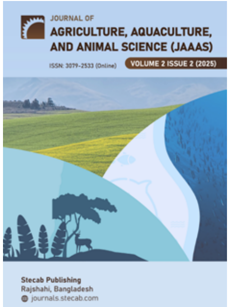

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Research Article

Performance Indices, Carcass Characteristics, Organs, and Thermal Stress Responses of Broiler Chicken Exposed to Dietary Betaine Hydrochloride During Hot Season

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About Article

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ABSTRACT

The impact of varied levels of betaine hydrochloride on performance indices, carcass characteristics and thermal stress of broilers during the hot season was assessed by this study. 180 day-old broiler chicks were distributed into 5 treatments labeled T1, T2, T3 and T4 randomly. Replicated three times, each treatment had 36 birds while 12 birds were allotted to each replicate. The treatments were as follows: T1 (control: 0 g of betaine/kg feed); T2 (1 g of betaine/kg feed); T3 (2 g of betaine/kg feed); T4 (3 g of betaine/kg feed); and T5 (4 g of betaine/kg feed). The birds were placed on these diets for 10 weeks. From the findings, it was found that the growth parameters were not different, with no significant (p>0.05) changes in the weights of the primal cuts when compared with the birds on the control diet. At weeks 7 to 10, there was a decrease in the panting rate of the broilers as betaine level increased, implying that the addition of betaine in the broiler diets lowered their thermal stress. In weeks 3 to 10, the rectal temperatures were not different apart from week 8 which was affected significantly. From these results, it is evident that commercially produced betaine HCL administered at 2g/kg diet can enhance broiler chicken performance during the hot season.

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1. INTRODUCTION

Among all the livestock investments in the tropics, the poultry enterprise seems to be the most common sector being the most generally accepted source of dietary protein – chicken and egg - without any cultural and religious bias, and steady income (Paswan *et al.*, 2014; Chaiban *et al.*, 2020). In 2013, it was reported that Nigeria has about 165 million birds (Sahel Capital, 2015), and it is hoped that poultry production will end Africa's pronounced inadequacy of animal protein orchestrated by climate change, biosecurity challenges, skyrocketing cost of feed and population growth.

Broiler production in West Africa has gained more popularity because of growing demand, urbanization and short production cycle which consequently ensures quick returns on investment. With the high nutrient content of broiler chicken, Nigeria is still witnessing low production as depicted by the discrepancy between demand and supply of the product (Olorunwa, 2018). This considerable discrepancy between demand and supply could be attributed to the challenge of high environmental temperature usually faced by broiler producers especially during the dry season. Quite a number of farmers have recorded huge losses as a result of stress caused by too much heat (St-pierre *et al.*, 2003; Nawab *et al.*, 2018; Apalowo *et al.*, 2024). Global discussions about heat stress gained traction in 2021 when the world's ambient temperature rose by 0.84℃ over the mean value of the 21st century (Nawaz *et al.*, 2021). This has serious implications on the survival of the birds.

Therefore, this study aimed to evaluate the efficacy of five graded levels of dietary betaine hydrochloride on performance and thermoregulatory responses of broiler chickens reared during the hot season.

2. LITERATURE REVIEW

As at 2012, the annual global chicken meat production stood at about 103.5 million (F.A.O, 2012) representing about 34% of meat produced worldwide (Pawar *et al.*, 2016). This data is enough to conclude that poultry enterprise has advanced greatly leading to doubling of poultry meat consumption (Sebho, 2016).

Stress in a phenomenon that has been viewed differently by many scholars. Stott (1981) referred to stress as any factor that induces triggering of physiological stress response by an animal. Heat stress is the inequality between the heat within the animal body's and that of its immediate environment (Lara & Rostagno, 2013). Just like any other stressor, heat stress usually stimulates the Hypothalamus-Pituitary-Adrenal (HPA) axis together with the Sympathetic-Adrenal-Medullar (SAM) axis thus raising the glucose level needed to survive under stress (Shini *et al.*, 2008). Wiepkema and Koolhaas (1993) opined that acute stress is a one-time exposure to a stressor, while chronic stress occurs whenever the stressor or the effect it produces continues to exist for a long time thereby impacting negatively on food security as a result of its effects on livestock (Shukla *et al.*, 2019).

