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Haematological responses of grower-finisher broiler chickens to dietary ginger and graded levels of Vitamin C

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ABSTRACT: The haematological responses of broiler chickens to dietary ginger and vitamin C were investigated. The objective of this study was to evaluate the effects of dietary ginger in combination with graded levels of vitamin C on the haematological parameters of grower-finisher broiler chickens. One hundred and fifty (150) unsexed *Agrited* day-old chicks were used in the study. On arrival at the experimental site, chicks were brooded for 4 weeks. The experiment followed a completely randomised design (CRD), and after brooding, birds were randomly allotted to five dietary treatment groups. Each treatment group comprised 30 birds with three (3) replicates of 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; Treatment 2 (T_2) contained 10 g/kg ginger + 100 mg/kg vitamin C; Treatment 3 (T_3) contained 10 g/kg ginger + 200 mg/kg vitamin C; Treatment 4 (T_4) contained 10 g/kg ginger + 300 mg/kg vitamin C; and Treatment 5 (T_5) contained 10 g/kg ginger + 400 mg/kg vitamin C. Birds received their experimental diets for 4 weeks, after which blood was collected from 9 birds per treatment group (3 per replicate). Birds in the treatment groups (T_2–T_5) had significantly ($p<0.05$) higher packed cell volume (PCV) values than the control (T_1), with T_3 and T_4 demonstrating the highest values. Haemoglobin (Hb) and red blood cell (RBC) counts mirrored the PCV pattern. White blood cell (WBC) counts of T_3–T_5 were significantly ($P < 0.05$) higher than those of T_1 and T_2. Neutrophil percentages were significantly higher in T_1 birds than in the treatment groups, while lymphocyte proportions showed the opposite trend. The treatment groups also exhibited higher lymphocyte : neutrophil (LYM:NEU) ratios. Dietary ginger and vitamin C improved haematological parameters of broiler chickens, indicating enhanced health and welfare. Results are presented in tabular form (Tables 1 and 2). The combination of 10 g/kg ginger and 200 mg/kg vitamin C is recommended as the optimal level.

Keywords: Broiler chicken, Ginger, Haematology, Vitamin C.

INTRODUCTION

Phytogenic feed additives derived from plants play important roles in supporting animal health and performance by stimulating the immune system and exerting antimicrobial, anti-parasitic, antiviral, and antioxidant activities (Abdelli *et al.*, 2021). Through these mechanisms, phytogenic compounds have significant implications for the blood characteristics of animals, thereby improving their productivity (Rafeeq *et al.*, 2023). Phytogenic compounds also enhance the activity of lymphocytes, macrophages, and natural killer cells; stimulate phagocytosis; and promote interferon synthesis, collectively protecting livestock, including poultry, from infection (Abdelli et *al*., 2021).

Ginger (*Zingiber officinale* Roscoe) is a phytogenic plant whose bioactive compounds—*gingerdione*, *gingerdiol*, *gingerol*, and *shogaol*—activate digestive enzymes and reduce microbial activity (Seyedi and Toghyani, 2023). Ginger also exerts its effects through functional oils and phenolic compounds that are hepato-protective (Unigwe and Igwe, 2022). Through these mechanisms, ginger can improve haematological parameters and support efficient blood circulation and overall animal well-being.

Vitamin C is an essential micronutrient that functions as a cofactor in numerous metabolic processes, including those involved in circulatory and immune health (Shakeri *et al.*, 2020). Dietary Vitamin C supports the immune

system by promoting the production and function of white blood cells, which are critical in combating infections (Van Hieu *et al.*, 2022). Although the roles of ginger and vitamin C in immune function and antioxidant defence are individually well established, information on their synergistic relationship in relation to haematological parameters in broiler chickens is scarce. Therefore, the objective of this study was to investigate the effects of the dietary combination of ginger and graded levels of vitamin C on the haematological parameters 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 sourced from a reputable poultry dealer in Port Harcourt. On arrival, chicks were brooded for 4 weeks to acclimatise them to their environment. At the end of the brooding period, birds were randomly allotted to five dietary treatment groups according to a completely randomised design (CRD). Each group comprised 30 birds with three (3) replicates of ten (10) birds each. Pens, feeders, and drinkers were thoroughly 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 a further 4 weeks, giving a total experimental period of 8 weeks.

