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RESEARCH ARTICLE

Effects of Copper oxide nanoparticles on productive performance of broiler chickens under climate change conditions

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Abstract

This study aimed to investigate the effects of green Nano-Copper oxide (Nano-CuO) on growth performance, and serum biochemistry of broiler chickens. A total of 96One-day old broiler chickens were randomly distributed into two equal treatment groups. Treatment groups were fed a control diet or a control diet supplemented with green synthesis of Nano-CuO (8 mg/kg). The feeding trial lasted for 35 days. Each treatment had six replicates with eight birds each. The diets were formulated to meet Ross 308 broiler recommendations. Chicks were full access to feed and water during the experimental period. The brooding temperatures were 38.5, 36.5, and 30.9°C during 1–10, 10–21, and 22–42 d of age, respectively. The results showed that body weight gain and feed conversion ratio were significantly improved Nano-CuO treated group than non-supplemented group. Furthermore, carcass characteristics were significantly improved ($P<0.01$) in Nano-CuO compared to control groups. Likewise, supplementation of Nano-CuO significantly improved liver and kidney functions as indicated from serum metabolites. Therefore, it can be concluded that Nano-CuO, achieved sustainable development in broiler production under climate change challenges.

Keywords: Broilers; Climate change; Green Nano-CuO; Productions.

1. Introduction

One of the most important problems that could limit the expansion of the poultry industry is an increase in environmental temperature, which causes heat stress in birds. The average global surface temperature will have increased by 1.4°C to 5.8°C by the year 2100, according to the Intergovernmental Panel on Climate Change (IPCC, 2007), which will have a substantial effect on the poultry business. Given that efforts to mitigate the effects of weather change have fallen short of IPCC (2014) guidelines, this constraint is expected to be more severe, especially in the tropics and subtropics. The endocrine system and homeostasis are both negatively impacted by high temperatures. Additionally, newly hatched broiler chicks are vulnerable to oxidative stress, infectious diseases, and high ambient temperatures, which increase mortality and cause financial losses (Ghanima *et al.*, 2020; Ibrahim *et al.*, 2020). Heat stresses puts the host's capacity to grow, absorb nutrients, digest food, and engage in other physiological functions in danger and accelerates the spread of infectious diseases (Saleh *et al.*, 2020; Abdel-Moneim *et al.*, 2020). Essential minerals in the form of nanoparticles (NPs) with sizes ranging from 1 to 100 nm could replace conventional forms of elements in animal diets (Mohamed *et al.*, 2016; Kociova *et al.*, 2020). According to recent studies (Abdollahi *et*

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al., 2020; Ouyang *et al.*, 2021), much smaller doses of nanoparticles than bulk minerals will be needed to meet animal needs for elements. As a result, the environmental impact brought on by the high concentration of inorganic salts will be lessened (Vijayakumar and Balakrishnan, 2014; Ouyang *et al.*, 2021). The green synthesis of Nano-CuO has also recently emerged as a novel technology and is gaining importance among researchers. However, a variety of stabilisers, such as donor ligands, polymers, and surfactants, are needed for the production of Nano-Cu in order to prevent agglomeration. When added to the diet, especially at 50% of the birds' estimated demand under heat stress, copper oxide nanoparticles may enhance bird performance, lower bird temperature, and raise bird tolerance to the detrimental effects of high temperature. Furthermore, more research is still needed to validate the bioavailability of Nano-CuO in broilers. Therefore, this study aimed to investigate the effects of green Nano-Copper oxide (Nano-CuO) on growth performance, carcass criteria and serum biochemistry of broiler chickens.

