DR-1675
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RESEARCH ARTICLE Asian Journal of Dairy and Food Research

Effect of Nano Zinc Supplementation on Production Performance, Immune Response and Carcass Characteristics in Japanese Quail Broiler

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ABSTRACT

Background: Nano-technology is currently an emerging field and giving promising results with cost economics in the poultry nutrition sector. A study was conducted to investigate the effects of nano Zn supplementation on production performance, immune response and carcass characteristicsin Japanese quail broiler.

Methods: Synthesis of zinc oxide nano-particles was carried out by chemical method and characterized by standard techniques. Day old Japanese quail chicks (n=240) were randomly allotted in four treatment groups for feeding trial and fed with basal diet and source of zinc *viz*. for T_1 inorganic Zinc Oxide, for T_2, T_3 and T_4 nano Zinc Oxide was used at 75%, 50% and 25% levels of BIS recommendation for Zinc. Production parameters, immune response, carcass characteristics and cost economics were studied.

Result: Based on the data analysed T_3 and T_4 showed significantly ($P<0.05$) improved performance in production parameters like body weight gainand cumulative feed conversion ratio than T_1 and T_4. HI, titer value and carcass characteristics data also showed similar trend.

Key words: Japanese quail, Nano zinc oxide, Production performance.

INTRODUCTION

Japanese quail are characterized by many favorabletraits such as a fast growth rate, quick sexual maturity, shortgeneration interval, small body size and significant egg production ratio compared to other farm birds (Narinc *etal*. 2014; Molino *et al*. 2015).

Zinc is an essential trace mineral for Japanese quail since it is required for normal growth, bone development, feathering (Sahin *et al*. 2009). A high concentration of Zn can affect the balance of other trace elements such as Ca, Cu and Fe in the body (Sundaresan *et al*. 2008). Zinc supplementation exhibits a positiveeffect on growth performance of Japanese quail (Sahin *et al*. 2005; Rouhalamani *et al*. 2014).

Zinc oxidenanoparticles (ZnONPs), as an alternative to theconventional zinc sources, represent a good alternativein livestock feeding. The usage of ZnONPs has gainedattention due to the larger surface area, higher surfaceactivity and catalytic efficiency and stronger adsorbing quality compared with the conventional use of Zn (Javad *et al*. 2013). Zhao *et al*. (2014) reported that supplementation of nano-zinc in broilers at 20, 60 and100 ppm significantly improved the feed conversionand growth rate compared with the control group (60 mg/kg ZnO). With the emergence of nanotechnology, zinc can be added as a feed supplement in many forms to improve the efficiency of trace minerals in poultry and livestock (Attia *et al*. 2013); Geetha *et al*. 2020). Hence, this study was designed in an attemptto examine the effects of ofnano Zn on production performance, immune response and carcass characteristics and cost economics in Japanese quail broiler.

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How to cite this article: Arulnathan, N., Chellapandian, M., Geetha, K., Thirumeignanam, D., Vijayakumar, M.P. (2021). Effect of Nano Zinc Supplementation on Production Performance, Immune Response and Carcass Characteristics in Japanese Quail Broiler. Asian Journal of Dairy and Food Research. DOI: 10.18805/ajdfr.DR-1675.

Submitted: 07-04-2021 **Accepted:** 31-08-2021 **Online:** 17-09-2021

MATERIALS AND METHODS

This experiment was designed and carried out at the Department of Animal Nutrition, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Tirunelveli, Tamil Nadu, India during the September- October of 2020. To assess the effect of Nano zinc on production performance, immune response and carcass characteristics the experiments were fabricated as follows.

Synthesis and characterization of zinc oxide nanoparticles that were used in this experiment

The zinc oxide nanoparticles (ZnO-NPs) were synthesized by chemical method described by Geetha *et al*., (2020). Zinc

acetate dihydrate was used as a precursor for producing zinc oxide nanoparticles and Sodium hydroxide as a reducing agent. 0.1 M zinc acetate homogenous mixture was dissolved double distilled water at a pH of 11 for 2 hours. 0.1M NaOH was slowly added into zinc acetate solution with constant stirring. Then, the final mixture solution was stirred for 4 hours at a pH of 7. The precipitate was filtered and then the colloidal zinc oxide was lyophilized. The powdered Zinc oxide nanoparticles were collected and stored for further characterization and use in the feeding experiment in a Japanese quail broiler.