Ginger procurement and powder preparation

Fresh ginger rhizomes were sourced from the local market in their raw, unprocessed state. The ginger was carefully washed with clean water to remove dirt, debris, and microbial contaminants. After cleaning, the rhizomes were chopped into smaller, uniform pieces to facilitate even drying and prevent fungal growth.

The chopped ginger was subjected to sun drying, a traditional but effective method that helps retain its natural bioactive compounds. The drying process was continuously monitored until the rhizomes attained a crisp, low-moisture state suitable for mechanical grinding.

The dried ginger was then ground into fine powder using a petrol-powered mechanical grinding machine commonly used for agro-processing. The machine operates with high-speed rotary blades that efficiently pulverise the dried ginger into a uniform powder texture. Before grinding, the machine was thoroughly cleaned and sanitised to prevent cross-contamination from previously processed materials.

Operators wore protective clothing, including gloves and nose masks, to ensure hygiene and safety during the process. The grinding was carried out in a well-ventilated, dust-free environment, ensuring the quality and integrity of the final product.

The resulting ginger powder was sieved through a fine mesh to achieve uniform particle size and subsequently stored in airtight, moisture-proof containers to preserve its bioactive potency, aroma, and nutritional quality until incorporation into the experimental diets, following the procedure described by Kairalla *et al.* (2022) and Dosu *et al.* (2023).

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 odour uniformity, and no signs of degradation, clumping, or discolouration were observed. Additionally, the potency of the vitamin C (pharmaceutical-grade L-ascorbic acid; NAFDAC-registered; minimum purity 99%) 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 haematological 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 samples

Table 1. Mean values of PCV, Hb, and RBC of broiler chickens fed ginger- and vitamin C-supplemented diets

Parameter	Treatments					SEM
	T_1	T_2	T_3	T_4	T_5	
PCV (%)	32.11^{c}	36.22^{b}	39.44^{a}	38.22^{a}	36.33^{b}	0.64
Hb (g/dl)	9.97^{b}	10.89^{b}	12.56^{a}	12.33^{a}	11.78^{ab}	0.34
RBC (ul^{3})	4.38^{c}	4.76^{bc}	5.51^{a}	5.07^{ab}	4.67^{bc}	0.16

$^{a, b, c}$ Means with different superscripts within the same row are significantly ($p<0.05$) different. PCV = packed cell volume; Hb = haemoglobin; RBC = red blood cell; SEM = standard error of the mean.

Table 2. Mean values of WBC count and its differentials in broiler chickens fed ginger- and vitamin C-supplemented diets.

Parameter	Treatments					SEM
	T_1	T_2	T_3	T_4	T_5	
WBC (ul^{3})	9.40^{b}	10.03^{b}	11.80^{a}	11.43^{a}	11.16^{a}	0.23
NEU (%)	45.56^{a}	42.33^{ab}	39.56^{bc}	40.00^{b}	34.89^{c}	1.66
LYM (%)	46.00^{c}	50.33^{bc}	53.89^{ab}	52.22^{b}	57.56^{a}	1.56
EON (%)	3.33	2.22	2.44	2.56	2.78	0.42
MON (%)	5.11	5.11	4.11	5.22	4.78	0.64
BAS (%)	-	-	-	-	-	-

$^{a, b, c}$ Means with different superscripts within the same row are significantly ($p<0.05$) different. WBC = white blood cell; NEU = neutrophil; LYM = lymphocyte; EON = eosinophil; MON = monocyte; BAS = basophil; SEM = standard error of the mean.

were collected into labelled ethylenediaminetetraacetic acid (EDTA) tubes and analysed using an automated haematology analyser (BC-2300). All samples were properly labelled and immediately transported to the laboratory for analysis. The entire process adhered to the humane slaughter and animal care guidelines outlined by the Federation of Animal Science Societies (FASS, 1999).

Haematological parameters were analysed following standard procedures outlined by Jain (1986) and included: packed cell volume (PCV), haemoglobin (Hb), red blood cell count (RBC), white blood cell count (WBC), and its differentials—neutrophil (NEU), lymphocyte (LYM), eosinophil (EON), and monocyte (MON).

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 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 $P \leq 0.05$.

RESULTS

The effects of dietary supplementation with ginger and vitamin C on haematological parameters of broiler chickens are presented in Tables 1 and 2.