The recent industrialization witnessed throughout the world has led to a climate change which has resulted in the menace of heat stress that currently stands as one of the major environmental factors challenging the growth of poultry industry in the tropic (Alagawany *et al.*, 2017). For instance, chickens exposed to excessive environmental temperatures tend to show physiological and immunological changes which can impair their normal functioning (Nawab *et al.*, 2018).

Of all livestock species, poultry birds appear to be the most vulnerable to the effect of high temperature owing to their plumage and absence of sweat gland (Vandana *et al.* 2021), causing a serious concern in the business. The body temperature range for chicken is 41 - 42℃, with a thermoneutral zone of 18 – 21℃ which is required for an impressive growth rate (Kumari and Nath, 2018). When they are exposed to heat, feed intake is reduced with subsequent behavioral changes (Bahry *et al.*, 2018). Heat stress negatively impacts growth efficiency (Awad *et al.* 2020), intestinal health (Fouad *et al.* 2016), and immune system function (Tang & Chen, 2016).

Betaine, a trimethyl derivative of glycine, which occurs naturally in plants like wheat has been utilized to lower the impact of elevated environment temperature in poultry birds (Abd El-Ghany & Babazadeh, 2022), with betaine hydrochloride the most commonly used types of betaine in livestock production (Eklund *et al.*, 2005). Studies have shown that supplementation of chicken diet with betaine enhances growth performance, metabolism of fat as well as immunity (Akhavan & Ghasemi, 2016). Furthermore, betain has been utilized for osmo-regulation which is crucial for cardiovascular and renal metabolic processes (Sakomura *et al.*, 2013).

3. METHODOLOGY

3.1. Experimental site

The experiment took place at the Poultry Research Unit, Teaching and Research Farm, Ekiti State University in Ado-Ekiti, Ekiti State, Nigeria.

3.2. Preparation of experimental site

The site was carefully fumigated with formalin after thorough washing with clean water.

3.3. Design of the experiment

180-day-old broiler chicks of Arbor Acre strain were acquired from a trusted commercial hatchery. There were 5 treatments with thirty-six birds in each treatment. Each treatment, replicated thrice contained 12 chicks in a completely randomised experimental design.

3.4. Diets

Five different diets (starter and finisher) supplemented with betaine were designed for the study (Table 1). Treatment 1 was the control diet (no betaine) while betaine was added per kilogram of feed to treatments 2, 3, 4 & 5 at 1, 2, 3, and 4g inclusion levels respectively.

Table 1. Experimental diets (g/100kg)

Ingredients	Starter	Finisher
Corn	52.50	57.65
Soyabean Meal	20.50	12.96
Groundnut cake	11.75	18.00
Fish meal	4.50	3.50

Dicalcium Phosphate	5.00	0.20
Limestone	0.95	1.97
Corn bran	4.00	5.02
Vitamin-Mineral premix	0.30	0.25
Methionine	0.10	0.10
Lysine	0.10	0.10
Salt	0.30	0.25
Total	100	100
Calculated Nutrients		
Energy (MEKcal/kg)	3,000	3,100
Crude protein (%)	23.00	20.00
Crude fibre (%)	5.00	8.00

3.5. Management of birds

All chicks were presented with the formulated diets with water unrestricted for 70 days. During the early days of the chicks, artificial sources of heat were made available while vaccination schedule was strictly adhered to.

3.6. Data analysis

Analysis of Variance (ANOVA) techniques from the 2007 version of Minitab statistical software was utilized for the statistical evaluation of all collected data. Where the group standard errors of means showed significance, the Duncan Multiple Range Test (DMRT) was used in comparing treatment means with group averages at a significance level of 0.05.

