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Effects of *Crinum glaucum* Bulb Extract on Growth Performance, Carcass and Organ Traits, Haemato-Biochemistry Parameters, and Oxidative Enzyme Markers in Broiler Chickens

Research Article

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ABSTRACT

This research investigated the effects of *Crinum* bulb extract as an alternative antibiotic on growth performance, carcass and organ traits, haemato-biochemistry, and oxidative enzyme markers in broiler chickens. A total of 240-day-old unsexed Ross 308 broiler chicks were randomly assigned to 5 treatment groups for a 56-day study. Each treatment group was replicated 4 times, with 12 birds per replicate. The treatment groups were as follows: the negative control group (NC) received just a basal diet + 0 mL of *Crinum* bulb extract per litre of drinking water; the positive control group (PC) received the basal diet + 1 g of antibiotics (erythromycin) per litre of drinking water; and the 5CB, 10CB, and 15CB groups received the basal diet + *Crinum* bulb extract at 5, 10, and 15 mL per litre of drinking water, respectively. The results indicated that *Crinum* bulb extracts significantly (P<0.05) improved body weight, body weight gain, feed intake, and feed conversion ratio during the finisher and overall periods, but no significant (P>0.05) differences were observed in the starter phase. During the starter phase, no significant effect on haematological parameters was observed. However, in the finisher phase, except for haemoglobin, packed cell volume, neutrophils, and lymphocytes, the haematological indices of the broiler birds were not affected. Compared with those in the NC group, broiler birds receiving PC and varying levels of *Crinum* bulb extract presented improved carcass characteristics. Except for the spleen weight, the organ weights improved significantly. *Crinum* bulb extract had no significant (P>0.05) effect on serum biochemical or oxidative enzyme markers during the starter or finisher phase. In conclusion, the extracts of *Crinum* bulbs improved growth performance and carcass and organ traits without negatively impacting the health status of broiler chickens. These findings indicate that *Crinum* bulb extract may be a feasible natural alternative for antibiotic growth promoters.

KEY WORDS blood profile, broilers, carcass, *Crinum* bulb, feed additives, plant extracts, performance.

INTRODUCTION

Over the years, antibiotics have been widely used in livestock and poultry farming to control infections and promote growth. However, concerns about antibiotic resistance have led to stringent global regulations, including a complete ban on the use of antibiotics in farm animal production as growth promoters in many countries since 2006 (Hassan *et al.* 2024). This global movement, initiated by the European Union (EU), aimed to address the growing public health threat of antimicrobial resistance (AMR), which has emerged as one of the most pressing global public health threats of the 21st century (Ahmed *et al.* 2024). Hence, several countries have adopted similar policies, urging the livestock industry to find alternatives to maintain animal health and productivity without relying on antibiotics as growth enhancers. Notably, while antibiotics help reduce morbidity and mortality by combating harmful pathogens, they can also contribute to the development of drug-resistant bacteria, which pose public health risks (Ahmed *et al.* 2024). As a result, the poultry industry has increasingly explored alternative bioactive compounds and natural supplements to maintain poultry health and productivity without relying on antibiotics (Chukwudi *et al.* 2024). These alternatives include probiotics (Ahmad *et al.* 2022), prebiotics (Al-Khalaifah, 2018), organic acids (Scicutella *et al.* 2021; Abbas *et al.* 2022), essential oils (Movahedi *et al.* 2024), and plant extracts as well as other phytogenic feed additives (Cristo *et al.* 2022; Mohamed and Hassan, 2023). These alternatives are believed to optimize growth performance, enhance immunity, and ensure food safety while preventing the emergence of antibiotic-resistant microflora.

The genus *Crinum* is a tender perennial bulbous medicinal plant with feathery green leaves and belongs to the family Amaryllidaceae. Across the world, it thrives in tropical and subtropical climates, especially in Africa, Asia, Australia, and America (Senbeta *et al.* 2019; Mahomoodally *et al.* 2021). Commonly known as poison bulb, *Crinum* lily, or spider lily, *Crinum* species are particularly rich in alkaloids, which exhibit a wide range of pharmacological properties, including antioxidant, antimicrobial, antiviral, antifungal, and anti-inflammatory activities (Senbeta *et al.* 2019). In addition to its medicinal properties, the *Crinum* plant is also valuable for its ornamental uses (Tan *et al.* 2019). In Africa, *Crinum* species have long been used for medicinal purposes because of their high safety profile, availability, and low cost. These properties indicate that *Crinum* can be used to improve poultry health status and growth performance. In addition, its bioactive properties make it a promising alternative to antibiotics, potentially promoting growth, reducing antibiotic residues in animal products, lowering environmental pollution, and supporting the production of safer, hazard-free animal products (Hassan *et al.* 2024). While plant-based feed additives have been extensively researched in poultry nutrition and recent studies have reported promising results, including oak acorn (Afiouni *et al.* 2023), *Eucalyptus globulus* (Ayoob *et al.* 2023), and *Froriepia subpinnata* (Rostampour *et al.* 2024), the application of *Crinum* bulb extract represents an innovative approach due to its diverse pharmacological properties. As of the time of this study, no prior research has evaluated *Crinum glaucum* bulbs as a potential alternative to antibiotics in poultry nutrition. Therefore, this research investigated the effects of *Crinum glaucum* bulb extract as an alternative to conventional antibiotics on growth performance, carcass and organ traits, haematological indices, the serum biochemical profile, and oxidative enzyme markers in broiler chickens.

