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Full Length Research

The effects of dietary ginger and graded levels of Vitamin C on antioxidant and pro-oxidant status in grower-finisher broiler chickens

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ABSTRACT: The antioxidant and pro-oxidant responses of broiler chickens to dietary ginger and vitamin C were investigated. Antioxidants studied included glutathione (GSH), glutathione peroxidase (GPx), catalase (CAT), and superoxide dismutase (SOD), while malondialdehyde (MDA) served as the pro-oxidant indicator. One hundred and fifty (150) unsexed *Agrited* day-old chicks were used. On arrival, chicks were brooded for 4 weeks before being randomly assigned to five dietary treatment groups. Each group comprised 30 birds with three (3) replicates of ten (10) birds each. Ginger was fixed at 10 g/kg while vitamin C was graded as follows: Treatment 1 (T_1), the negative control, contained 0 g/kg ginger + 0 mg/kg vitamin C; T_2: 10 g/kg ginger + 100 mg/kg vitamin C; T_3: 10 g/kg ginger + 200 mg/kg vitamin C; T_4: 10 g/kg ginger + 300 mg/kg vitamin C; and T_5: 10 g/kg ginger + 400 mg/kg vitamin C. After 4 weeks on their respective experimental diets, 9 birds per group (3 per replicate) were sacrificed for blood collection. GSH, GPx, CAT, and SOD levels in T_2–T_5 were significantly ($p<0.05$) higher than in T_1, with T_3 recording the highest values. MDA levels were significantly ($p<0.05$) highest in T_1 and T_5, and lowest in T_3. It was concluded that dietary ginger and vitamin C improve antioxidant status and reduce oxidative stress in broiler chickens, particularly at the combination of 10 g/kg ginger and 200 mg/kg vitamin C.

Keywords: Antioxidants, broiler chicken, ginger, malondialdehyde, oxidative stress, Vitamin C.

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) is a natural phytogenic plant that has been reported to reduce oxidative stress induced by heat stress and other environmental stressors (Abubakar *et al.*, 2023). As a natural antioxidant, ginger is a promising candidate for dietary supplementation in poultry to support health and enhance productivity (Al-Khalaifah *et al.*, 2022). Similarly, vitamin C supplementation in broiler diets enhances the antioxidant status of tissues and supports various immune functions (Van Hieu *et al.*, 2022). Vitamin C acts as an antioxidant by protecting cells from damage caused by free radicals, thereby supporting the body's defence against oxidative stress (Fatima, 2026). Furthermore, vitamin C has been shown to ameliorate heat stress-induced immunosuppression, reduce oxidative stress, and decrease morbidity and mortality in broiler chickens (Shakeri *et al.*, 2020).

Vitamin C also supports immune function through the promotion of white blood cell production and activity, which are critical in combating infections (Van Hieu *et al.*, 2022). Although considerable literature supports the individual roles of ginger and vitamin C in the animal defence system, data on their synergistic antioxidant activities in poultry are scarce. With poultry production increasingly central to global food security, given that poultry meat carries no religious dietary restrictions, and with the prohibition of antibiotic growth promoters in many countries, nutritionists are actively seeking alternatives, including phytobiotics and vitamins (Rafeeq *et al.*, 2023). Therefore, the objective of this study was to investigate the effects of dietary ginger in combination with graded levels of vitamin C on the antioxidant and pro-oxidant status of grower-finisher broiler chickens.

MATERIALS AND METHODS

Experimental site

The study was conducted at the poultry unit of the Teaching and Research Farm, Department of Animal Science, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria.

Experimental animals, management, and design

One hundred and fifty (150) unsexed *Agrited* day-old chicks were purchased from a reputable poultry dealer in Port Harcourt. On arrival, chicks were brooded for 4 weeks to acclimatise them to their environment. The 4-week brooding period is standard management practice in tropical climates such as Port Harcourt, Nigeria, where brooding is primarily aimed at providing supplemental heat and early protection for newly hatched chicks during the critical post-hatch phase, irrespective of ambient temperature. At the end of the brooding period, birds were randomly allotted to five dietary treatment groups in a completely randomised design (CRD). Each group comprised 30 birds with three (3) replicates of ten (10) birds each. Pens, feeders, and drinkers were cleaned and disinfected before stocking. Feed and water were provided *ad libitum* throughout. Standard management procedures were followed, including routine medication. At the end of brooding, birds received their respective experimental diets for an additional 4 weeks, giving a total experimental period of 8 weeks.