4. RESULTS AND DISCUSSION

Table 2. Growth performance

Parameters	**Betaine Levels**					
	T_1 Control	**T_2 1g/kg**	**T_3 2g/kg**	**T_4 3g/kg**	**T_5 4g/kg**	**SEM**
Initial Live Wt. (gram)	250.10	253.17	251.25	254.41	252.10	0.06
Final Live Wt (gram)	2029.00	2182.20	2079.56	2068.81	2100.20	15.42
F. I (gram/bird/day)	106.35	107.00	106.58	106.56	106.28	0.57
BWG (gram/bird/day)	31.99	32.78	32.79	32.79	32.79	0.18
FCR	3.32	3.26	3.25	3.25	3.24	0.01

F.I = Feed Intake; BWG = Body Weight Gain; FCR = Feed Conversion Ratio; SEM = Standard Error of Means

Table 3: Relative Weight of Primal Cuts

Parameters (%)	**Betaine Levels**					
	T_1 Control	**T_2 1g/kg**	**T_3 2g/kg**	**T_4 3g/kg**	**T_5 4g/kg**	**SEM**
Neck	4.90	4.92	4.90	5.50	5.12	0.01
Drumstick	10.27	10.67	10.74	10.66	9.68	0.02
Breast	21.21	22.41	23.17	21.67	23.31	0.05
Wing	7.17	7.22	7.29	7.27	7.30	0.01
Back	12.00	13.14	13.47	13.21	13.30	0.02
Thigh	10.36	10.29	10.72	10.69	10.26	0.02
Leg	354	3.47	3.54	3.63	3.90	0.02

SEM = Standard Error of Means.

Table 4. Relative Weight of Some Organs

Parameters (%)	**Betaine Levels**					
	T_1 Control	**T_2 1g/kg**	**T_3 2g/kg**	**T_4 3g/kg**	**T_5 4g/kg**	**SEM**
Proventriculus	0.36	0.32	0.33	0.40	0.31	0.01
Intestine	5.99	5.62	5.43	5.19	5.98	0.01
Spleen	0.12	0.11	0.12	0.26	0.18	0.01
Kidney	0.34	0.35	0.32	0.40	0.38	0.01

Gizzard	1.77	1.98	1.13	1.30	1.64	0.01
Liver	1.46	1.62	1.61	1.85	1.59	0.02
Lung	0.75	0.96	0.47	0.46	0.57	0.01
Heart	0.60	0.52	0.50	0.51	0.46	0.01

Table 5. Respiratory Rates

Week	Betaine Levels					
	T_1 Control	T_2 1g/kg	T_3 2g/kg	T_4 3g/kg	T_5 4g/kg	SEM
	Breath/min					
3	49.00	48.00	47.80	47.50	47.00	0.11
4	51.67	51.00	51.00	50.00	50.00	0.42
5	53.00	52.33	51.33	50.67	50.67	0.37
6	43.00	43.00	42.33	41.33	40.67	0.29
7	42.67	42.00	42.00	38.33	39.67	0.28
8	43.33	42.33	42.33	41.33	41.33	0.39
9	35.67	34.67	34.00	33.00	31.67	0.72
10	32.00	31.50	30.33	30.20	29.80	0.28

Table 6. Rectal temperature

Week	Betaine Levels					
	T1 Control	T_2 1g/kg	T_3 2g/kg	T_4 3g/kg	T_5 4g/kg	SEM
	Rectal Temperature (℃)					
3	41.27	41.27	41.17	41.04	40.97	0.02
4	41.60	41.20	41.17	41.00	41.00	0.03
5	41.53	41.40	41.27	41.20	41.07	0.02
6	41.93	41.53	41.50	41.40	41.33	0.02
7	41.37	41.33	41.30	41.27	41.17	0.01
8	41.93^{a}	41.63^{ab}	41.57^{ab}	40.63^{c}	40.30^{c}	0.03
9	42.07	41.57	41.47	41.40	41.30	0.02
10	42.05	41.56	41.47	41.42	41.32	0.02

Table 7. Panting rate

Betaine Levels								
Week	Time	Temp.	T_1 Control	T_2 1g/kg	T_3 2g/kg	T_4 3g/kg	T_5 4g/kg	SEM
7	11 a.m.	27 ± 1	5.33	5.31	5.28	5.28	5.00	0.006
	1 p.m.	35 ± 1	5.37^{a}	5.36^{a}	5.01^{b}	4.83^{c}	4.68^{d}	0.002
	3 p.m.	35 ± 1	5.64^{a}	5.40^{b}	5.43^{b}	5.24^{c}	5.09^{d}	0.002
8	11 a.m.	27 ± 1	5.42^{a}	5.41^{a}	4.72^{b}	4.71^{b}	4.62^{c}	0.001
	1 p.m.	35 ± 1	5.61^{a}	5.56^{ab}	5.56^{ab}	5.55^{b}	5.45^{b}	0.001
	3 p.m.	35 ± 1	5.79^{a}	5.68^{b}	5.64^{b}	5.63^{b}	5.63^{b}	0.002
9	11 a.m.	27 ± 1	4.50^{a}	4.51^{a}	4.33^{b}	4.00^{c}	3.53^{d}	0.002
	1 p.m.	35 ± 1	5.42^{a}	5.41^{a}	4.72^{b}	4.71^{b}	4.62^{c}	0.001