MATERIALS AND METHODS

Preparation of *Crinum glaucum* bulb extract

The bulbs of *Crinum glaucum* were identified and authenticated by the Department of Plant Science and Biotechnology, Federal University Oye-Ekiti. They were sourced from the Ikole Local Government Area of Ekiti State, Nigeria. Fresh bulbs of *Crinum glaucum* harvested were thoroughly cleaned under fresh running water to remove dirt and contaminants. The cleaned bulbs were cut into smaller pieces and ground via a mechanical grinder to obtain homogeneous pulp. For liquid extraction, the pulp was soaked in distilled water at a ratio of 1:4 (1 part bulb pulp to 4 parts distilled water). The mixture was stirred intermittently and left at room temperature for 24 hours to allow the extraction of water-soluble compounds. The mixture was filtered through a fine mesh sieve to obtain a clear liquid extract. The filtrate was stored in airtight containers and refrigerated at 4 °C until use.

Experimental design, birds, and management

This research was conducted with the approval of the Animal Welfare and Ethics Committee of the Department of Animal Production and Health, Federal University Oye-Ekiti (approval number:APH/R-001/14/05/24), and adhered to the ethical guidelines for the use of animals in research. A total of 240-day-old unsexed Ross 308 broiler chickens were purchased from a reputable hatchery and used for this experiment. The birds were randomly assigned to 5 treatment groups for a 56-day study. Each treatment group was replicated 4 times, with 12 birds per replicate (n = 48 birds per treatment). The treatment groups were as follows: the negative control group (NC) received just a basal diet + 0 ml of *Crinum* bulb extract per litre of drinking water; the positive control group (PC) received the basal diet + 0.1 g of antibiotics (erythromycin) per litre of drinking water; and the 5CB, 10CB, and 15CB groups received the basal diet + *Crinum* bulb extract at 5, 10, and 15 ml per litre of drinking water, respectively. The birds were subjected to the same housing and conditions, with experimental pens measuring 1.3 m × 1.2 m and furnished with dry wood shavings as bedding material. During the first week, the room was equipped with heating facilities to maintain the temperature at 33 ± 1 °C, which was gradually reduced every other week until 24 ± 1 °C was reached. The humidity was maintained between 60–70% during the first week and 50–60% subsequently. During the experiment, strict biosecurity measures were taken, and the birds were vaccinated against Newcastle disease on the 7th and 21st days of age and against Gumboro disease on the 14th and 28th days of age. Fresh feed and water were provided *ad libitum* throughout the experimental period. Lighting was provided for 8 hours at night for feeding using an automated 400 W solar-LED floodlight. The ingredients and nutrient compositions of the basal diets fed during the starter (1–28 d) and finisher (29-56 d) phases are presented in Table 1 and were formulated to meet the nutrient requirements for broiler chickens specified by the NRC (1994).

Growth performance

The birds were weighed on the first day of arrival to determine the initial body weight and then weighed weekly throughout the remaining experimental period to obtain the body weight gain (BWG). The feed intake (FI) of each replicate was estimated as the difference between the amount of feed given and the residue remaining. The feed conversion ratio (FCR) was calculated by dividing the FI by the BWG of the birds.

Carcass and organ evaluation

At the end of the experiment, 3 birds from each replicate (n=12 birds per treatment) were randomly selected and fasted overnight for carcass and organ evaluation. Each bird was weighed to determine the live weight immediately before severing the jugular vein and then allowed to bleed for about 3 minutes. After bleeding, the broiler chickens were scalded in hot water at 60 ± 5 °C for approximately 30 s to facilitate feather removal. Immediately after the feathers were removed completely, each broiler bird was weighed to obtain the defeather weight before the evisceration of internal organs, head, and feet. After evisceration, the carcasses were weighed to obtain the carcass weight. Carcass cuts and internal organs, including the breast, wing, head, neck, drumstick, thigh, back, shank, liver, spleen, heart, gizzard, kidney, and intestine weights were measured using a sensitive digital scale.