Ginger procurement and powder preparation

Fresh ginger rhizomes were obtained from a local market. They were washed thoroughly to remove dirt and surface contaminants, then chopped into uniform pieces to promote even drying. The chopped rhizomes were sun-dried until a crisp, low-moisture state was achieved, after which they were ground into fine powder using a petrol-powered mechanical grinder. The machine was cleaned and sanitised prior to use, and operators wore gloves and nose masks throughout the process. The resulting powder was sieved to ensure uniform particle size and stored in airtight, moisture-proof containers to preserve bioactive potency and nutritional quality until dietary incorporation.

Vitamin C preparation

Vitamin C was obtained in pharmaceutical-grade powder form from a reputable and certified supplier, duly registered with relevant national regulatory agencies, including the National Agency for Food and Drug Administration and Control (NAFDAC) and the Standards Organisation of Nigeria (SON). The product label clearly stated its compliance with Good Manufacturing Practice (GMP) standards and bore a valid NAFDAC registration number.

The powdered supplement was pharmaceutical-grade L-ascorbic acid, specified to contain a minimum purity of 99%, and was packaged in tamper-proof, sealed containers with a clearly indicated batch number and expiry date to ensure authenticity and potency.

Before use, the product was visually inspected for colour, texture, and odor uniformity, and no signs of degradation, clumping, or discolouration were observed. Additionally, the potency of the vitamin C was verified by confirming that it was still within its stated shelf-life period and stored under manufacturer-recommended conditions; in a cool, dry place, away from direct sunlight and moisture, to maintain its biochemical stability throughout the experimental period.

Dietary treatment groups

Ginger was fixed at 10 g/kg diet in all treatment groups while vitamin C was graded: T_1 (negative control): 0 g/kg ginger + 0 mg/kg vitamin C; T_2: 10 g/kg ginger + 100 mg/kg vitamin C; T_3: 10 g/kg ginger + 200 mg/kg vitamin C; T_4: 10 g/kg ginger + 300 mg/kg vitamin C; and T_5: 10 g/kg ginger + 400 mg/kg vitamin C. All birds received their respective diets for 4 weeks.

Blood collection and antioxidant/pro-oxidant analyses

At the end of the study, 9 birds per treatment group (3 per replicate) were randomly selected and humanely slaughtered by severing the jugular vein. Blood was collected into labelled non-EDTA tubes for antioxidant and pro-oxidant analyses. GSH and GPx were determined by the method of Agergaard and Jensen (1982). CAT activity was determined by the method of Aebi (1984). SOD activity was measured by the method of Misra and Fridovich (1972). MDA concentration was determined by the thiobarbituric acid reactive substances (TBARS) method of Varshney and Kale (1990).

Statistical analyses

Data were subjected to one-way analysis of variance (ANOVA) using the general linear model (GLM) procedure of SAS (2012). Treatment means were separated using Tukey's honestly significant difference (HSD) test. The statistical model was: $Y_{ij} = \mu + X_i + E_{ij}$; where Y_{ij} = individual observation; μ = population mean; X_i = effect of the ith treatment (i = 1–5); E_{ij} = error term. Significance was declared at $p \leq 0.05$.

Table 1. Mean serum antioxidant values of broiler chickens fed ginger and vitamin C supplemented diet.

Parameter	Treatments					SEM
	T_1	T_2	T_3	T_4	T_5	
GSH (iu/mg)	1.76^d	2.12^c	3.06^a	2.33^b	2.29^b	0.06
GPx (iu/mg)	0.05^c	0.07^b	0.09^a	0.07^b	0.07^b	0.00
CAT (iu/mg)	2.70^d	3.07^c	3.94^a	3.51^b	2.80^d	0.04
SOD (iu/mg)	0.32^d	0.37^b	0.43^a	0.34^c	0.27^c	0.00

$^{a, b, c, d}$ Means with different superscripts within the same row are significantly (P < 0.05) different. GSH = glutathione; GPx = glutathione peroxidase; CAT = catalase; SOD = superoxide dismutase; SEM = standard error of the mean.

Table 2. Mean serum MDA values of broiler chickens fed ginger and vitamin C supplemented diet.

Parameter	Treatments					SEM
	T_1	T_2	T_3	T_4	T_5	
MDA (umol/L)	0.35^a	0.30^b	0.21^c	0.31^b	0.37^a	0.01

$^{a, b, c}$ Means with different superscripts within the same row are significantly (P < 0.05) different. MDA = malondialdehyde; SEM = standard error of the mean.

