



Comparative Effects of Sodium Bicarbonate, Vitamin C and Oregano on Growth Performance and Heat Stress Responses of Finisher Broilers Raised During the Hot Season of Semi-arid Environment

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Abstract: Background: Heat stress represents a significant environmental constraint to broiler chicken productivity, physiological homeostasis, and welfare, particularly in tropical regions. This study investigated the effects of selected dietary anti-stress supplements on the growth performance and physiological responses of finisher broiler chickens raised under hot environmental conditions in Sokoto, Nigeria. Methods: A total of 192 Ross 308 broiler chickens were randomly allotted to four dietary treatments in a Completely Randomized Design, with three replicates of 16 birds each. The treatment 1 served as control diet without supplementation, while treatments 2, 3, and 4 were supplemented with sodium bicarbonate, vitamin C, and oregano, at 150g/100kg 100g/100kg and 200g/100kg of feeds respectively. Growth performance, mortality, rectal temperature, and respiratory rate were evaluated. Results: Dietary supplementation had no significant effect ($p > 0.05$) on growth performance parameters and rectal temperature. However, respiratory rate was significantly influenced ($p < 0.05$) by dietary treatments, with birds supplemented with vitamin C and oregano exhibiting lower respiratory rates compared with the control group. The results indicate that vitamin C and oregano may improve physiological responses of heat stressed broiler finishers reared under hot environmental conditions. Conclusion: It could therefore, be concluded that dietary of Vitaminc and Oregano may serve as a useful nutritional strategy for supporting broiler finisher's physiological response to heat stress during the hot season of semi-arid environment.

Keywords: broiler chickens, heat stress, oregano, sodium bicarbonate, vitamin C.

INTRODUCTION

Poultry production is a fast-growing agricultural sector in Nigeria, playing a critical role in meeting the protein needs of the population and supporting the livelihoods of farmers (FAO, 2019). Broiler chickens are especially important because of their short production cycle, high feed conversion efficiency, and market demand (Nawab *et al.*, 2018).

However, broiler production is substantially influenced by environmental conditions, particularly in regions experiencing high temperatures and humidity (Mangan & Siwek, 2024). Such conditions impair the thermoregulatory ability of poultry, thereby intensifying the adverse effects of heat stress on productive performance (Vandana *et al.*, 2021).

Previous studies have demonstrated that heat stress in broiler chickens adversely affects feed intake, growth performance, fat deposition, and meat quality (Zaboli *et al.*,

2018; Goo et al., 2019). This challenge is even more pronounced in semiarid environments, which is characterized by high ambient temperatures and low humidity levels, heat stress presents a major challenge to broiler production, which occurs when the heat produced by the body exceeds the body's ability to dissipate it, leading to physiological and biochemical disturbances (Lin et al., 2006).

According to Sa'adu et al., (2018) Broiler production in semi arid region is constrained by high ambient temperatures, which often exceed the thermoneutral zone of poultry. Such condition alters endocrine function, suppresses immune responses, and impairs growth performance (Quinteiro-Filho et al., 2012). Similarly, birds under heat stress exhibit increased respiration rate, elevated rectal temperature, oxidative stress, and altered electrolyte balance (He et al., 2018), which can be quantitatively measured using biomarkers such as corticosterone, malondialdehyde (MDA), heat shock proteins (especially HSP70), and blood electrolytes (Mashaly et al., 2004; Lara & Rostagno, 2013).

To mitigate the adverse effects of heat stress and support homeostasis in broiler production, dietary supplements such as sodium bicarbonate (NaHCO_3), ascorbic acid (vitamin C), and plant-derived additives like oregano are commonly investigated as nutritional strategies (Sayed & Downing, 2011). Sodium bicarbonate acts as an alkalinizing agent that helps maintain acid-base balance, stabilize electrolyte levels, and support thermoregulation under heat stress, with its effectiveness influenced by environmental conditions and management practices (Sayed & Downing, 2011; Attia, Al-Harthi, & Abd El-Hack, 2009). Ascorbic acid on the other hand, has been widely studied for its antioxidant properties and its ability to improve immune function and physiological responses in heat-stressed broilers; supplementation with vitamin C has been shown to alleviate negative impacts of heat on performance and stress biomarkers, enhance thermoregulatory responses, and support metabolic stability in chickens exposed to high temperatures (Attia et al., 2009; Shakeri et al., 2020; Sumanu et al., 2024).