Blood collection and analysis

On the 28th and 56th days of the experiment before blood sample collection, the feed was removed from all the birds for a period of 6 h in an attempt to stabilize the blood constituents. Three broiler birds with body weights (BW) close to the mean were selected from each replicate (n=12 birds per treatment) for blood sampling, and approximately 5 mL blood samples were collected from the wing vein using a disposable syringe and needle into tubes containing ethylene diamine tetra acetic acid (EDTA) as an anticoagulant for haematological analysis and tubes without anticoagulant for serum and oxidative markers analysis. Haematological indices, including white blood cell (WBC) counts, red blood cell (RBC) counts, haemoglobin (Hb) concentration, packed cell volume (PCV), and differential counts (neutrophils, monocytes, lymphocytes, eosinophils, and basophils), were measured on the day of collection via a Mindray BC-2800 auto-haematology analyser. For serum biochemistry analysis, blood samples were kept at room temperature for 45 minutes to allow clotting and then centrifuged at 4000 rpm for 15 minutes to obtain clear supernatant serum. The clear serum samples were stored at –20 °C until further analysis. Serum samples were analysed for total protein, globulin, albumin, total cholesterol, triglyceride, high-density lipoprotein (HDL), low-density lipoprotein (LDL), aspartate aminotransferase (AST), alanine transaminase (ALT), and total bilirubin levels via a BS-3000M semi-automatic chemistry analyser. The levels of the oxidative markers, including catalase (CAT), superoxide dismutase (SOD), glutathione (GSH), and malondialdehyde (MDA) were analysed via a commercially available test kit (Randox Laboratories Ltd., UK).

Statistical analysis

All the data were analysed using a one-way analysis of variance (ANOVA) with the PROC GLM procedure in SAS software (SAS, 2013). The normality of the data distribution was evaluated using the Kolmogorov–Smirnov test. Treatment means showing significant differences were compared using Tukey's HSD test (honestly significant difference), with significance accepted at $P < 0.05$.

RESULTS AND DISCUSSION

The results on the growth performance of broiler birds administered varying doses of *Crinum* bulb extract are presented in Table 2. *Crinum* bulb extracts significantly ($P<0.05$) improved BW, BWG, FI, and FCR in the finisher and overall periods, but no significant ($P>0.05$) differences were observed in the starter phase for BW, BWG, FI, or FCR. Compared with those in the other treatment groups, broiler birds in the treatment group receiving 5 ml of *Crinum* bulb extract (5CB) had the highest ($P<0.05$) BW and BWG in both the finisher and overall phases. The FCR was significantly better in broiler birds that received 5CB and 10CB. However, the highest ($p < 0.05$) value for FCR was observed in the NC group.

As shown in Table 3, the haematological indices of the broiler birds treated with various doses of *Crinum* bulb extract did not significantly differ ($P<0.05$) in any of the parameters measured during the starter phase. During the finisher phase, Hb, PCV, neutrophils, and lymphocytes only showed significant effects. RBC, WBC, monocytes, eosinophils, and basophils counts were not significantly ($P<0.05$) affected in the treatment groups.

Table 1 Ingredients and nutrient composition of the experimental basal diets

Ingredients (kg)	Starter (1–28 d)	Finisher (29–56 d)
Maize	45.00	60.00
Wheat offal	13.30	3.25
Soybean meal	35.00	31.00
Fish meal	3.00	2.00
Limestone	1.00	1.00
Bone meal	2.00	2.00
Salt	0.25	0.25
Vitamin-mineral premix[1]	0.25	2.50
Methionine	0.20	0.20
Total	100	100
Nutrient composition (%)		
Crude protein	23.00	20.00
Ether extract	3.70	3.74
Crude fibre	4.68	3.94
Calcium	1.24	1.15
Phosphorus	0.79	0.73
Lysine	1.27	1.08
Methionine	0.57	0.54
Cystine	0.37	0.32
Metabolizable energy (kcal/kg)	2925.91	3150.31

[1] Vitamin-mineral premix (per 2.5 kg) contains: antioxidant: 1250 mg; Biotin: 750 mg; Chlorine chloride: 175000 mg; Cobalt: 200 mg; Copper: 3000 mg; Folic acid: 500 mg; Iodine: 1000 mg; Iron: 20000 mg; Manganese: 40000 mg; Niacin: 20000 mg; Pantothenic acid: 5000 mg; Selenium: 200 mg; vitamin A: 8500000 IU; vitamin B1: 1600 mg; vitamin B_{12}: 10 mg; vitamin B_2: 4000 mg; vitamin B_6: 1500 mg; vitamin D_3: 150000 IU; vitamin E: 10000 mg; vitamin K_3: 1500 mg and zinc: 30000 mg.

Table 2 Growth performance of broiler birds administered varying doses of *Crinum* bulb extract

