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Original Research

Influence of Graded Levels of Different Sources of Zinc on Growth Performances and Production Economics in Chicken

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Abstract

An experiment was undertaken to evaluate the growth performance and economic benefits of nano-zinc compared to inorganic and organic sources of zinc supplementation. A total of 336 day old Giriraja chicks were allotted in seven treatments with four replicates in each group having 12 chicks in each replicate (48 chicks per treatment) in Completely Randomized Design. Dietary treatments consisted of Zinc sulphate and Zinc methionine at (30 and 60 ppm) respectively; while15, 30 and 60 ppm for nano-zinc. Body weights (g), feed consumption and FCR were recorded weekly. Body weight and FCR were higher during all weeks with comparatively higher ($P \leq 0.05$) feed consumption and higher return for nano-zinc at 60 ppm supplementation level. The profit was highest (Rs 68.41) for zinc sulphate at 30 ppm with lowest profit (Rs 66.35) for nano-zinc at 60 ppm. It can be concluded that growth performance and production economics are better for nano zinc supplementations at 60 ppm compared to other zinc sources.

Keywords: Economics, Growth, Zinc Source

Introduction

Essential micronutrients, especially zinc have important role in normal metabolism and growth of poultry. Zinc is the second most abundant trace mineral which requires regular dietary intake to regulate the cell division by regulating the synthesis of protein and DNA (Frassinatti *et al*., 2006). Zinc plays catalytic, structural and regulatory roles as a component in more than 300 metallo-enzymes and hormones identified in biological systems. Two predominant sources of zinc used by the animal feed industry are ZnO and $ZnSO_4.H_2O$ (Zalewski *et al*., 2005). Nano zinc (nZn) represents one of the nano technological approaches to prepare mineral salt having particle size of 1 to 100nm (Feng *et al*., 2009). The reduced size of zinc in nano scale will enhance bioavailability by increased ionization of zinc. The sudden rise in the demand in zinc oxide nanoparticles is mostly attributed to its antibacterial properties than the conventional ZnO (Padmavathy and Vijayaraghavan, 2008). Additives from nano technology in poultry ration have been tried to achieve positive effect on production (Ahmadi and Fariba, 2010). This has been used in diversified areas as nanomineral particles have higher potential than their conventional sources (Sindhura *et al*., 2014). The added advantage of nZn is that, it can be synthesized by using physical, chemical or biological methods (Swain *et al*., 2015) which are cheap and easy. Due to higher bioavailability of Zn from nano-zinc than inorganic and organic sources, they have a better absorption than other two sources resulting in better growth. Hence, present study was planned to assess the growth performance and economic benefits of nZn supplementation in Giriraja chicken production compared to inorganic and organic sources of zinc.

Materials and Methods

A total of 336 numbers of day-old straight run Giriraja chicks were procured, wing banded, weighed and randomly divided into seven groups with four replicates in each group having 12 chicks in each replicate (48 chicks per treatment) in a completely randomized design (Pillai and Sinha, 1968). The chicks were reared in deep litter system with all standard managemental practices till eight weeks of age. Standard vaccination schedule was followed for immunizing the chicks. The experimental diets (mash form) were formulated as per BIS, (2007) specifications from first to eight weeks of age. Birds were fed with pre-starter (0-3weeks), starter (4-6weeks) and finisher (7-8weeks). Actual ingredient composition of the experimental diets has been given in Table 1.

