Nigerian J. Anim. Sci. 2020 Vol. 22 (3): 17-25 (ISSN:1119-4308)

Effects of supplemental Vitamins E and C on growth performance and physiological responses of broiler chicken under environmental heat stress

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Abstract

Growth and physiological responses of broiler chicken fed supplemental Vitamins E and C in feeds under heat stress was evaluated. One hundred and twenty Arbor acre broiler chickens were used for the experiment. At day-old, the birds were acclimatized for 7 days, after which the birds were randomly allotted into 4 treatment groups which was replicated three times with 10 birds per replicate in a Completely Randomized Design. Four experimental diets were formulated in which the first treatment (T_1) served as the control without vitamin, second treatment (T_2) had 100mg of vitamin C per kg of feed, third treatment (T_3) had 200mg of vitamin E per kg of feed, and fourth treatment (T_4) had combination of 100mg vitamins C and 200mg Vitamin E per kg of feed. Data were collected on feed intake, weight gain, feed conversion ratio, environmental temperature, relative humidity, rectal temperature, pulse rate and respiratory rates of the chicken. Data were subjected to descriptive statistics, correlation analysis and Analysis of Variance using SAS (9.13). There were no significant effects on growth performance parameters monitored. Physiological indices showed mean values of 40.08 ± 5.85 ^{0}C, 67.41 ± 7.22 beats/min and 60.34 ± 5.84 breathes/min for rectal temperature, pulse rate and respiratory rate of the broiler chicken, respectively. There were low and positive correlations between rectal temperature and pulse rate of the chickens ($r = 0.23$); rectal temperature and respiratory rate ($r = 0.15$); pulse rate and respiratory rate ($r = 0.32$). There were significant ($p<0.05$) effects of Vitamins C and E on rectal temperature, respiratory rate and pulse rate of the chickens. Based on the findings of this study, it was concluded that Vitamin C supplement was most effective than Vitamin E and their combination in suppressing thermo-physiological responses of the broiler chicken.

***Keywords:** Humidity, response, temperature, physiology, supplement*

Description of Problem

Poultry species are particularly sensitive to temperature-associated environmental challenges, especially heat stress. It has been reported that modern poultry genotypes produce more body heat as a result of their increased metabolic activities (1). Environmental variation is one of the major factors that affect sustainability of livestock production systems in tropical climate (2). One of the major challenges to poultry production in Nigeria and the warm humid tropics is heat stress on broilers. Under high temperature conditions, broiler alter their behavior and physiological homeostasis seeking thermoregulation, thereby decreasing body temperature (3). Animals maintain thermoregulation and homeostasis through several means when subjected to high environmental temperatures including increasing radiant, convective and evaporative heat loss by vasodilatation, perspiration (4). Chickens, as homeotherms, maintain constant body temperature within the thermoneutral zone of 18 to 24°C (5; 6). This, however, requires the loss of excessive body heat. Heat exchange could be assessed directly from physiological measurements, such as rectal temperatures, respiratory rate, panting, heat production and growth rate.

High temperature coupled with humidity is more stressful that results in major economic losses to the poultry industry by reducing growth, egg production, hatchability and increasing mortality. Broiler needs the ambient temperature in a range that is appropriate to live in comfortable conditions, which is called thermoneutral zone such that if broiler was reared above this condition such bird will be vulnerable to environmental heat stress (7). Heat stress not only adversely affects production performance but also inhibits immune function (8). Exposure of birds to high environmental temperature generates behavioral, physiological and immunological responses, which impose detrimental consequences to their productivity (9). The environment surrounding an animal at any particular instant influences the amount of heat exchange between it and the environment. Under humid tropical climatic conditions, high temperature and relative humidity are major environmental factors that result in heat stress which in turn influence the productivity and physiological development of animals. In such an environment (10) when animals are exposed to higher temperature, the heat dissipation must be carried out to maintain its body temperature. Thermoregulation is an important role in maintaining the homeostasis and it is controlled by central, metabolic and endocrine systems (11). Thermoregulatory capacities of animal play an adaptive role to survive in adverse environment. Under high environmental temperature, birds change their behavioural and physiological responses to maintain their body temperature through seeking thermoregulation (11). Respiration is also another means by thermoregulation mechanism is conducted. The significance of the increase in respiration is that it enables the animal to dissipate heat by vaporizing high moisture through the respiratory air which accounts for about 30% of the total heat dissipation (12). According to (13) when the chickens are exposed to hot environmental conditions, the physiologic responses include an increase in respiratory frequency, a mechanism aimed to maintain the equilibrium of body temperature through the evaporative heat loss, and when this mechanism is disrupted the consequence is an increase in body temperature