Parameters	Treatments					SEM	P-value
	NC	PC	5CB	10CB	15CB		
Initial body weight (g)	40.06	39.60	39.41	39.19	39.38	0.07	0.192
Starter phase							
Body weight (g)	1163.48	1187.33	1171.59	1148.49	1155.71	5.83	0.378
Body weight gain (g)	1123.42	1147.73	1132.18	1109.30	1116.33	2.45	0.672
Feed intake (g)	1721.31	1688.98	1710.10	1693.87	1680.22	4.34	0.529
Feed conversion ratio	1.53	1.47	1.51	1.53	1.51	0.02	0.071
Finisher phase							
Body weight (g)	2741.70^{c}	2860.71^{bc}	3082.56^{a}	2939.88^{ab}	2979.34^{ab}	20.13	0.000
Body weight gain (g)	1578.22^{c}	1673.38^{bc}	1910.97^{a}	1791.39^{ab}	1823.63^{ab}	12.77	0.000
Feed intake (g)	4.009.09^{c}	4069.12^{b}	4145.05^{a}	4164.33^{a}	4178.43^{a}	11.57	0.000
Feed conversion ratio	2.54^{a}	2.43^{ab}	2.17^{b}	2.32^{ab}	2.29^{b}	0.09	0.001
Overall phase							
Body weight (g)	2741.70^{c}	2860.71^{bc}	3082.56^{a}	2939.88^{ab}	2979.34^{ab}	20.13	0.000
Body weight gain (g)	2701.64^{c}	2821.11^{bc}	3043.15^{a}	2900.69^{ab}	2939.96^{ab}	18.16	0.000
Feed intake (g)	5730.40^{c}	5758.10^{b}	5855.15^{a}	5858.20^{a}	5853.65^{a}	12.89	0.000
Feed conversion ratio	2.12^{a}	2.04^{ab}	1.92^{b}	2.02^{ab}	1.99^{b}	0.03	0.001

NC: negative control; PC: positive control group fed antibiotics; 5CB: 5 mL *Crinum* bulb extract per litre of water; 10CB: 10 mL *Crinum* bulb extract per litre of water and 15CB: 15 mL *Crinum* bulb extract per litre of water.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Broiler birds in the PC and treatment groups receiving *Crinum* bulb extract presented higher PCV values than those in the NC group did. However, broiler birds in the PC group showed significantly (P<0.05) higher Hb levels than those in the other treatment groups. Notably, higher neutrophils were observed in the broiler birds in the 5CB and 10CB treatment groups, whereas the lowest (P<0.05) value was recorded in the broiler birds in the 15CB treatment group. However, compared with the other treatment groups, the 15CB treatment group presented the highest value of monocytes.

Table 4 shows the results of the carcass characteristics of broiler birds administered varying doses of *Crinum* bulb extract.

The results revealed that *Crinum* bulb extract significantly (P<0.05) affected all the parameters measured in this study.

Table 3 Haematological indices of broiler birds administered varying doses of *Crinum* bulb extract

Parameters	Treatments					SEM	P-value
	NC	PC	5CB	10CB	15CB		
Starter phase (d 28)							
Haemoglobin (g/dL)	8.50	8.87	8.63	8.19	8.43	0.02	0.201
Packed cell volume (%)	29.34	30.89	30.67	29.76	30.07	0.38	0.121
Red blood cell ($x10^3$/uL)	398.00	407.34	400.22	410.33	403.47	3.80	0.120
White blood cell ($x10^3$/uL)	21.30	20.13	21.90	23.00	22.30	1.20	0.187
Neutrophils (%)	62.67	63.33	61.00	60.00	60.00	2.00	0.526
Monocytes (%)	5.63	5.00	5.67	6.00	5.00	0.09	0.161
Lymphocytes (%)	30.49	31.38	31.00	30.33	33.00	1.03	0.329
Eosinophils (%)	2.28	2.03	2.43	2.00	2.00	0.21	0.215
Basophils (%)	0.33	0.37	0.00	0.00	0.00	0.01	0.424
Finisher phase (d 56)							
Haemoglobin (g/dL)	7.90^b	9.87^a	8.05^b	8.70^b	7.90^b	0.22	0.001
Packed cell volume (%)	28.67^b	30.00^a	30.00^a	30.00^a	32.00^a	0.97	0.000
Red blood cell ($x10^3$/uL)	411.00	410.67	417.50	420.00	413.00	5.20	0.120
White blood cell ($x10^3$/uL)	24.93	23.60	27.90	26.00	26.30	1.98	0.187
Neutrophils (%)	66.67^{ab}	59.33^{ab}	69.00^a	69.00^a	57.00^b	2.32	0.026
Monocytes (%)	9.33	8.00	7.80	8.67	8.33	0.42	0.161
Lymphocytes (%)	35.00^{ab}	35.67^{ab}	37.00^b	37.00^b	42.00^a	2.23	0.029
Eosinophils (%)	3.00	3.33	3.00	3.67	3.10	0.34	0.215
Basophils (%)	0.33	0.67	0.00	1.00	0.00	0.19	0.424

NC: negative control; PC: positive control group fed antibiotics; 5CB: 5 mL *Crinum* bulb extract per litre of water; 10CB: 10 mL *Crinum* bulb extract per litre of water and 15CB: 15 mL *Crinum* bulb extract per litre of water.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 4 Carcass characteristics of broiler birds administered varying doses of *Crinum* bulb extract