Table 1: Percent ingredient composition of basal experimental diet

Ingredients	Pre-starter (0-3 weeks)	Starter (4-6 weeks)	Finisher (7-8 weeks)
Yellow maize	52.25	58.5	63.56
Soyabean meal (46%)	40.55	33.3	28.1
Vegetable oil	3.5	4.95	5.25
Oyster shell	1	1	0.9
Dicalcium phosphate	1.6	1.2	1.15
Common salt	0.35	0.35	0.35
Mineral mixture*	0.55	0.55	0.55
Vitamin premix **	0.1	0.1	0.1
DL-Methionine	0.1	0.055	0.04
Total	100	100	100
Nutrient Composition			
ME (Kcal/kg)[a]	2948.5	3076.65	3129.61
Crude protein (%)[b]	22.83	19.99	18.01
Calcium (%)[a]	1.01	0.91	0.855
Phosphorous (%)[a]	0.46	0.37	0.355
Lysine (%)[a]	1.4	1.18	1.03
Methionine (%)[a]	0.49	0.39	0.342

**Mineral mixture: Each 100 g contains Magnesium oxide-1.48g, Ferrous sulphate-6.0g, copper sulphate-0.05g, Manganese Sulphate-0.04g, Potassium Iodide-0.001g, Potassium Chloride-17.09g and Sodium selenite-0.001g.*

***Vitamin-mineral Premix: Each 100g contains Vitamin AD_3 (Vitamin A-10,00,000 IU/g, Vitamin D-200000 IU/g)-0.165g, Vitamin K_3-0.103g, Vitamin E-2.4g, Thiamine Mononitrate-0.206g, Riboflavin-0.513g, Pyridoxine hydrochloride-0.309g, Cyanocobalamine-0.00031g, Folic acid- 0.103g, Niacin-4.124g, Ca-D-Pantothenate-1.031g, Biotin-1.5g, Maltodextrine-89.545g; [a] calculated values; [b] analyzed values*

Experimental feed samples were analyzed for proximate composition according to the AOAC (2012) with Zinc concentration of 30 ppm by atomic absorption spectrophotometry (ICP-OES; Perkin Elmer Optima 8000) in the basal diet. Zinc was excluded from the premix and added separately based on the treatments for the sources and amount as follows:

Treatment 1: Basal diet + 30 ppm Zinc sulphate ($ZnSO_4.H_20$)
Treatment 2: Basal diet + 60 ppm Zinc sulphate ($ZnSO_4.H_20$)
Treatment 3: Basal diet + 30 ppm Zinc methionine (Zn-Met)
Treatment 4: Basal diet + 60 ppm Zinc methionine (Zn-Met)
Treatment 5: Basal diet + 15 ppm Nano zinc (nZn)
Treatment 6: Basal diet + 30 ppm Nano zinc (nZn)
Treatment 7: Basal diet + 60 ppm Nano zinc (nZn)

Body weights of chicks were recorded upto 8 weeks. The weekly feed consumption was recorded from which the feed conversion ratio (FCR) was calculated for every week. Data pertaining to various parameters obtained during the trial were analyzed statistically by ANOVA using SPSS 20 statistical software. Differences between the means were tested using Duncan's Multiple Range Test (Duncan, 1995) at ($P<0.05$). To assess the feed cost of production and cost incurred in production of per kg of bird live weight, the feed cost economics was calculated. The cost of feed ingredients involved was calculated according to prevailing market rate at the time of experiment. The cost of zinc supplemented diets was calculated by adding the cost of Zn to the cost of other feed ingredients. The cost of the Zn products ($ZnSO_4.4H_2O$: Rs.55/kg; Zinc methionine: Rs. 400/kg; Nanozinc: Rs.750/kg) were considered.

Results and Discussion

Body Weight Gain

Data presented in Table 2 suggested an improvement in body weight gain of nano zinc supplemented group at the level of 60 ppm. Sahoo *et al.* (2016) reported that supplementation of organic zinc at 7.55 ppm were similar to that of nano zinc (0.06ppm) and the same is recorded in Zn-Met group at the level of 60 mg/kg; comparable to that of nano zinc supplemented groups at the level of 15 and 30 mg/kg and can be used as substitution of each other. The body weight of $ZnSO_4$ and Zn-Met groups were insignificant. Similar findings were also reported by Tronina *et al.* (2007) and Rossi *et al.* (2007) wherein Zn from an organic source had no influence on body weight gain. The lack of consistent effects of dietary Zn on performance of chickens may be due to the amount of Zn present in the basal diet (Leeson and Summers, 2005) or to the amount and sources added.