Vitamins are essential organic nutrients to animals and participate as cofactors in many metabolic processes acting in more than 30 cellular metabolic reactions (14). Vitamins also act as immune-modulators in the endogenous metabolism for improving immune function and resistance to infection in poultry and other domestic animals (15). Vitamin C has been reported to enhance immune response by modifying corticosteroid synthesis in adrenal gland (3). Vitamin E protect the lymphocytes and macrophages due to its anti-oxidant property and enhanced proliferation and function of these cells (16) Many studies have reported that the inclusion of vitamin E in broiler diets not only reduces oxidative stress, but also improves the overall performance of the birds (17). Vitamins C and E are used in poultry diet because of their anti-stress effects and also because of their synthesis is reduced during the heat stress (18). Thus, this study sought to evaluate the thermo-physiological responses of broiler chicken fed supplemental Vitamins E and C due to change in diurnal temperature.

Materials and methods

Experimental site

The experiment was carried out at the Student Project Research Unit, Bora Poultry Farm, of Federal College of Animal Health and Production Technology, Moor plantation, Ibadan. Ibadan is located on longitude $03^{0}51$E, latitude $07^{0}23$N and altitude 65^{o}S, in the humid zone of rain forest belt 0703.25 of south western Nigeria. Ecologically it is in the rainforest zone experiencing mean annual rainfall of 1220 mm and mean temperature of 26^0C with two seasons- the dry and wet season.

Experimental birds and their management

A total of one hundred and fifty (150) Abor Acre broiler chicks were collected from the school's hatchery and one hundred and twenty of the chickens were used for the experiment. At day-old, the birds were acclimatized for 7 days, after which the birds were randomly allotted into 4 treatment groups. The birds were reared under continuous thermal stress environment, which was above thermoneutral zones (Ambient temperature = 26.95 – 36.71^{o}C; Relative humidity = 85.24 – 93.95%) (7). Digital thermo-hygrometer was hung inside the experimental house to record the ambient temperature and relative humidity of the environment. During the experiment, 60watt bulb lamp was used as heater in the experimental house which was switched on for 24 hours.

Experimental Design

After days of acclimatization the birds were randomly allotted into four treatment groups which were replicated three times with 10 birds per replicate in a Completely Randomized Design.

Experimental Diets

Four experimental diets were formulated in which the first treatment (T_1) served as the control without vitamin, second treatment (T_2) had 100mg of vitamin C per kg of feed, third treatment (T_3) had 200mg of vitamin E per kg of feed, and fourth treatment (T_4) had a combination of 100mg Vitamin C and 200mg Vitamin E per kg of feed. The ingredients composition of experimental diets for starter and finisher phases are presented in Tables 1 and 2 respectively.

Table 1: Gross composition of broiler starter diet

Ingredients	T1 (Control)	T2 (Vitamin C)	T3 (Vitamin E)	T4(Vitamins C+E)
Maize	50.00	50.00	50.00	50.00
Soya bean meal	30.00	30.00	30.00	30.00
Fish meal	2.00	2.00	2.00	2.00
Groundnut cake	7.20	7.20	7.20	7.20
Wheat bran	8.00	7.90	7.80	7.70
DCP	2.00	2.00	2.00	2.00
Salt	0.25	0.25	0.25	0.25
Broiler premix	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Methionine	0.10	0.10	0.10	0.10
Vitamin E	-	-	0.20	0.10
Vitamin C	-	0.10	-	0.20
Total	100.00	100.00	100.00	100.00
Crude protein	23.16	23.16	23.16	23.16
Metabolizable energy (kcal/kg)	2831.30	2831.30	2831.30	2831.30

Table 2: Gross composition of broiler finisher diet

Ingredients (%)	T1 (Control)	T2 (Vitamin C)	T3 (Vitamin E)	T4 (Vitamins C)
Maize	55.00	55.00	55.00	55.00
Soya meal	30.00	30.00	30.00	30.00
Fish meal (72%)	2.50	2.50	2.50	2.50
Groundnut cake	3.80	3.80	3.80	3.80
Wheat bran	6.00	5.90	5.80	5.70
DCP	2.00	2.00	2.00	2.00
Salt	0.25	0.25	0.25	0.25
Premix broiler	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10
Vitamin E	-	-	0.20	0.10
Vitamin C	-	0.10	-	0.20
Total	100.00	100.00	100.00	100.00
Crude Protein (%)	21.38	21.38	21.38	21.38
Metabolized Energy (kcal/kg)	2861.10	2861.10	2861.10	2861.10