Parameters (g)	Treatments					SEM	P-value
	NC	PC	5CB	10CB	15CB		
Live weight	2504.33^b	2784.67^a	2860.67^a	2790.33^a	2755.33^a	43.39	0.000
Defeather weight	2369.34^c	2446.65^{ab}	2484.30^{ab}	2553.17^b	2669.99^a	38.20	0.000
Carcass weight	1715.67^c	1919.02^b	1950.01^b	1960.49^b	2081.05^a	42.14	0.000
Head	48.69^b	53.19^a	53.66^a	52.19^a	52.42^a	0.71	0.013
Neck	81.11^d	86.78^{cd}	88.74^c	102.79^a	95.75^b	2.07	0.000
Breast	664.28^b	840.85^a	751.44^{ab}	792.93^{ab}	852.65^a	23.26	0.034
Wing	182.00^c	187.00^b	185.00^{ab}	188.00^b	198.00^a	1.20	0.001
Back	192.68^b	290.68^{ab}	349.17^a	350.41^a	391.58^a	23.37	0.031
Drumstick	194.05^b	244.75^a	221.17^{ab}	219.64^{ab}	239.49^a	5.60	0.007
Thigh	253.74^b	291.06^a	310.33^a	291.93^a	302.53^a	8.92	0.340

NC: negative control; PC: positive control group fed antibiotics; 5CB: 5 mL *Crinum* bulb extract per litre of water; 10CB: 10 mL *Crinum* bulb extract per litre of water and 15CB: 15 mL *Crinum* bulb extract per litre of water.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Compared with those in the NC group, the live weight and head weight of the broiler birds in the PC group and the birds in the treatment groups that received *Crinum* bulb extract were significantly greater (P<0.05). Compared with those in the other treatment groups, broiler birds in the 15CB group presented greater (P<0.05) defeather weights, carcass weights, and wing weights. Broiler birds receiving 10CB recorded the highest neck weight, whereas those in the 15CB group and the PC group presented the highest breast weight. Compared with those in the NC group, the back, drumstick, and thigh weights of the broiler birds in the PC, 5CB, 10CB, and 15CB treatment groups were significantly greater (P<0.05).

The birds in the NC group presented the lowest values for all the parameters measured.

It was observed that all parameters were significantly (P<0.05) affected except for spleen weight (Table 5). Broiler birds in the NC group had the lowest heart and kidney weight compared to the other treatment group. Liver and lung weight were significantly (P<0.05) higher in the 15CB treatment group, while broiler birds in the NC group recorded the lowest value. Broiler birds in the PC group and the treatment groups receiving *Crinum* bulb extract were observed to have the highest (P<0.05) intestine weight compared to the NC group. The NC group recorded the lowest (P<0.05) value for gizzard weight, while the 5CB treatment group recorded a significantly (P<0.05) higher value for shank weight compared to other treatment groups.

The results of the serum biochemical profile and the oxidative enzyme markers of broiler birds administered varying doses of *Crinum* bulb extract are presented in Table 6 and Table 7, respectively. During the starter and finisher phases, the results indicated that *Crinum* bulb extract had no significant (P>0.05) effect on the total protein, albumin, globulin, total cholesterol, triglyceride, HDL, LDL, AST, ALT, total bilirubin, SOD, CAT, GSH, or MDA values.

Antibiotic feed additives have long been used as growth-promoting supplements to increase performance and yield in poultry production (Naderiboroojerdi *et al.* 2022). However, the routine use of antibiotics in the diet of broilers is now considered to increase the antimicrobial resistance of human and animal bacteria (Kothari *et al.* 2020). Hence, various non-antibiotic alternatives, such as phytogenic feed additives, have been explored. Phytogenic feed additives have received increased attention as possible growth performance enhancers for animals in the last decade (Hassan *et al.* 2024). According to Ijoma *et al.* (2024), the use of phytogenic feed additives for poultry birds is a highly effective method of promoting growth in poultry and providing antioxidant, immunomodulatory, and antimicrobial properties.