Table 2: Live body weight gain (Mean ± SE) affected by $ZnSo_4$, Zn-Met and nZn supplementation

Treatment	Zinc source	Level (mg/kg)	I week	II week	III week	IV week	V week	VI week	VII week	VIII week
T1	**$ZnSo_4$**	**30**	$82.41±1.00^{a}$	$196.23±3.52^{a}$	$366.64±5.60^{a}$	$588.57±11.02^{a}$	$833.39±9.63^{a}$	$1068.90±18.79^{a}$	$1337.65±13.29^{a}$	$1598.67±13.52^{a}$
T2	**$ZnSo_4$**	**60**	$86.62±1.06^{b}$	$199.88±4.05^{a}$	$369.55±4.11^{a}$	$596.80±11.53^{a}$	$846.28±10.18^{ab}$	$1085.29±13.89^{ab}$	$1353.93±11.07^{a}$	$1615.47±13.33^{ab}$
T3	**Zn-Met**	**30**	$87.24±1.26^{b}$	$204.50±3.41^{ab}$	$375.00±7.48^{ab}$	$605.92±14.31^{a}$	$857.23±7.86^{abc}$	$1100.18±14.21^{abc}$	$1371.26±12.52^{ab}$	$1631.43±17.49^{abc}$
T4	**Zn-Met**	**60**	$86.44±1.59^{b}$	$212.12±3.75^{bc}$	$382.18±4.67^{abc}$	$612.41±10.84^{ab}$	$868.09±9.92^{bc}$	$1114.05±14.89^{abc}$	$1391.15±10.95^{bc}$	$1658.27±15.52^{bcd}$
T5	**nZn**	**15**	$87.91±0.96^{bc}$	$215.13±2.45^{c}$	$387.29±5.09^{bc}$	$618.12±11.55^{ab}$	$878.20±10.02^{bc}$	$1121.00±14.62^{bcd}$	$1400.36±11.06^{bc}$	$1671.76±15.58^{cd}$
T6	**nZn**	**30**	$91.04±0.75^{c}$	$219.54±2.53^{c}$	$392.32±4.55^{c}$	$624.75±11.51^{ab}$	$888.54±12.61^{cd}$	$1137.72±17.91^{cd}$	$1422.53±14.56^{cd}$	$1695.92±16.12^{d}$
T7	**nZn**	**60**	$96.80±1.54^{d}$	$230.09±2.30^{d}$	$409.86±4.10^{d}$	$645.830±9.30^{b}$	$910.92±14.42^{d}$	$1164.18±18.10^{d}$	$1455.18±13.89^{d}$	$1741.72±14.85^{e}$

Means having same superscript column wise do not differ significantly

Feed Consumption

Result presented in Table 3 showed that the intakes were insignificant ($P≤0.05$) in all the treatment groups at different weeks except I and II week. During the first and second week, a higher feed intake (g/bird) was recorded in T_7 (Nano zinc, 60 ppm) compared to other groups. The lack of response in feed intake might be due to increased synthesis of intestinal metallothionein which reduces the zinc absorption. One possible reason may be the purity of the source used (99.99%), whereas the purity of the present source for nano zinc was 26%.

Table 3: Feed consumption (g/bird) (Mean ± SE) affected by $ZnSo_4$, Zn-Met and nZn supplementation