Data collection

Data were collected on growth performance characteristics of the chickens; these include average feed intake, weight gain, feed conversion ratio. Data were also collected on rectal temperature, pulse rate, respiratory rate of the chicken. Rectal temperature was taken using a digital rectal thermometer inserted into the cloaca and left in position for a minute to a depth of 1-2cm, thereafter the reading was taken. Respiratory rate was recorded as the number of frequency of flank movements per 20 seconds and was calculated as breathes/ minute (10, 19). Pulse rate was also recorded as beats per seconds by placing the stethoscope on the thigh of the chicken to determine the rhythmic beats of the heart which and was calculated as number beats/ minute (10, 19).

Data analyses

Data subjected to descriptive statistics analysis; analysis of variance (ANOVA), the relationship between the physiological parameters was tested using correlation analysis of (20).

Results and Discussion

Result of growth performance of broiler chickens fed Vitamins C and E supplements is presented in Table 3. The result showed that there were no significant effects ($p<0.05$) of Vitamin C and E supplements on final weight, average weight gained, average daily intake, average daily weight and mortality. However, birds fed supplements of Vitamin E recorded highest values of final weight; those fed both Vitamin C and E supplements had the highest values of average weight gain, average daily weight, feed intake, average daily intake and mortality. The result further revealed that there was significant effects ($p<0.05$) of Vitamin C and E supplements on feed conversion ratio of the chickens with highest feed conversion ratio obtained in chickens that were not fed supplements of Vitamins C and E. Contrarily, it has been reported that dietary Vitamin E improved feed conversion ratio without affecting the body weight and feed intake of birds under heat stress (21). Previous study revealed that quails fed vitamin C supplemented-diet under heat stress improved feed intake and feed efficiency (22).

Table 3: Growth performance of broiler chicken fed Vitamin C and E supplements

Parameters (g)	T1 (Control)	T2 (Vit.C)	T3 (Vit.E)	T4 (Vit.C + E)	SEM (±)
Initial weight	120.13	117.87	115.83	113.80	1.74
Final weight	2367.14	2127.38	2393.06	2446.82	79.75
AWG	2247.01	2009.52	2277.22	2333.02	79.55
ADW	45.86	40.40	46.47	47.61	1.65
Feed intake	1329.43	1431.13	1421.23	1615.17	55.71
ADI	27.13	29.21	29.00	32.96	1.13
FCR	1.70[a]	1.39[b]	1.60[ab]	1.45[ab]	0.04
Mortality (%)	0.20	0.27	0.27	0.37	0.03

[ab] means of different superscripts along the same row are significantly different.
AWG – Average weight gained; ADI – Average daily intake; ADW – Average daily weight; FCR- Feed conversion ratio.

Table 4 shows the descriptive statistics of physiological traits of broiler chicken fed Vitamins C and E. The result showed the mean values of 40.08 ± 5.85 ^{0}C , 67.41 ± 7.22 beats/min and 60.34 ± 5.84 breathes/min for rectal temperature, pulse rate and respiratory rate of the broiler chicken respectively. The result indicated that rectal (body) temperature of broiler chickens in this study were still within the normal range as reported in an earlier study (23); the authors reported that normal body temperature range in chickens was 41-42 ^{o}C; pulse rate was also within the normal 200 – 400 beats per min. However, the result obtained for respiratory rate was higher than the normal range 15 – 30 breaths per min. The result further revealed that highest coefficient of variation was obtained for pulse rate (8.12%), followed by that of respiratory rate (6.26%) and the least was obtained in rectal temperature (2.12%). The coefficient of variation obtained in the result of this study is an indication of accuracy of the result for means values of physiological traits of the broiler chicken as reported by (24, 25) that the smaller the coefficient of variation, the better the accuracy of the test and the smaller the error of the result.

Table 4: Descriptive statistics of thermo-physiological trait of broiler chicken

Physiological traits	Mean	Standard deviation	Coefficient of variation
RT (^{0}C)	40.08	5.85	2.12
PR (beats/min)	67.41	7.22	8.12
RR (breathes/min)	60.34	5.84	6.26

RT – Rectal temperature during, RR – Respiratory rate, PR am – Pulse rate during cool period of the day

Overall ambient temperature and relative humidity during the experimental period is as shown in Fig.1. Generally, the ambient temperature reduced along the weeks of the experiment while there was increase in the relative humidity.