Characterization of zinc oxide nano particles

The produced samples were characterized at the Division of Nano Technology, Periyar Maniyammai Institute of Science and Technology (PMIST), Thanjavur by standard techniques to confirm its morphology (SEM-TESCAN, VEGA3 LMU) and optical absorption spectrum by UV-Visible spectroscopy (UV 1800 Spectrophotometer, SHIMADZU).

Feeding experiment

Experimental mineral mixtures by the inclusion of zinc oxide nanoparticles were formulated to fulfill BIS specifications for Japanese quail broiler on starter and finisher ration. For T_1 inorganic zinc oxide was used. For T_2 to T_4 Zinc oxide nanoparticles (ZnO-NPs) were used as 75%, 50% and 25% levels of BIS recommendation for zinc.

For the feeding experiment, 240 numbers of days-old Japanese quail broiler chicks belonging to a single hatch were purchased from the Livestock farm Complex Hatchery, Veterinary College and Research Institute, Tirunelveli. Upon arrival, Japanese quail chicks were weighed individually and distributed randomly into four treatment groups, each treatment consist of six replicates comprised ten birds each.

The experimental birds were housed in two-tier well-ventilated battery cages provided with artificial lighting. The Japanese quail broiler rations were iso-caloric and iso-nitrogenous. Both starter and finisher mash feed met the nutrient requirement as per BIS (2007). The metabolisable energy and crude protein content of starter and finisher ration was 3000, 2900 kcal/kg diet and 28, 24 per cent, respectively. The ingredient compositions of the experimental ration were furnished in Table 1. The source of Zinc oxide and their inclusion levels are the key variables in these rations.The management practices adopted were as per the standards and were uniform for all the treatments. Initial body weight, weekly body weight gain, daily and weekly feed intake and weekly feed conversion ratio were recorded for four weeks during this experimental period. Serum samples were collected to assess the immune response by HI titer against the experimental vaccination for NDV on the 7th and 21st day of the trial. Six birds in each treatment groupwere slaughtered by the Halal method at the end of the experiment on the 28th day. The carcasses were skinned, eviscerated and dressing per centage was calculated and cutoff parts were weighed to study the carcass characteristics. Finally, the cost economics was worked out to assess the economic impact of the use of nano zinc oxide in Japanese quail production.

Statistical analysis of experimental data was carried as per (Snedecor and Cochran, 1994) and by SPSS statistics for windows, version 17.0 (2008).

RESULTS AND DISCUSSION

Nano zinc oxide synthesis and characterization

SEM analysis

The SEM photograph of the sample is shown in Fig 1. The SEM images of ZnO samples obtained from the precipitation chemical method revealed the presence of nanoparticles of spherical shape with minimal agglomeration. The particle size varied from 70 to 200 nm as observed from the SEM image shown Fig 1.

UV-visible absorption spectrum

UV-visible absorption spectroscopy is used to examine the optical proper-ties of nanosized particles. It is obvious from Fig 2, nano zinc oxide powder exhibits a strong absorption band at about 335 nm, which lies below the bandgap wavelength of 388 nm of bulk ZnO. The excitation absorption of ZnO powder and bulk ZnO material appeared at ~327 nm and ~373 nm was reported. The excitation peak at 335 in Fig 2 is similar to the previous report of Getie *et al*. (2017) and Fayiz *et al*. (2021).

Table 1: Per cent Ingredient composition of Japanese quail starter and finisher experiment ration.