RESULTS

The effects of dietary ginger and vitamin C on serum antioxidant levels are presented in Table 1. Significant differences (P < 0.05) were observed among treatments for glutathione (GSH), glutathione peroxidase (GPx), catalase (CAT), and superoxide dismutase (SOD). Birds in T_2–T_5 recorded higher GSH concentrations compared with the control group (T_1), with T_3 showing the greatest increase (3.06 iu/mg). GPx activity was also enhanced in supplemented groups, with T_3 exhibiting the highest value (0.09 iu/mg). Similarly, CAT activity was significantly elevated in supplemented diets, with T_3 again recording the highest level (3.94 iu/mg), while T_1 and T_5 had the lowest values. SOD activity followed the same trend, with T_3 showing the highest activity (0.43 iu/mg), whereas T_1 and T_5 had significantly lower values. These results indicate that ginger and vitamin C supplementation improved antioxidant enzyme activities, with the combined treatment in T_3 being most effective.

The effects of dietary ginger and vitamin C on serum malondialdehyde (MDA) are presented in Table 2. Dietary treatments also significantly influenced serum MDA concentrations (p<0.05). Birds in T_1 (0.35 µmol/L) and T5 (0.37 µmol/L) had the highest MDA levels, indicating greater lipid peroxidation. In contrast, T_3 recorded the lowest MDA concentration (0.21 µmol/L), followed by T_2 and T_4. This reduction in MDA suggests that ginger and vitamin C supplementation, particularly in T_3, effectively mitigated oxidative stress in broiler chickens.

DISCUSSION

Ginger has long been recognised as both a culinary and medicinal herb. Its bioactive compounds, including *gingerol*, *shogaol*, and *gingerdione*, exert potent antioxidant activities by modulating the expression of antioxidant genes and enhancing the production of enzymatic antioxidants such as SOD, CAT, GPx, and GSH while reducing MDA and lipid peroxidation (Putri *et al.*, 2024). Dietary ginger has been identified as beneficial to broiler production performance and antioxidant status (Abubakar *et al.*, 2023). Al-Khalaifah *et al.* (2022) demonstrated that ginger inclusion significantly improved antioxidant indices in broiler sera and liver, and concurrently reduced MDA concentrations. Kairalla *et al.* (2022) also confirmed that dietary ginger powder improved antioxidant status and haematological parameters of broiler chickens.

Malondialdehyde is a widely used biomarker of lipid peroxidation and the degree of oxidative stress experienced by an animal. In the present study, dietary supplementation with ginger and vitamin C significantly improved antioxidant enzyme activities (GSH, GPx, CAT, and SOD) and reduced serum MDA. These findings are consistent with those of Al-Khalaifah *et al.* (2022) for ginger, and Van Hieu *et al.* (2022) for vitamin C supplementation in poultry. Vitamin C has been shown to decrease MDA while increasing SOD, GSH-Px, and total antioxidant capacity in broiler chickens (Van Hieu *et al.*, 2022). The reduction in serum MDA in T_2-T_4 supports the conclusion that combined dietary ginger and vitamin C mitigated lipid peroxidation and oxidative stress. Notably, T_5 (400 mg/kg vitamin C) produced MDA levels comparable to the negative control, suggesting a potential pro-oxidant effect at excessive dietary vitamin C concentrations, a phenomenon that warrants further investigation.

The reduction in MDA is further supported by Abubakar *et al.* (2023), who reported that oral ginger essential oil supplementation protected cardiac, hepatic, and splenic tissues against oxidative stress in broiler chickens. Dosu *et al.* (2023) demonstrated that ginger root extract enhanced antioxidant capacity and reduced lipid peroxidation in broilers. Similarly, Fatima (2026) confirmed that vitamin C at 500 mg/kg improved antioxidant ability in broilers by increasing SOD and CAT activities and reducing MDA levels, corroborating the antioxidant role of vitamin C observed in the present study.

Conclusion

Dietary supplementation with ginger and vitamin C improved antioxidant status and reduced oxidative stress in grower-finisher broiler chickens. The combination of 10 g/kg ginger and 200 mg/kg vitamin C is recommended as the optimal level, as it best enhanced antioxidant enzyme activities and minimised lipid peroxidation. The elevated MDA observed at 400 mg/kg vitamin C warrants further investigation into the dose-dependent effects of combined supplementation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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