The results of this experiment revealed that *Crinum* bulb extracts significantly improved BW, BWG, FI, and FCR in broiler chickens compared with both the NC and PC groups. These findings align with those of Al-khalaifah *et al.* (2020), who reported similar enhancements in broiler growth performance with Egyptian leek leaf extract supplementation at 0.5%, 0.10%, 0.15%, and 0.20% in the broiler chicken diet. The beneficial effects in their study were attributed to sulphur-containing compounds in the leaves, which act as potent antimicrobial agents (Abo Ghanima *et al.* 2023). Similarly, El-Khabery *et al.* (2016) reported improved FBW, BWG, FI, and FCR in broilers fed diets containing Egyptian leek leaf powder (*Allium porrum* L.), further supporting the role of bioactive plant-derived compounds in promoting growth performance. In this study, the observed improvements in growth performance may be attributed to multiple biochemical and physiological mechanisms. The increased nutrient absorption and digestibility, which likely contributed to increased performance, could be linked to the bioactive compounds present in *Crinum glaucum* bulbs, such as alkaloids (lycorine and glaucine), flavonoids, and saponins (Senbeta *et al.* 2019). These compounds are known for their anti-inflammatory, antioxidant, and antimicrobial properties, which collectively improve gut health by reducing oxidative stress, decreasing the proliferation of pathogenic bacteria, and enhancing beneficial microbial populations in the gastrointestinal tract. Improved gut health likely increases the absorptive surface area, optimizing nutrient uptake and energy utilization. This finding is consistent with the findings of Omar *et al.* (2020), who highlighted the role of plant-based bioactive compounds in metabolic stimulation and enzymatic activity. Contrasting studies, such as that of Lee *et al.* (2022), who reported no impact of fermented and non-fermented Chinese chives on the overall productive performance of broilers, suggest that the effectiveness of phytogenic additives depends on factors such as the plant species, dosage, route of administration, and environmental factors. Similarly, Vasilopoulos *et al.* (2022) reported that dietary supplementation with pomegranate and onion aqueous and cyclodextrin-encapsulated extracts in broiler diets did not significantly improve growth parameters, likely because of differences in the bioactive compound profiles and their interactions with the gastrointestinal system. Interestingly, Hassan *et al.* (2024) demonstrated that thyme, ginger, and their nanoparticles significantly improved broiler growth performance, comparable to antibiotic supplementation, but did not affect feed intake. These findings suggest that nanotechnology-based delivery systems may enhance the bioavailability of bioactive compounds, which is a potential avenue for future research with *Crinum glaucum*. Furthermore, the aqueous garlic extract at concentrations of 1% and 2% markedly improved broiler BW compared with the negative and positive ciprofloxacin controls. In particular, the 1% supplementation level resulted in the greatest weight gain and FCR, further highlighting the dose-dependent nature of plant-derived additives (Noman *et al.* 2016).

According to Thema *et al.* (2024), “generally, a blood assay is necessary to examine the pathophysiological and nutritional state of birds.” Furthermore, Ijoma *et al.* (2024) noted that blood indices are valuable indicators for assessing the pathological, physiological, and nutritional status of animals because they reflect various metabolic changes in organs and tissues. The results of this study indicated that varying inclusion levels of *Crinum* bulb extracts in the drinking water of broiler chickens significantly affected only Hb, PCV, neutrophils, and lymphocytes during the finishing phase.

There were no significant effects on RBC, WBC, monocytes, eosinophils, or basophils. In this study, the significant increase in Hb observed in the PC group compared with the groups that received *Crinum* bulb extract and the NC group suggested that while the extract had some effects on blood health, it did not fully increase Hb to the same extent as the PC group did.

Table 5 Organ characteristics of broiler birds administered varying doses of *Crinum* bulb extract

Parameters (g)	Treatments					SEM	P-value
	NC	PC	5CB	10CB	15CB		
Heart	9.46[b]	12.67[a]	11.99[a]	12.12[a]	13.71[a]	0.40	0.000
Kidney	9.66[b]	16.69[a]	13.71[ab]	14.71[a]	15.37[a]	0.73	0.004
Liver	38.85[c]	52.73[b]	52.73[b]	50.35[b]	59.46[a]	1.82	0.000
Lung	12.53[b]	14.32[a]	13.09[ab]	13.69[ab]	14.89[a]	0.27	0.000
Spleen	2.17	2.40	2.35	2.58	2.52	0.07	0.399
Intestine	107.79[b]	156.51[a]	164.70[a]	167.52[a]	162.30[a]	5.76	0.000
Gizzard	74.89[c]	90.32[b]	93.18[a]	91.20[ab]	91.93[ab]	1.82	0.000
Shank	76.60[b]	76.93[b]	82.67[a]	80.24[ab]	79.43[ab]	0.64	0.001

NC: negative control; PC: positive control group fed antibiotics; 5CB: 5 mL *Crinum* bulb extract per litre of water; 10CB: 10 mL *Crinum* bulb extract per litre of water and 15CB: 15 mL *Crinum* bulb extract per litre of water.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 6 Serum biochemical profile of broiler birds administered varying doses of *Crinum* bulb extract