While Oregano (*Origanum vulgare*), rich in bioactive compounds such as thymol and carvacrol, has been shown to improve antioxidant status, modulate blood biochemical parameters, and enhance growth performance in broilers under heat stress conditions, for example, Abdullahi et al. (2023) in Sokoto demonstrated that supplementation with oregano leaf powder positively influenced finisher broiler performance indices, highlighting its potential as a practical nutritional strategy for mitigating heat stress in semi-arid regions. These studies collectively show that sodium bicarbonate, ascorbic acid, and oregano are effective nutritional interventions for maintaining electrolyte balance and improving physiological resilience in broilers raised during hot seasons in semi-arid environment. But their comparative effects have not been reported, therefore, this study aimed to evaluate the comparative effects of these feed supplements with a view to find the most effective in improving broiler finishers' responses to heat stress during the hot season of semi-arid environment.

MATERIALS AND METHODS

Location of the Experiment

The experiment was carried out at the Production and Research Facility of the Department of Animal Science, Faculty of Agriculture, Usmanu Danfodiyo University Sokoto, located at

the Sokoto Veterinary Clinic on Aliyu Jodi Road in Sokoto, Sokoto State, Nigeria. The location is located in Nigeria's Sudan savanna ecological zone, at around 12° 55' N and 50° 10' E. The average annual rainfall is about 600 mm, with mean temperatures ranging between 35 °C and 40 °C, low relative humidity, and a prolonged dry season that pre-disposed poultry birds to heat stress (Adejuwon, 2006). Heat stress negatively affects the physiological performance, productivity, and welfare of poultry birds (Saeed *et al.*, 2019).

Preparation of the Experimental Pens

Two weeks before the arrival of the chicks, the pen was thoroughly cleaned, washed using detergent, disinfected, and fumigated using formalin and potassium permanganate (KMnO₄). Wood shavings were spread on the floor as litter material at a depth of approximately 3 cm. Feeding trays and drinkers were placed in position.

Sourcing of the Experimental Birds

Experimental Animals and Design

We purchased 192 day-old Ross 308 broiler chicks from Agritech Ltd. in Ibadan, Oyo State, Nigeria. Before the feeding trial started, the chicks were given three days to acclimate after arriving.

Experimental Design

The experiment was conducted using a Completely Randomized Design (CRD). The 192 broiler chicks were randomly assigned to four dietary treatments, comprising 48 birds per treatment. Each treatment was replicated three times, with 16 birds allocated to each replicate.

Experimental Treatments

Treatment 1: Control (No supplement)

Treatment 2: Sodium bicarbonate (150 g/100 kg)

Treatment 3: Vitamin C (100 g/100 kg)

Treatment 4: Oregano (200 g/100 kg)

Experimental Diet Formulation and Compounding

The experimental diets were formulated using feed formulation software to meet the nutrient requirements of broiler chickens as recommended by NRC (2011). Macro feed ingredients (maize, soya meal) were first weighed and spread on a clean mixing surface, after which micro ingredients (methionine, lysine, premix, acidifier, toxin binder) were measured and mixed using the principle of serial dilution.

Table 1: Gross and Nutrient Composition of the Experimental Diet

INGREDIENTS	QUANTITY (%)
Maize	54.90
Soyabean meal	33.00
Wheat offal	6.00
Limestone	2.20
Soya oil	1.00
Methionine	0.30
Lysine	0.20
DCP	0.10
Salt	0.25
Bone meal	1.80
Premix*	0.25
Total	100.00
CALCULATED NUTRIENT COMPOSITION	
Metabolizable energy (kcal/kg)	2866.51
Crude protein%	19.60
Crude Fat%	3.89
Crude fiber%	4.30
Calcium%	1.31
Available phosphorus%	0.62
Lysine%	1.58
Methionine%	0.57

*Vitamin A (10,000,000 I.U), VITAMIN D3 (2,000,000 I.U), Vitamin E (10,000 I.U), Vitamin K3 (2000 I.U), Thiamine B1 (1500 mg), Riboflavin B2 (1400 mg), Pyridoxine B6 (1500 mg), Vitamin B12 (10 mg), Niacin (15,000 mg), Pantothenic Acid (5000 mg), Folic Acid (300 mg), Biotin (20 mg), Choline (200,000 g), Cobalt (5 g), Iodine (1.2 g), Iron (20 g), Manganese (80 mg), Selenium (200 g), Zinc (50 g), Antioxidant (125 mg).