	3 p.m.	35 ± 1	5.60^{a}	5.51^{b}	5.52^{b}	4.88^{c}	4.89^{c}	0.001
10	11 a.m.	27 ± 1	4.56^{a}	4.53^{ab}	4.52^{b}	4.51^{b}	4.50^{b}	0.001
	1 p.m.	35 ± 1	6.08^{a}	5.25^{b}	4.64^{c}	4.62^{c}	3.83^{d}	0.001
	3 p.m.	35 ± 1	6.08^{a}	6.02^{a}	5.51^{b}	5.01^{c}	4.77^{d}	0.002

4.1. Discussion

The average daily F.I, BWG and FCR of the birds were not statistically different (Table 2). This finding conflicts with the report of Dunshea *et al.* (2007); Sakomura *et al.* (2013) and Awad *et al.* 2014. The disparity in the findings could be as a result of differences in the route of administration and the brand of betaine used.

Furthermore, relative weights of the major cuts were similar; a result that corroborates the reports of Waldroup and Fritts (2005), that betaine supplementation in broiler diets produced no effect in the breast meat. This result however contradicts the findings of Noll *et al.* (2002), Pirompud *et al.* (2005) and Zhan *et al.* (2006) who reported improvements in the meat quality of the broiler chickens. Moreover, no liver weight gain was observed in this study which showed that there was no fat accumulation (Neto *et al.*, 2000; Konca *et al.*, 2008).

Also, there was no difference in the weight of the heart as observed in this study. The heart functions in ensuring that there is an increase in blood flow to body organs especially the brain so that heat dissipation from organs like the comb, wattles, and respiratory tracts can be enhanced to facilitate heat transfer (Yahav *et al.*, 1997). The conclusions of Vahdatpour *et al.* (2009) that betaine produced no significant effects on the weights of visceral organs (gizzard, kidney, and intestine), are consistent with the non-significant changes in visceral organ weights in this study.

Rectal temperature was observed to be lower, relative to the control in week 8. This supports the reports of Hassan *et al.* (2011) and Nofal *et al.* (2015) who found that supplementing diets with betaine considerably reduced rectal temperature being an osmolyte (Klasing *et al.*, 2002). The result however is not in line with those of Gudev *et al.* (2011), who reported no effect on rectal temperature.

It was also found out that betaine supplementation in broiler chicken diets lowered the rate of panting from the 7th to 10th week, emphasizing the efficacy of betaine in relieving birds of heat stress. Egbuniwe *et al.* (2018) and Ademu *et al.* (2020) also found that there was a remarkable reduction in the number of broiler chickens panting with administration of a combination of betaine and vitamin C. Consequent upon the osmolytic property of betaine, there is a tendency that it exerts stability on all the cells exposed to osmotic stressors (Klasing *et al.*, (2002) via controlling osmoregulation of tissue metabolism particularly along the gut (Lipinski *et al.*, 2012), thereby ameliorating the consequences of heat stress. Panting is a thermoregulation strategy characterized by opening of beak and wing drooping for increased evaporative cooling. This usually involves muscular activity requiring energy (Vinales *et al.*, 2019; Wasti *et al.*, 2020; Cartoni *et al.*, 2023). Thus, dietary betaine could be said to result in energy conservation as a result of reduced panting rate thereby improving the wellbeing of the chickens.

5. CONCLUSION

It has been established from this study that utilizing commercially manufactured betaine did not significantly improve growth and carcass yield but significantly improved thermoregulatory responses (panting and , in one week, rectal temperature). Therefore, dietary supplementation with betaine at 2g/kg of feed is hereby recommended for improved wellbeing of broiler chickens during the hot season.

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