Parameters	Treatments					SEM	P-value
	NC	PC	5CB	10CB	15CB		
Starter (d 28)							
Total protein (g/dL)	5.88	6.21	5.67	5.91	6.27	2.89	0.728
Albumin (g/dL)	2.78	3.12	2.49	2.65	3.03	1.47	0.129
Globulin (g/dL)	3.10	3.08	3.18	3.26	3.24	0.95	0.233
Total cholesterol (mg/dL)	92.17	93.33	90.00	89.57	87.53	3.78	0.671
Triglyceride (mg/dL)	41.00	39.13	39.63	40.60	41.67	2.21	0.975
High-density lipoprotein (mg/dL)	59.67	63.11	60.00	62.33	63.40	0.18	0.430
Low-density lipoprotein (mg/dL)	75.29	77.62	73.22	71.66	73.89	1.17	0.417
Aspartate aminotransferase (IU/L)	237.44	241.59	235.90	239.71	237.89	12.55	0.810
Alanine transaminase (IU/L)	107.57	103.19	105.67	103.88	100.67	13.04	0.139
Total bilirubin (µmol/L)	5.11	4.87	5.33	5.00	5.89	0.73	0.258
Finisher (d 56)							
Total protein (g/dL)	4.60	4.37	4.95	5.40	5.57	2.19	0.209
Albumin (g/dL)	2.37	2.00	2.58	2.79	2.88	0.72	0.413
Globulin (g/dL)	2.23	2.37	2.37	2.61	2.69	0.25	0.195
Total cholesterol (mg/dL)	99.87	102.87	96.67	100.57	97.53	0.16	0.141
Triglyceride (mg/dL)	47.10	41.17	47.77	41.10	43.30	3.06	0.794
High-density lipoprotein (mg/dL)	61.33	61.30	61.63	61.40	61.88	0.05	0.057
Low-density lipoprotein (mg/dL)	73.10	71.17	67.50	69.73	71.60	0.14	0.302
Aspartate aminotransferase (IU/L)	220.30	212.90	216.83	213.97	217.60	8.16	0.563
Alanine transaminase (IU/L)	91.57	96.30	92.93	93.10	96.20	5.42	0.765
Total bilirubin (µmol/L)	5.80	6.30	5.70	5.63	4.20	0.34	0.067

NC: negative control; PC: positive control group fed antibiotics; 5CB: 5 mL *Crinum* bulb extract per litre of water; 10CB: 10 mL *Crinum* bulb extract per litre of water and 15CB: 15 mL *Crinum* bulb extract per litre of water.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 7 Oxidative enzyme markers of broiler birds administered varying doses of *Crinum* bulb extract

Parameters	Treatments[1]					SEM	P-value
	NC	PC	5CB	10CB	15CB		
Starter (d 28)							
Superoxide dismutase (µmol/mL)	18.17	19.33	20.65	20.47	19.87	0.34	0.523
Catalase (µmol/mL)	4.56	4.30	4.22	4.00	5.07	0.10	0.362
Glutathione (µmol/mL)	5.45	4.80	4.00	4.97	4.33	1.10	0.079
Malondialdehyde (nmol/mL)	4.37	3.89	3.44	3.79	3.98	0.37	0.082
Finisher (d 56)							
Superoxide dismutase (µmol/mL)	29.42	28.93	27.33	28.89	28.67	0.11	0.207
Catalase (µmol/mL)	4.38	4.33	4.38	4.13	4.25	0.94	0.651
Glutathione (µmol/mL)	5.20	5.27	5.20	5.26	5.24	0.02	0.491
Malondialdehyde (nmol/mL)	4.11	4.67	4.71	4.33	4.30	0.01	0.473

NC: negative control; PC: positive control group fed antibiotics; 5CB: 5 mL *Crinum* bulb extract per litre of water; 10CB: 10 mL *Crinum* bulb extract per litre of water and 15CB: 15 mL *Crinum* bulb extract per litre of water.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

This may indicate that the bioactive compounds in *Crinum* bulb extract, such as alkaloids and flavonoids, support erythropoiesis but are not as potent as antibiotics in promoting oxygen-carrying capacity. It is noteworthy that Hb, a critical indicator of oxygen transport capacity, reflects the overall health and physiological state of broiler chickens (Thema *et al*. 2024). This result is contrary to the reports of Islam *et al*. (2020) and Abo Ghanima *et al*. (2023). As shown in Table 5, broiler birds in the PC group and the group that received *Crinum* bulb extract had significantly higher PCV compared to the NC group. This finding is consistent with the report of Kairalla *et al*. (2022), who noted an increase in PCV in broiler chickens supplemented with 0.1%, 0.2%, or 0.3% dietary garlic powder. The increased PCV values observed in this study could be attributed to the positive effects of lycorine, the bioactive substance found in the *Crinum* bulb (Mahomoodally *et al*. 2021). PCV is crucial in the transport of oxygen and absorbed nutrients, with increased PCV indicating better transportation, which in turn helps prevent anaemia (Olumide and Odunowo, 2019). Despite not being significantly affected in this study, RBC facilitates the delivery of oxygen to animal tissues for oxidation, which releases energy. They also release carbon dioxide away from tissues while synthesising haemoglobin (Onunkwo *et al*. 2022). Furthermore, WBC, which is a critical marker of immune status, defends the body against invasion by foreign organisms and supplies antibodies for immune response (Onunkwo *et al*. 2022). The similarity of these parameters indicates good physiological and pathological status of the broiler birds (Ijoma *et al*. 2024). Egenuka *et al*. (2023) reported that 0.5% sundried ginger and 0.5% fresh ginger did not significantly affect the haematological parameters of 8-week-old broiler chickens. In addition, Islam *et al*. (2020) reported that supplemental aloe vera gel and amla fruit extract in the drinking water of broiler chickens had no significant effect on blood profiles (WBC, RBC, PCV and Hb). However, in this study, neutrophils were significantly elevated in the treatment groups receiving 5 ml and 10 ml of *Crinum* bulb extract, whereas a significant decrease was observed in the group receiving a higher dosage (15 mL) of *Crinum* bulb extract. Higher neutrophil counts are indicative of an enhanced innate immune response, likely triggered by the anti-inflammatory and antimicrobial properties of *Crinum* bulb extract. This is particularly notable, as neutrophils are a type of WBC that has crucial functions in the first immune response to infections, implying that *Crinum* bulb extract could increase bird resilience to pathogenic challenges. A higher percentage of neutrophils indicates an enhanced initial response to infections, which may benefit bird health. Conversely, a lower percentage implies a reduced initial immune response, potentially increasing the susceptibility of the birds to infections. However, the values in this study are within standard ranges (Alonge *et al*. 2017). The significantly higher lymphocyte counts in the treatment group receiving the highest dose of *Crinum* bulb extract observed in this study may indicate a heightened adaptive immune response, which could be attributed to the immune-modulating effects of the *Crinum* bulb extract phytochemicals. However, the inverse relationship between neutrophil and lymphocyte levels across different doses suggests a complex immunomodulatory mechanism, which warrants further investigation. The non-significant changes in monocytes, eosinophils, and basophils across the groups indicate that these cell types were not markedly affected by the administration of *Crinum* bulb extract, possibly due to the specific immune pathways through which the *Crinum* bulb extract exerts its effects.