2. Materials and Methods

2.1. Experimental design and dietary treatments

During the experiment, the birds were housed and handled according to the South Valley University Institutional Animal Care Committee's recommendations (SVU-AGRI-7-2022). Chicks were kept in a closed housing in a three-tier wire floor battery cages. Chicks in each replicate were placed in cages with an iron slatted bottom. The cages had sizes of 120, 70, and 50 cm in length, width, and height, respectively. During the trial, the chicks had unrestricted access to feed and water. A total of 96 One-day old broiler chickens were randomly distributed into two equal treatment groups. Treatment groups were fed a control diet or a control diet supplemented with green synthesis of Nano-CuO (8 mg/kg). The feeding trial lasted for 35 days. Each treatment had six replicates with eight birds each. The diets were formulated to meet Ross 308 broiler recommendations. Chicks were full access to feed and water during the experimental period. The brooding temperatures were 38.5, 36.5, and 30.9°C during 1–21, and 22–35 d of age, respectively. Birds were fed commercial diets according to Ross 308 recommendations to meet the nutrient requirements (Table 1) for starter (1-21 d) and grower (22-35 d) phases, respectively.

2.2. Green synthesis of nanoparticles of copper oxide

The process of green synthesis is used to create copper oxide nanoparticles. When 10 ml of basil extract (6%) was added dropwise to the beaker holding an aqueous solution of Cu (NO) 2.3H2O (50 ml, 0.5 M) salt while the mixture was being constantly stirred, the colour of the solution changed. After the extract had finished, it took the combination around 10 minutes to become bright green and create a homogenous solution. The pH of the solution was then brought to 10 by adding drops of NaOH (1M) solution. The mixture was then heated for two hours to 90 °C. The produced nanoparticles were centrifuged, three times washed in distilled water, once in 70% alcohol, dried at 40 °C, and then calcified for three hours at 650 °C.

2.3. Broiler performance parameters

From the beginning to the end of the experiment, the body weight of the birds in each pen was noted on a weekly basis. The day the birds were weighed also included a measurement of feed residue to determine the amount of feed consumed in each pen. The amount of feed consumed by the weight gained in each pen was divided to obtain at the feed conversion ratio. The magnitude of production variables such as feed consumption and body weight were adjusted appropriately for the dying birds.

2.4. Carcass criteria and internal organs

A total of 40 birds in each treatment were processed after 35 days to assess carcass criteria and internal organs. Individually weighed birds were sacrificed in a humane manner, left to bleed, and then plucked. After the neck, head, viscera, shanks, spleen, digestive tract, heart, gizzard, and belly fat were removed, the rest of the body was weighed. The dressing percentage was determined by dividing the carcass and giblets weight by the live weight. The heart, empty gizzard, spleen, and abdominal fat of each bird were separately weighed and expressed as a percentage of live body weight.

Table 1. Chemical composition of basal diet (as-fed basis)

Ingredients (%)	Starter diet	Grower diet
Corn, ground	27.59	30.00
Sorghum, ground	27.59	30.00
Soybean meal (44% CP)	28.50	25.00
Corn gluten meal (60% CP)	9.50	6.00
Vit & Min. Premix[a]	0.30	0.30
Sunflower oil	3.00	5.52
Dicalcium phosphate	2.00	1.80
Limestone	1.00	1.00
Salt	0.38	0.38
DL-methionine	0.04	---
L- lysine HCl	0.10	---
Total	100	100
Nutrient Analysis		
ME (kcal/ kg diet)	3000	3187
Crude protein (g/kg)	236.7	204.6
Calcium (g/kg)	10.0	10.0
Available phosphorus (g/kg)	5.00	5.00
Lysine (g/kg)	11.6	11.6
Methionine (g/kg)	5.20	5.20

[a] *Supplied per kg diet, vitamin A, 1900 IU; vitamin, D_3 1300 IU; vitamin E, 10000 mg; vitamin K_3, 1000 mg; vitamin B1, 1000 mg; vitamin B2, 5000 mg; vitamin B6, 1500 mg; vitamin B12, 0.046 mg; Biotin, 50 mg; BHT, 10000 mg; Pantothenic acid, 10000 mg; folic acid, 1000 mg; Nicotinic acid, 30000 mg. Supplied Mn 60 mg; Zinc 50 mg; Fe 30 mg; Cu 4 mg; I 3 mg; Selenium 0.1 mg; Co 0.1 mg.*