Management of Experimental birds

The birds were reared in a tropical open-sided pen using wood shavings as litter material. Each pen was equipped with adequate feeders and drinkers. Feed and clean water were provided *ad libitum* throughout the experimental period. Routine management practices such as cleaning, vaccination and medications schedules as recommended for the area, and biosecurity measures were strictly observed.

Data Collection

Growth Performance Parameters

The initial body weight was determined at the start of the finisher phase, and the birds were weighed weekly using a digital weighing scale. The average body weight each bird was then computed. Feed offered and residues were assessed weekly, and feed intake was calculated by subtracting the amount of residual feed from the total amount supplied. The average daily feed intake (ADFI) was then computed using the recorded feed consumption. Average Daily Gain (ADG) was calculated by dividing the difference between final and initial body weights by the feeding trial's duration in days. The Feed Conversion Ratio (FCR) was

calculated as the ratio of total feed consumed to total body weight growth during the trial period. Mortality was observed and documented everyday throughout the. Mortality was monitored and documented daily throughout the study.

Environmental and Physiological Stress Parameters

Ambient temperature (°C) and relative humidity (%) were recorded daily using a thermo-hygrometer positioned at the birds' level, with measurements taken during the morning and afternoon periods. Core body temperature (°C) was determined in 2-3 birds per replicate using a clinical thermometer. Respiratory rate (breaths per minute) was assessed by counting the number of breaths taken per minute in selected birds from each replicate during periods of peak environmental heat.

Statistical Analysis

All data collected were subjected to one-way Analysis of Variance (ANOVA) using SPSS version 25.0 statistical software. Significant means were separated using Duncan's or Tukey's Multiple Range Test at a 5% level of significance ($p < 0.05$). Results were presented as mean $\pm$ standard error of the mean (SEM).

RESULTS AND DISCUSSION

Growth Performance of Finisher Broiler Chickens

Table 2 shows the growth performance metrics of finisher broiler chicks fed different anti-stress dietary supplements in hot climatic circumstances. The results revealed no significant difference ($P > 0.05$) between initial and final weight, total weight gain, average daily weight gain, and feed conversion ratio. The average daily feed intake differs ($P < 0.05$) across treatments.

Table 2: Growth performance of finisher broilers fed anti-stress dietary supplements

Parameter	T1 (Control)	T2 (NaHCO ₃)	T3 (Vit C)	T4 (Oregano)	SEM	p-value
Initial Weight (g/bird)	741.88	703.13	688.11	696.67	10.65	0.319
Final Weight (g/bird)	1870.83	1867.36	1903.39	1940.77	67.79	0.985
Total Weight Gain (g/bird)	1128.95	1164.24	1215.28	1244.10	67.18	0.951
ADG (g/bird/day)	51.32	52.92	55.24	56.55	3.05	0.951
ADFI (g/bird/day)	1071.59 ^b	1432.71 ^a	1345.50 ^{ab}	1269.93 ^{ab}	52.29	0.056
FCR	2.78	1.97	1.90	2.04	0.17	0.216
Total Mortality (Birds)	8	3	6	6	—	—

^{a, b} Means within the same row carrying different superscripts differ significantly ($p \leq 0.05$). SEM = Standard Error of Mean; ADG = Average Daily Gain; ADFI = Average Daily Feed Intake; FCR = Feed Conversion Ratio.

Birds in control group recorded lower ($P < 0.05$) average daily intake compared to birds supplemented with sodium bicarbonate. There is no significant difference ($P > 0.05$) between birds in control to those supplemented with Vit C and Oregano. So also, no difference ($P > 0.05$) was observed between birds supplemented with sodium bicarbonate to those supplemented with Vit C and Oregano. Average daily feed intake was more responsive to dietary treatment, with sodium bicarbonate supplementation showing an apparent improvement in feed consumption. Heat stress normally suppresses appetite as birds reduce metabolic heat production as shown in the present study, while excessive panting can cause respiratory alkalosis and disrupt nutrient metabolism (Branton et al., 1986). Sodium bicarbonate may alleviate these effects by improving electrolyte and acid-base balance. This agrees with Teeter et al. and Ahmad et al. (2006), who demonstrated that dietary sodium sources, particularly sodium bicarbonate, could improve performance and heat tolerance in broilers. Similarly, Majekodunmi et al. (2012) reported that dietary electrolytes and antioxidant supplementation could positively influence performance in broilers exposed to high environmental temperatures.