Treat ment	Zinc source	Level (mg/kg)	I week	II week	III week	IV week	V week	VI week	VII week	VIII week
T1	**$ZnSO_4$**	**30**	58.13 ± 1.21^{a}	275.53 ± 5.85^{a}	601.23±3.68	1039.96±11.32	1482.19±33.84	2051.36±18.9	2649.05± 50.25	3506.49± 32.77
T2	**$ZnSO_4$**	**60**	61.42 ± 1.31^{ab}	279.87 ± 6.80^{ab}	602.33±4.05	1050.37±7.5	1490.00±11.88	2066.47± 22.23	2666.66± 58.12	3520.83± 27.89
T3	**Zn-Met**	**30**	61.73 ± 1.13^{b}	285.91 ± 4.49^{abc}	604.26±5.81	1052.28±9.76	1509.01±9.09	2076.79± 27.31	2683.52± 15.37	3541.36± 30.38
T4	**Zn-Met**	**60**	61.95 ± 1.03^{b}	287.66 ± 5.67^{abc}	609.20±7.59	1053.97±12.31	1515.90±15.9	2085.41± 34.08	2705.68± 30.45	3573.86± 35.31
T5	**nZn**	**15**	61.38 ± 0.96^{ab}	292.79 ± 5.13^{bcd}	611.51±3.94	1052.65±23.15	1525.00±14.55	2093.18± 37.18	2717.80± 39.13	3583.83± 73.57
T6	**nZn**	**30**	61.875 ± 0.92^{b}	296.56 ± 3.03^{cd}	612.7±3.95	1060.75±19.15	1525.00±25	2108.33± 36.22	2743.37± 28.4	3615.90± 50.7
T7	**nZn**	**60**	63.44 ± 1.00^{b}	307.70 ± 2.43^{d}	612.57±4.16	1061.75±22.65	1529.16±29.16	2145.83± 20.83	2764.20± 27.46	3636.36± 30.3

Means having same superscript column wise do not differ significantly

Feed Conversion Ratio (FCR)

Data presented in Table 4 indicated that nano zinc at 60 ppm significantly ($P\leq0.05$) affected the FCR. The FCR between $ZnSO_4$, Zn-Met treated groups at different levels were insignificant. These results agree with the reports of Iqbal *et al.* (2011) that the FCR of broiler chicken was not influenced by supplementation of Zn inorganic and organic sources. Among the nano zinc fed groups, better FCR was recorded @ 60 ppm and was close to the other nano zinc supplemented groups. Loss of appetite with lower feed consumption resulting in slower growth rate of the group as compared to others appears to be responsible for decline of feed intake in these $ZnSO_4$ groups (Jahanian *et al.*, 2008). Lower absorption rate of Zn from inorganic sources caused the need for high levels of supplemental Zn to meet nutritional requirements of chick. However, Bao and Choct (2009) recorded an increase of FCR when zinc was chelated with organic sources of Fe and Cu which might be the role of Cu in growth hormone level.

Table 4: Feed conversion ratio (Mean ± SE) affected by $ZnSo_4$, Zn-Met and nZn supplementation

Treatment	Zinc Source	Level (mg/kg)	I week	II week	III week	IV week	V week	VI week	VII week	VIII week
T1	**$ZnSo_4$**	**30**	0.70 ± 0.03^{b}	1.40±0.40	1.63 ± 0.01^{e}	1.76 ± 0.01^{b}	1.77 ± 0.04^{b}	1.91±0.01	1.98±0.03	2.19 ± 0.02^{b}
T2	**$ZnSo_4$**	**60**	0.70 ± 0.01^{b}	1.40±0.03	1.62 ± 0.01^{de}	1.76 ± 0.01^{b}	1.76 ± 0.01^{ab}	1.90±0.02	1.96±0.04	2.18 ± 0.01^{b}
T3	**Zn-Met**	**30**	0.70 ± 0.01^{b}	1.39±0.02	1.61 ± 0.01^{cde}	1.73 ± 0.01^{b}	1.76 ± 0.01^{ab}	1.88±0.02	1.95±0.01	2.17 ± 0.01^{ab}
T4	**Zn-Met**	**60**	0.71 ± 0.01^{b}	1.35±0.01	1.59 ± 0.01^{bcd}	1.72 ± 0.02^{ab}	1.74 ± 0.02^{ab}	1.86±0.03	1.94±0.02	2.15 ± 0.02^{ab}
T5	**nZn**	**15**	0.69 ± 0.01^{b}	1.36±0.02	1.57 ± 0.01^{bc}	1.70 ± 0.03^{ab}	1.73 ± 0.01^{ab}	1.86±0.03	1.94±0.02	2.14 ± 0.04^{ab}
T6	**nZn**	**30**	0.67 ± 0.01^{a}	1.35±0.01	1.56 ± 0.01^{b}	1.69 ± 0.03^{ab}	1.71 ± 0.02^{ab}	1.85±0.03	1.92±0.01	2.13 ± 0.03^{ab}
T7	**nZn**	**60**	0.65 ± 0.01^{a}	1.33±0.01	1.49 ± 0.01^{a}	1.64 ± 0.03^{a}	1.67 ± 0.03^{a}	1.84±0.01	1.89±0.01	2.08 ± 0.08^{a}