2.5. Blood sampling and laboratory analyses

For serum collection, blood was collected from the wing vein of 30 birds per treatment with sterilized needles and syringes and placed in vacutainer tubes at the end of the experiment (35 days of age). The feeder was not removed from the feed before the blood was taken. At ambient temperature, the blood was centrifuged for 10 minutes (3000 g). The serum was collected in tubes and kept at -20°C until it was analyzed. Colorimetric analysis of liver enzymes such as aspartate aminotransferase and alanine transaminase, as well as kidney function tests such as urea and creatinine, was performed (Diagnostic kits, Biodiagnostics, Cairo, Egypt), using Clinical chemistry analyzer SBA 733 plus (Sunostik Medical Technology Co., Ltd, China).

2.6. Statistical analysis

The general linear model (GLM) approach of Statistical Analysis System (SAS 2005, Institute, Inc., Cary, NC, USA) software was used to analyze all data. To compare means, Duncan's multiple range test was utilized. Replicate pens were the experimental units for all analyses. The significance level was set at $P \leq 0.05$.

3. Results

3.1. Growth performance and feed intake

The effects of Nano-CuO on productive performance of broiler chickens are summarized in Tables 2 and 3. The results showed that improvements were observed in body weight and body weight gain (P < 0.05) in Nano-CuO treated group than non-supplemented group (Table 2). Additionally, the feed conversion ratio was significantly improved (P < 0.05) by Nano-CuO treated groups compared to the non-supplemented group (Table 3). There was no significant difference in the feed intake among all groups (P > 0.05).

Table 2. Body weight and daily body weight gain (g) of broilers in response to Nano-CuO supplementation.

Items	Body weight, g		Daily Body weight gain, g			
	1 day	21 days	35 days	1-21 days	21-35 days	1-35 days
Control	41.11	810^{b}	1977^{c}	769^{b}	1167	1936^{c}
Nano-CuO	41.38	900^{a}	2070^{b}	859^{a}	1170	2029^{b}
SEM	0.19	16.96	22.84	16.90	16.14	22.79
P-Value	0.712	0.027	0.003	0.027	0.492	0.003

$^{a-c}$ Means not sharing a common superscript in a row are significantly different (P<0.05)
SEM; Standard error of the means.

Table 3. Daily feed intake and daily feed conversion ratio of broilers in response to Nano-CuO supplementation.

Items	Daily feed intake, g			Daily feed conversion ratio		
	1-21 days	21-35 days	1-35 days	1-21 days	21-35 days	1-35 days
Control	1110	2198	3441	1.44^{a}	1.88	1.77^{a}
Nano-CuO	1113	2177	3324	1.29^{b}	1.86	1.63^{b}
SEM	13.10	28.47	37.52	0.02	0.01	0.02
P-Value	0.428	0.750	0.741	0.014	0.421	0.029

$^{a-c}$ Means not sharing a common superscript in a row are significantly different (P<0.05)
SEM; Standard error of the means.

3.2. Carcass criteria

In terms of carcass criteria (Table 4), broilers supplemented with Nano-CuO had significantly higher dressing and breast percentages and lower abdominal fat percentages at the end of the experimental period compared to CONT. However, Nano-CuO had no effect on the leg, liver, heart, spleen, gizzard, small intestine, or cecum of broilers (P > 0.05).

Table 4. Effect of Nano-CuO on carcass criteria and internal organs of broilers

Items %	Treatments		SEM*	P- value
	Control	Nano-Cuo		
Dressing	72.12^{b}	76.36^{a}	0.68	0.012
Liver	1.96	1.81	0.07	0.566
Heart	0.39	0.34	0.01	0.272
Gizzard	1.19	1.01	0.03	0.440
Spleen	0.16	0.16	0.01	0.949
Fat	0.70^{a}	0.52^{b}	0.03	0.029

$^{a-c}$ Means not sharing a common superscript in a row are significantly different (P<0.05)
SEM; Standard error of the means.