The similarity in initial body weights among treatment groups indicates that the birds were relatively homogeneous at the beginning of the experiment, allowing subsequent responses to be attributed mainly to dietary treatments and environmental conditions. The absence of significant differences in final body weight and weight gain may be due to the complex effects of heat stress on feed intake, nutrient utilization, endocrine function, immunity, and energy partitioning. Thus, dietary supplements may improve physiological adaptation without necessarily producing significant changes in growth performance. This observation agrees with Ghazi et al. (2015), who reported improved body weight and feed efficiency in heat-stressed broilers supplemented with vitamin C and oregano, although some performance parameters remained unaffected.

Physiological Stress Indicators

The descriptive statistics for the physiological responses of finisher broiler chickens monitored under heat stress conditions are presented in Table 3. The results showed significant difference ($P < 0.05$) in respect to respiratory rates the experimental treatments, while rectal temperature remains similar ($P > 0.05$) across the treatment groups.

Table 3: Descriptive statistics for physiological stress indicators of finisher broilers

Parameter	T1 (Control)	T2 (NaHCO ₃)	T3 (Vit C)	T4 (Oregano)	SEM	p-value
Respiratory Rate (breaths/min)	49.33 ± 3.84 ^a	48.00 ± 2.08 ^{ab}	42.33 ± 1.20 ^b	42.67 ± 0.67 ^b	1.34	0.038
Rectal Temperature (°C)	40.06 ± 0.19	39.90 ± 0.71	39.93 ± 0.22	40.56 ± 0.40	0.25	0.612

^{a, b} Means within the same row carrying different superscripts differ significantly ($p < 0.05$). Values are presented as Mean ± Standard Deviation.

Birds in control group had higher ($P < 0.05$) respiratory compared to those supplemented with vitamin C and oregano and similar ($P > 0.05$) to those supplemented with

sodium bicarbonate. Birds supplemented with sodium bicarbonate, Vit. C and oregano had similar respiration rates. Respiratory rate was significantly influenced by dietary treatment, with birds supplemented with vitamin C and oregano exhibiting lower respiratory rates than the control group. Respiratory rate is a sensitive indicator of heat stress in poultry because birds depend largely on panting for evaporative heat loss due to their limited capacity for non-evaporative cooling (Madkour *et al.*, 2024). Excessive panting may result in excessive carbon dioxide loss, respiratory alkalosis, and disturbances in blood acid-base and electrolyte balance, thereby affecting normal metabolism and performance. The reduced respiratory rates observed in vitamin C- and oregano-supplemented birds therefore suggest a lower physiological heat burden and improved adaptation to hot environmental conditions.

The observed response to vitamin C agrees with Ijadunola *et al.* (2023) and Abioja *et al.* (2020), who reported beneficial effects of vitamin C on thermophysiological responses of broilers exposed to heat stress. Similarly, the antioxidant properties of oregano may reduce oxidative damage and inflammation associated with heat exposure, thereby improving cellular resilience. Although rectal temperature was not significantly ($P>0.05$) affected by dietary treatment, its relatively stable values suggest that the birds maintained core body temperature through compensatory thermoregulatory mechanisms such as panting, increased peripheral blood flow, and behavioural adjustments. The significant differences in respiratory rate despite similar rectal temperatures indicate that respiratory rate may be a more sensitive indicator of changes in physiological heat load among the dietary treatments.

CONCLUSION

Dietary supplementation with vitamin C and oregano reduced the physiological response to heat stress, as evidenced by lower respiratory rates, while growth performance and rectal temperature were maintained across treatments. The study therefore suggests that dietary anti-stress supplements, particularly vitamin C and oregano, may support the adaptation of finisher broilers to hot environmental conditions.

Author contributions: This work was carried out in collaboration between all authors. Author AS designed the study, wrote the protocol, analyses the data, provided training for author MMK and finalized the manuscript. Author KMA managed the experimental process and wrote the first draft of the manuscript. Author AMI critiqued the manuscript. All authors read and approved the final manuscript.

Ethics approval: Application has been sent to the Institutional Animal Care and Use Committee (IACUC) of Usman Danfodiyo University, Sokoto for Approval.

AI Tool Usage Declaration: The author(s) hereby state that no generative AI tools such as Large Language Models (ChatGPT, COPILOT, etc.) or text-to-image generators were utilized in the drafting or editing of this work; rather, Grammarly was used to correct the use of sentences and editorials.

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