Packed cell volume (PCV), haemoglobin (Hb), and red blood cell (RBC)

Birds in the supplemented groups (T2–T5) recorded significantly higher ($p<0.05$) PCV values compared to the control (T1). The highest PCV values were observed in T3 (39.44%) and T4 (38.22%), while T1 had the lowest (32.11%). A similar trend was observed for haemoglobin concentration, where T3 (12.56 g/dl) and T_4 (12.33 g/dl) were significantly higher than the control (9.97 g/dl). RBC counts followed the same pattern, with T_3 (5.51 ul^{3}) showing the highest value, significantly greater than T1 (4.38 ul^{3}) (Table 1). These results indicate that ginger and vitamin C supplementation enhanced erythropoiesis and oxygen-carrying capacity in broiler chickens.

White blood cell (WBC) and its differentials

WBC counts were significantly ($p<0.05$) higher in birds fed supplemented diets (T3–T5) compared to the control (T1). The highest WBC count was recorded in T3 (11.80 ul^{3}), while T1 had the lowest (9.40 ul^{3}). Neutrophil percentages were significantly higher in the control group (T1) (45.56%) compared to the supplemented groups, with the lowest value observed in T5 (34.89%). Conversely, lymphocyte percentages increased significantly in the supplemented groups, with T5 recording the highest (57.56%) compared to T1 (46.00%). The treatment groups also exhibited higher LYM:NEU ratios than the control, suggesting improved immune competence. Eosinophil and monocyte

percentages showed no significant differences among treatments, while basophils were absent across all groups.

DISCUSSION

Haematological parameters are widely recognised as major indices for assessing the nutritional and health status of animals. Changes in blood constituents relative to a negative control can reflect the metabolic state of the animal and the quality of its diet (Unigwe and Igwe, 2022). Haematological parameters also provide valuable information on animal health, welfare, and the nutritional adequacy of the diet (Joshua *et al.*, 2022).

The present study evaluated the effects of dietary ginger and graded levels of vitamin C on haematological parameters of grower-finisher broiler chickens. Dietary supplementation produced beneficial effects on all blood parameters examined: PCV, Hb, RBC, WBC, and its differentials, particularly NEU and LYM. The observed significant increases in PCV, Hb, and RBC are indicative of improved erythropoiesis and oxygen-carrying capacity, suggesting enhanced health and welfare. These results support the use of dietary ginger and vitamin C as feed additives in broiler nutrition, as they appear to mitigate oxidative stress and inflammation while supporting healthy blood circulation—factors central to the prevention of blood disorders (Seyedi and Toghyani, 2023; Sun *et al.*, 2023).

White blood cells are fundamental to the immune and stress response of birds (Yasoob *et al.*, 2025). WBCs and their synergistic interactions are critical in stimulating immune responses (Abdelli *et al.*, 2021). The finding of increased WBC counts in this study is therefore indicative of enhanced immune function conferred by the dietary supplementation. This is consistent with the observation that ginger root extract enhances immunocompetence in broiler chickens (Dosu *et al.,* 2023). Furthermore, dietary ginger has been reported to improve growth performance, immunity, and gut health in broilers (Al-Khalaifah et al., 2022).

Vitamin C activates phagocytes and immune stimulants, and protects WBCs against oxidative damage, thereby reducing the risk of infection and immune disorders (Van Hieu *et al.*, 2022). Lohakare *et al.* (Shojadoost et al., 2021) demonstrated that vitamin C supplementation enhanced antibody-mediated immunity in broilers. Sun *et al.* (2023) also demonstrated that vitamin C improved the immune organ index and antioxidant status of broilers under stress. These findings corroborate the immunomodulatory role of vitamin C observed in the present study.

Conclusion

Dietary supplementation with ginger and vitamin C improved haematological parameters of grower-finisher broiler chickens, indicating enhanced health status and welfare. Ginger and vitamin C can therefore be recommended as feed additives for the poultry industry. The combination of 10 g/kg ginger and 200 mg/kg vitamin C is recommended as the optimal level, as it best supported all blood parameters studied. It is however, acknowledged that serum metabolic and biochemical parameters were not assessed in the present study; future investigations should incorporate serum biochemistry alongside haematology to provide a more comprehensive evaluation of the physiological effects of these dietary interventions.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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