Ingredients	Japanese quail starter (0-21 days)	Japanese quail finisher (22-28 days)
Maize	40.00	60.00
Soyabean meal	53.60	36.30
Vegetable oil	2.50	0.00
Calcite	1.40	1.32
DCP	1.00	1.00
Trace mineral mix*	0.10	0.10
Rovimix breeder	0.05	0.05
Phytase 5000	0.02	0.02
Salt	0.45	0.45
Sodium Bi carbonate	0.10	0.10
Methionine	0.24	0.12
Perivac plus forte	0.01	0.01
Choline chloride (60%)	0.10	0.10
Coxistac -120	0.10	0.10
Lysoforte	0.10	0.10
Zoom (BMD)	0.03	0.03
US curaTox FS	0.10	0.10
Protease NSP	0.10	0.10
Total	100.00	100.00

*(Trace mineral mix formulated for this experiment - T_1 Inorganic Zinc Oxide was used. For T_2 to T_4 nano Zinc Oxide was used at 75%, 50% and 25% levels of BIS recommendation for zinc).

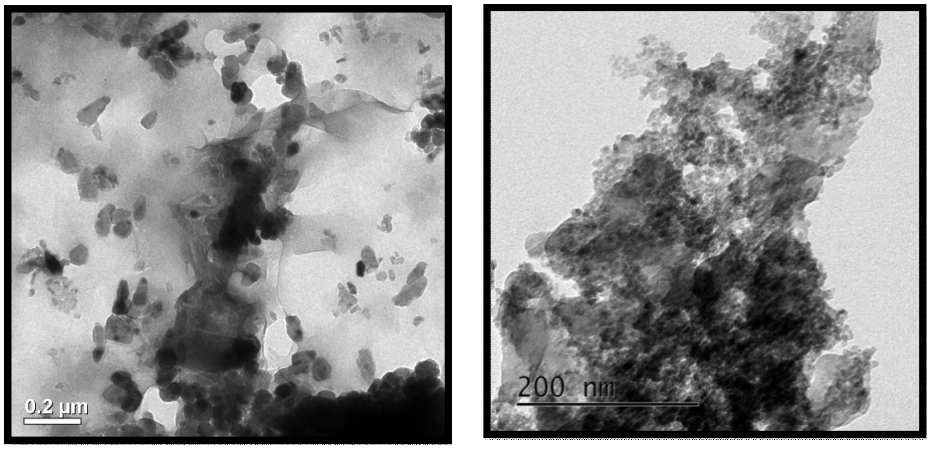

Fig 1: Scanning Electron Microscopy Image of ZnO nano partilces.

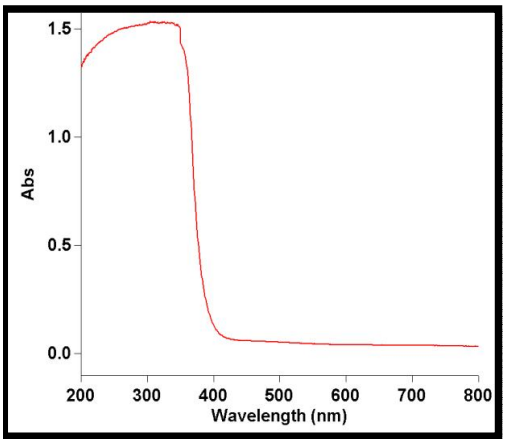

Fig 2: UV visible absorption of ZnO nano particles.

Feeding experiment

Production parameters

The data collected on growth performance in terms of body weight gain, feed intake and feed efficiency were analyzed and presented (Table 2).

There is no significant difference in the body of the birds on day old. The fourth-week body weight and final weight gain of the birds belong to T_3 significantly higher ($p<0.05$) and followed by T_3. There is no significant difference between T_1 and T_4 group of birds.