In this study, the experimental treatments significantly improved the carcass and internal organ characteristics but not the spleen weight. The results of this study are inconsistent with the report of Ijoma *et al*. (2024), who reported that dietary supplementation of West African black pepper and turmeric in a broiler chicken diet did not significantly increase carcass or organ traits. In a previous study, broiler chickens fed ginger-based diets did not significantly improve carcass or internal organ weight (Egenuka *et al*. 2023). The improved carcass and organ traits found in this study could be attributed to the improved BWG and FCR observed in this study. Additionally, the presence of bioactive compounds in *Crinum* bulb extract, known for their antioxidant, anti-inflammatory, and antimicrobial properties, may have contributed to the improved organ characteristics observed in this study. These compounds stimulate cell proliferation in these organs, thereby improving the condition of the broiler bird's immune system. The results of this study also disagree with reports from Kairalla *et al*. (2022), Naderiboroojerdi *et al*. (2022), and Odukoya *et al*. (2023). The inconsistency could result from the type of phytogenic feed additive used, the mode of administration, inclusion levels, strain of birds, and environmental factors.

In this study, *Crinum glaucum* bulb extract did not affect the serum biochemical or oxidative enzyme markers of broiler chickens. This finding is in accordance with the findings of Qorbanpour *et al*. (2018), who reported that dietary ginger (*Zingiber officinale* Roscoe) did not affect the serum biochemical parameters of broilers at 42 days of age. Kairalla *et al*. (2022) reported that diets supplemented with graded levels of garlic (*Allium sativum* L.) powder reduced LDL, total cholesterol, and triglycerides while increasing HDL levels in broilers. El-Khabery *et al*. (2016) detected no differences in total protein, albumin, globulin, ALT, AST, creatinine or urea among boilers fed leek leaves powder. However, they reported a decrease in total cholesterol, triglyceride, and LDL levels compared with those in the control group. It was observed that broilers fed diets containing West African black pepper and turmeric powder improved oxidative stress markers (Ijoma *et al*. 2024). The inconsistency of results may be due to the type of phytogenic feed additive, the phytochemical constituent of the feed additive, or the mode of action of the phytogenic feed additive. In this study, the non-significant effects on serum biochemical parameters across treatment groups may suggest that the bioactive compounds in *Crinum glaucum* bulbs, such as lycorine and glaucine, exert minimal or no influence on hepatic and renal function indicators at the tested inclusion levels. Furthermore, the non-significant changes in oxidative enzyme markers indicate that *Crinum glaucum* bulb extract neither induced oxidative stress nor enhanced antioxidant activity under normal physiological conditions. The non-significant results observed could also be attributed to the type and concentration of bioactive compounds in the *Crinum glaucum* bulb extract. Unlike additives with strong antioxidant or lipid-lowering effects, the mode of action of *Crinum glaucum* might focus more on antimicrobial or gut health benefits rather than systemic biochemical alterations. The inconsistencies in the reported effects of various phytogenic feed additives are often influenced by factors such as the plant source, phytochemical composition, dosage, method of administration, and interactions with other dietary components.

CONCLUSION

The findings of this study demonstrated that *Crinum* bulb extracts enhanced broiler chickens' growth performance and carcass and organ traits without negatively impacting their health status. These findings indicate that *Crinum* bulb extract may be a feasible natural alternative for antibiotic growth promoters. Future research should focus on investigating the effects of *Crinum* bulb extract on the immunological response, gut health, and microbial populations in the gastrointestinal system, especially in comparison with those of conventional antibiotics. Additionally, further research could explore the efficacy of *Crinum* bulb extract in broiler chickens under various environmental and management conditions to comprehensively assess its potential as a natural alternative to antibiotics in poultry nutrition.

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