Means having same superscript column wise do not differ significantly

Economic Efficiency

The economics (net returns) was calculated by analyzing FCR, total feed consumption and average feed cost (Table 5). The net return was highest in nano zinc supplemented groups followed by Zinc-methionine and lowest in Zinc-sulphate group. But when profit was calculated on the basis of FCR (Table 6) highest profit was recorded in $ZnSO_4$ group @ 30ppm with lowest profit in nZn group @ 60ppm. The present findings are in contrast to the findings of Osman *et al*., (2007) who reported that Hubbard broilers fed with 0.3g/kg Zn-Met gave the best economical and relative efficiency. The reason might be attributed with better FCR, better genetic credentials of the chickens used in the previous study.

Table 5: Effect of supplementing $ZnSO_4$, Zn-Met and nano zinc on feeding economics (INR/bird)

Description	$ZnSO_4$			$ZnSO_4$			Zn-Met			Zn-Met		
	Pre-starter	Starter	Finisher	Pre-starter	Starter	Finisher	Pre-starter	Starter	Finisher	Pre-starter	Starter	Finis-her
Feed Consumption (g/bird)	311.6	1524.5	3077.74	314.54	1535.61	3093.75	317.3	1546.18	3112.59	319.6	1551.76	3139.77
Cost of feed per kg	32.22	31.03	30.48	32.22	31.03	30.49	32.36	31.17	30.62	32.51	31.32	30.77
Total cost of feed	151.15			152.11			153.76			155.6		
Average wt/bird (kg)	2.7			2.82			2.88			2.96		
Rate/kg live weight	70			70			70			70		
Cost/chick	15			15			15			15		
* Other cost	10			10			10			10		
Gross return	189			197.4			201.6			207.2		
Net return	12.84			20.28			22.83			26.59		

Description	nZn			nZn			nZn		
	Pre-starter	Starter	Finisher	Pre-starter	Starter	Finisher	Pre-starter	Starter	Finisher
Feed Consumption (g/bird)	321.89	1556.94	3150.56	323.71	1564.71	3179.64	327.88	1538.81	3200
Cost of feed per kg	32.38	31.19	30.64	32.55	31.35	30.84	32.88	31.69	31.14
Total cost of feed	155.51			157.65			159.19		
Average wt/bird (kg)	2.99			3.23			3.33		
Rate/kg live weight	70			70			70		
Cost/chick	15			15			15		
* Other cost	10			10			10		
Gross return	209.3			226.1			233.1		
Net return	28.78			43.44			48.9		

**Cost* includes *the expenditure on brooding, medication, vaccination and labour charge*

Table 6: Profit on the basis of feed conversion ratio

Treatment	FCR	Feed cost	Unit cost (Rs)
$ZnSO_4$	2.19	31.24	68.41
$ZnSO_4$	2.18	31.24	68.1
Zn-Met	2.17	31.38	68.09
Zn-Met	2.15	31.53	67.78
nZn	2.14	31.4	67.19
nZn	2.13	31.58	67.26
nZn	2.08	31.9	66.35

Conclusion

From the present study, it can be concluded that body weight gain, feed consumption and FCR were higher with higher return for nanozinc at 60ppm level but considering economic efficiency on the basis of FCR, inorganic zinc at 30ppm has a better result.

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Conflict of Interests

There is no conflict of interest.

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