3.3. Blood biochemistry

In this study, the effects of Nano-Cu on a variety of blood biochemical tests in broilers were examined (Table 5). The broilers' serum levels of AST, ALT, creatinine, and urea were unaffected by Nano-CuO compared to control, which are indicators of liver and kidney functions.

Table 5. Effect of Nano-CuO on Blood criteria and internal organs of broilers

Items	Treatments		SEM*	P- value
	Control	Nano-Cuo		
ALT, IU/L	25.33	24.33	1.49	0.096
AST, IU/L	24.12	22.33	2.00	0.171
Urea, mg/dl	11.13	11.36	0.31	0.622
Creatinine, mg/dl	0.24	0.21	0.00	0.371

[a-c] Means not sharing a common superscript in a row are significantly different (P<0.05)
SEM; Standard error of the means.

4. Discussion

Global warming and climate change have a detrimental effect on the production of cattle and poultry in tropical and subtropical regions. Heat stress is one of the most significant stressors impacting chicken productivity in hot climates, resulting in significant financial losses for the poultry industry. Through the application of numerous practical strategies, the negative impacts of overheating have been diminished. One of these is food modification, which in many parts of the world is becoming more and more popular as a natural source of antioxidants, minerals, and electrolytes. Recent studies have proposed copper nanoparticles as a potential alternative to antibacterial medications and a growth promoter, depending on size, dose, and animal. The results in the current study showed that improvements were observed in body weight and body weight gain ($P < 0.05$) in Nano-CuO treated group than non-supplemented group. Additionally, the feed conversion ratio was significantly improved ($P < 0.05$) by Nano-CuO treated groups compared to the non-supplemented group. Increased uptake of Nano-CuO in the GIT may have an effect on animal growth and health. When Nano-CuO is added to the diet for poultry, it has been demonstrated to improve growth performance and feed utilization when compared to CuSO4 (Gonzales *et al.*, 2009; El Basuini *et al.*, 2016). Nano-greater CuO's bioavailability to CuSO4 salts was said to be the cause of the improvement. But it's still not apparent what mechanism underlies this advancement. Studies have speculated that the effects of Nano-CuO may be due to its antibacterial properties (Arias *et al.,* 2006), while others have hypothesised that improved energy and fat digestion may be the reason (Gonzales *et al.,* 2009). Nano-forms of micro- and macroelements are responsible for the majority of reported increases in body weight, average daily gain, and FCR (Yusof *et al.,* 2019). According to studies, Nano-antibacterial CuO's properties may be what causes its effects (Arias *et al.,* 2006), however other researchers have claimed that improved energy and fat digestion may also be to blame (Gonzales *et al.,* 2009; Scott *et al.,* 2016). In the current study, birds fed diet supplemented with Nano-CuO had significantly higher dressing and breast percentages and lower abdominal fat percentages at the end of the experimental period compared to control. The broilers' serum levels of AST, ALT, creatinine, and urea were unaffected by Nano-CuO compared to control, which are indicators of liver and kidney functions. Copper is an essential trace element in the diet of chickens due to its many biological functions. The blood analysis' findings are regarded as being within the normal range for a healthy chicken. Cu sources had no discernible influence on the blood's AST, ALT, uric acid, and creatinine levels (Ibrahim *et al.*, 2022). The findings of Tayeb and Qader (2012), Jegede *et al.* (2012), and Kwiecien *et al.* (2014) were in contradiction with these results, which showed significant differences in liver and kideny parameters between treatment groups enriched with copper and the control group.

5. Conclusion

It can be concluded that Green synthesis of Nano-CuO should be used in broiler diets with minimal danger to consumers because it can enhance the performance and health of birds. Nano-CuO achieved sustainable development in broiler production under climate change challenges.

Authors' Contributions

All authors are contributed in this research.

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Institutional Review Board Statement

All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement

Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate

Not applicable

Consent for Publication

Not applicable.

Conflicts of Interest

The authors disclosed no conflict of interest starting from the conduct of the study, data analysis, and writing until the publication of this research work.

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