_2 ZnO - 40	$1.282^{ab}\pm0.064$	$1.332^{a}\pm0.036$	$1.355^{a}\pm0.010$	$1.384^{ab}\pm0.009$	1.518 ± 0.011	$1.566^{a}\pm0.012$
T_3 ZnO - 80	$1.260^{a}\pm0.025$	$1.287^{a}\pm0.023$	$1.321^{a}\pm0.016$	$1.389^{ab}\pm0.017$	1.545 ± 0.023	$1.617^{ab}\pm0.026$
T_4 Znmet - 40	$1.312^{ab}\pm0.022$	$1.294^{a}\pm0.014$	$1.318^{a}\pm0.004$	$1.346^{a}\pm0.021$	1.516 ± 0.030	$1.625^{ab}\pm0.046$
T_5 Znmet - 80	$1.288^{ab}\pm0.041$	$1.315^{a}\pm0.021$	$1.355^{a}\pm0.017$	$1.424^{bc}\pm0.001$	1.569 ± 0.019	$1.673^{b}\pm0.011$
F value	2.173	4.498	8.849	8.842	1.637	2.609
Significance	*	*	*	**	NS	*

Mean bearing different superscripts within the sane coloum differ significantly (p<0.05)

Carcass yield

Interestingly, we found that, although broiler performance improved with the dietary supplementation of ZnO and Zn-methionine, none of the evaluated carcass traits (Eviscerated weight (%), Ready to cook yield (%), cut-up parts and giblet per cent) were influenced by the treatments as shown in table 6 and 7. The results of the present study are in agreement with Vladimir *et al*. (2010) [19] who found that groups fed with trace elements in proteinated form restricted to 50 per cent Cu, 20 per cent Fe, Zn and Mn and on regular levels of Se had same effect on carcass yield. On the other hand, Ellen *et al*. (2012) [4] who found that dressing percentage was significantly higher in group fed with 2.5g/ton, 11.25g/ton, 15.0g/ton, and 18.75g/ton of amino acid chelates of Cu, Zn, Mn and Fe, respectively.

Further studies were required to elucidate the mechanisms that regulate the digestibility of feed by organic and inorganic Zn supplements. This study was groundwork for future investigations evaluating zinc levels below broiler requirement for maximum performance in control diets.

Table 6: Effect of dietary ZnO and Zn-methionine on carcass characteristics at sixth week of age in commercial broiler chicken (Mean ± SE)

Treatments (in ppm)	Carcass characteristics						
	Live weight (g)	Blood (%)	Eviscerated weight (%)	Ready to cook yield (%)	Heart	Liver	Gizzard
T1 Control	2063.00 ± 95.89	2.66 ± 0.09	66.63 ± 0.79	71.91 ± 0.72	0.61 ± 0.06	1.88 ± 0.09	2.79±0.19
T2 ZnO - 40	2056.67 ± 72.11	2.49 ± 0.11	64.50 ± 1.44	69.29 ± 1.40	0.54 ± 0.03	1.81 ± 0.07	2.44±0.11
T3 ZnO - 80	2009.67±124.89	2.64 ± 0.07	66.29 ± 0.98	71.37 ± 0.98	0.52 ± 0.03	1.94 ± 0.10	2.61±0.10
T4 ZnMet - 40	1996.67 ± 83.75	2.60 ± 0.11	65.57 ± 0.68	70.77 ± 0.68	0.55 ± 0.05	1.76 ± 0.14	2.90±0.12
T5 ZnMet - 80	1955.67 ± 43.91	2.75 ± 0.14	65.12 ± 0.42	70.32 ± 0.54	0.53 ± 0.05	1.72 ± 0.06	2.96±0.18
Significance	NS – Not significant (P> 0.05)						

Table 7: Effect of dietary ZnO and Zn-methionine on cut-up parts (%) at sixth week of age in commercial broiler chicken (Mean ± SE)

Treatments (in ppm)	Cut-up-parts (%)					
	Brest	Drumstick	Wing	Neck	Back	Thigh
T1 Control	34.54 ± 0.95	16.02 ± 0.52	10.09 ± 0.34	3.83 ± 0.17	21.73 ± 0.63	14.01± 0.30
T2 ZnO - 40	35.56 ± 0.59	16.01 ± 0.25	$9.20^{a}\pm 0.21$	3.76 ± 0.20	21.27 ± 0.40	13.74 ± 0.34
T3 ZnO - 80	35.36 ± 0.24	16.68 ± 0.29	$9.12^{a}\pm 0.29$	3.61 ± 0.19	21.89 ± 0.33	13.00± 0.36
T4 ZnMet - 40	34.04 ± 0.58	17.47 ± 0.20	9.17 ± 0.27	3.81 ± 0.11	21.15 ± 0.77	14.37± 0.45
T5 ZnMet - 80	34.66 ± 0.54	16.99 ± 0.31	$8.80^{a}\pm 0.18$	3.81 ± 0.12	22.12 ± 0.23	13.69± 0.17
Significance	NS	NS	NS	NS	NS	NS

Conclusion

In summary, the present study indicated that the addition of zinc oxide and an organic Zn-methionine to broiler diets significantly improved body weight, weight gain and feed conversion ratio; however, the use of ZnO and Zn-met had no significant effect on carcass traits.

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