There is no significant difference noticed in the cumulative feed intake among the treatment groups. The treatment ration didn't influence the feed intake. This correlated with the report of Faiyz *et al.* (2021). T_2 treatment group birds showed significantly ($p<0.05$) higher final weight gainfollowed by T_3. There is no significant difference between the T_1 and T_4 group of birds in final body weight gain.A significant improvement in feed conversion ratio (FCR) as a result of feeding experimental diets was observed. At the end of the experimental period (4^{th} week) birds fed with 75% of BIS level as ZnO-NPs(T2) significantly achieved ($P<0.05$) the highest FCR being better by 9% compared to control and followed by those fed with ZnO-NPs as 50% of BIS level which was better by 7% than control. The supplementation of ZnO-NPs in the Japanese quail broiler ration had a positive effect on growth in this experiment may be due to the important role of Zn in the overall performance and physiological process of poultry, as it is the main component of a large number of enzymes known as metalloenzymes, which are involved in the metabolism of energy, nucleic acids and protein (Torres and Korver, 2018; Attia *et al*. 2019). The current experiment results are compatible with Fathi (2016) and Fayiz *et al*. (2021) which demonstrated that appropriate levels of nano-ZnO can promote body weight, weight gain and feed conversion ratio.

Immune response

The immune response data of Japanese quail fed with zinc oxide nanoparticles are shown in Table 3.

Data revealed that T_2 and T_3 treatment group birds showed significantly ($p<0.05$) higher HI than the T_1 and T_4. There is no significant difference between T_1 and T_4 group of birds in the HI titer value. ZnO-NP application up to 80 mg/kg in the diet is safe for broiler chickens and could improve their antioxidant defense and cellular immunity (Azza *et al.* 2019). Sahoo *et al*. (2014) found that 15 ppm organic zinc and 0.06 ppm nano-zinc when added to the basal diet, increased the antibody titer and immune organ response and so improved the immune status of the birds. The results of the study by Sridhar *et al* (2016) indicated that reducing the level of Zn from inorganic source (40 ppm) to 50% (20 ppm) supplementation from Zn-glycinate can result in comparable immune and antioxidant status in broiler chicks. This results clearly indicating that once the availability of the minerals increased the dose may be reduced when it supplement as inorganic source.So similar case would be the reason in the present study that the zinc supplemented as nano particle had better availability and hence better observation and the reduction in the dose when compare to the inorganic source of Zinc.

Carcass characteristics

Carcass characteristics and relative organ weights of growing Japanese quails, as influenced by dietary treatments, are tabulated in Table 4. T_2 treatment group birds showed significantly ($p<0.05$) higher dressing percentage than T_3, T_1 and T_4. There is no significant difference between the T_1 and T_4 group of birds in dressing percentage. There is no significant difference noticed among the treatment groups in the carcass characteristics in terms of breast, back, leg, wings, neck, liver and heart percentage of the carcass. The results of the present study were consistent with previous reports that Mohammadi *et al*. (2015) suggested that dietary ZnO-NPs at 80 mg/kg had significantly improved carcase yield and increased the relative weight of the digestive and lymphoid organs of broilers. On the other hand, in another study, adding zinc in excess to the basal diet had no significant effect on the carcass yield of broilers (Karthikeyan *et al.* 2017).

Cost economics

The effect of ZnO -NPs supplementation on cost economics is tabulated in Table 5. Based on the production cost and amount realized T_2 group bird fetch Rs. 4.67/- T_3- Rs. 2.24/ - additional net profit over the control. There is a very negligible difference between the T_1 and T_4 group of birds.

Table 2: Effect of nano zinc supplementation on production performance and feed efficiency of Japanese quail broiler.

Body weight (gm.)	T_1	T_2	T_3	T_4
Hatch weight ^{NS}	8.34 ± 0.05	8.34 ± 0.11	8.41 ± 0.15	8.39 ± 0.14
4th week weight	208.15^a ± 1.80	227.63^c ± 2.18	218.16^b ± 1.84	208.99^a ± 2.30
Final weight gain	199.81^a ± 1.80	219.29^c ± 2.15	209.75^b ± 1.80	200.59^a ± 2.37
Cumulative feed intake^{NS}	494.66 ± 5.79	501.83 ± 7.46	506.16 ± 5.68	498.66 ± 5.22
Cumulative feed conversion ration	2.51^a ± 0.04	2.27^b ± 0.03	2.34^b ± 0.03	2.50^a ± 0.02

Mean of 10 observations. Mean value sharing any one common superscript in a row did not differ significantly ($p<0.05$).

Table 3: Effect of nano zinc supplementation on immune response of Japanese quail broiler.

Parameters	T_1	T_2	T_3	T_4
HI Titre*	2.75^a ± 0.04	3.28^b ± 0.13	3.37^b ± 0.07	2.98^a ± 0.06

*HI Titre against NDV. Mean of six values. Mean valve sharing any one common superscript in a row did not differ significantly ($p<0.05$).

Table 4: Effect of nano zinc supplementation on carcass characteristics of Japanese quail broiler.

Carcass characteristics*	T_1	T_2	T_3	T_4
Live weight	208.15^a ± 1.80	227.63^c ± 2.18	218.16 ^{b} ± 1.84	208.99^a ± 2.30
Dressing percentage	63.16^a ± 1.16	66.39^b ± 0.24	65.51^b ± 0.24	63.34^a ± 0.61
Breast % of carcass	31.10 ± 0.89	33.65 ± 0.82	32.64 ± 0.47	31.19 ± 0.35
Back % of carcass	19.23 ± 1.77	20.96 ± 0.47	20.97 ± 0.62	20.39 ± 0.61
Leg % of carcass	17.70 ± 2.12	19.27 ± 1.73	19.54 ± 1.87	21.90 ± 0.33
Wings % of carcass	5.18 ± 0.31	4.98 ± 0.26	5.08 ± 0.23	4.80 ± 0.19
Neck % of carcass	4.80 ± 0.15	4.97 ± 0.24	5.11 ± 0.17	4.62 ± 0.15
Liver % of carcass	3.16 ± 0.25	3.34 ± 0.23	3.34 ± 0.33	3.61 ± 0.23
Heart % of carcass	4.14 ± 0.52	4.14 ± 0.45	4.16 ± 0.43	4.94 ± 0.21

Mean of six values. Mean value sharing any one common superscript in a row did not differ significantly ($p<0.05$).

Table 5: Effect of nano zinc supplementation on cost economics of Japanese quail broiler.

Parameters	T_1	T_2	T_3	T_4
Cost of day old Japanese quail chick (Rs.)	5	5	5	5
Total feed consumed (gm.)	494.66 ± 5.79	501.83 ± 7.46	506.16 ± 5.68	498.66 ± 5.22
Total feed cost* Rs./Kg	16.29	16.48	16.63	16.42
Miscellaneous cost (Rs.)	2.50	2.50	2.50	2.50
Total oroduction cost (Rs.)	23.79	23.98	24.13	23.92
Final body weight of the bird (gm.)	199.81^a ± 1.80	219.29^c ± 2.15	209.75^b ± 1.80	200.59^a ± 2.37
Market orice (Rs. 240/kg)	47.76	52.62	50.34	48.14
Net profit per bird (Rs.) sold on weight basis	23.97	28.64	26.21	24.22
Additional net orofit per bird over the control (Rs.)	-	4.67	2.24	0.25

*Including supplementation cost.

CONCLUSION

Based on the data analyzed T_3 and T_4 showed significantly ($P<0.05$) improved performance in production parameters like body weight gain, cumulative feed conversion ratio than T_1 and T_4. HI, titer value and carcass characteristics data also showed similar trend. $T_1$and T_4 birds showed a similar performance in all production parameters, immune response and carcass characteristics without any significant difference. It was concluded that the dose recommended for inorganic Zinc oxide (80 mg/kg diet for starter; 120 mg/kg diet for finisher quails) could be reduced up to 25% of BIS recommended dose (20 mg/kg diet for starter and 30 mg/kg diet for finisher quails) on supplementation of nano Zinc oxide without any adverse effect on production performance, immunity and carcass characteristics in Japanese reared for meat purpose. On increased inclusion up to 75% of BIS recommended dose level, significant high performance was observed which revealed additional profits. Supplementation of nano zinc oxide proved to be economical and cost-effective compared to inorganic zinc sources.

ACKNOWLEDGEMENT

The authors are very much grateful to the authorities of Tamil Nadu Veterinary and Animal Sciences University especially The Director of Research, TANUVAS, The Dean, Veterinary College and Research Institute, Tirunelveli for accorded permission and necessary facilities provided to carry out this research work.

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