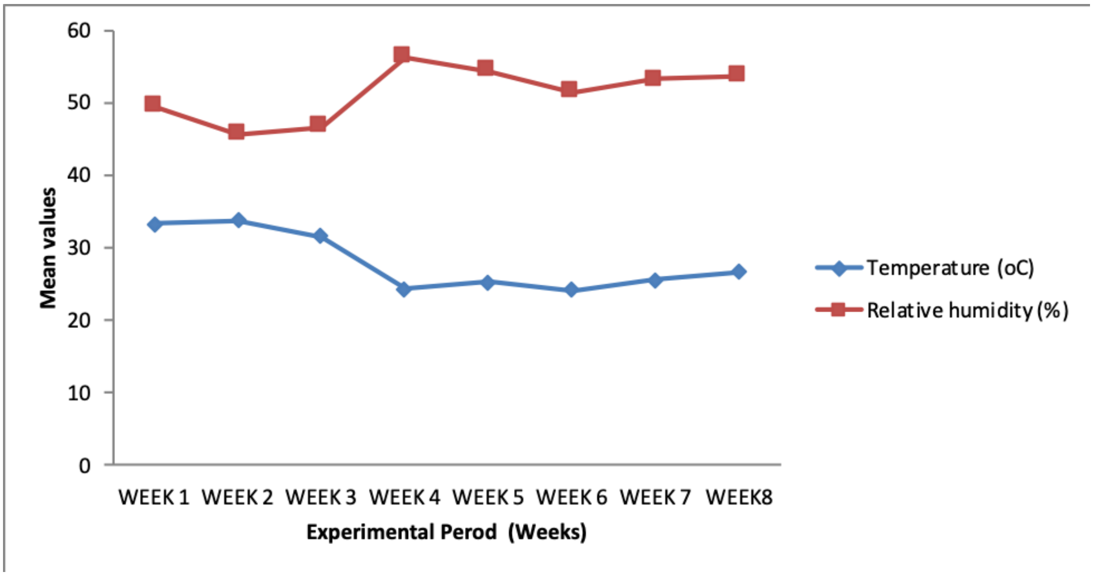

Fig.1. Temperature and relative humidity of experimental housing

Table 5 shows the relationship between the physiological traits of broiler chicken. Result revealed that there were positive and low correlations between rectal temperature and pulse rate of the chicken. The relationship between rectal temperature and respiratory rate was also low and positive. There was also low and positive relationship between respiratory rate and pulse rate of the chicken.

Table 5: Relationship between physiological traits of broiler chicken fed Vitamins C and E

Traits	RT	PR	RR
RT (°C)		0.23	0.15
PR (beats/min)			0.32
RR (breathes/min)			

RT – Rectal temperature during, RR – Respiratory rate, PR am – Pulse rate during cool period of the day

Table 6 shows the physiological traits of broiler chicken fed vitamins C and E. Result showed that there were significant effects ($p<0.05$) of Vitamins C and E on the rectal temperature of the chicken with birds served with Vitamin E having highest value of rectal temperature while the lowest was recorded in birds fed Vitamin C. There was also significant effect ($p<0.05$) of Vitamins C and E on pulse rate of the chicken; highest values of pulse rate were obtained in chicken fed Vitamins C and E while chicken fed Vitamin C recorded lowest value of pulse rate. The effect of Vitamins C and E was significant ($p<0.05$) on respiratory rate of the broiler chicken with highest value of respiratory rate recorded in birds fed Vitamin E and the lowest was recorded in birds fed Vitamin C. This result revealed that

Vitamin C supplement was most effective as anti-stress against heat in broiler poultry which was evidenced in the lowest values obtained for physiological traits of the broiler birds fed Vitamin C only. Mixture of Vitamins C and E supplement slightly suppressed the respiratory rate, pulse rate and rectal temperature of the broiler birds when thermally stressed, however, Vitamin E supplement in the diet of broiler chicken as obtained in this study was least effective as anti-stress against heat. Several researchers have reported positive effects of Vitamin C supplements given either in diets and / in drinking water to reduce stress related response of birds (26, 27).

Table 6: Effect of Vitamins C and E on thermo-physiological response of chicken

Physiological traits	T1 (Control)	T2 (Vitamin C)	T3 (Vitamin E)	T4 (Vitamins C + E)	SEM (±)
RT	40.32[a]	39.56[b]	40.34[a]	40.12[a]	0.05
PR	67.68[ab]	63.48[b]	67.75[ab]	70.73[a]	0.79
RR	58.87[b]	58.10[b]	63.13[a]	61.25[a]	1.02

RT – Rectal temperature during, RR – Respiratory rate, PR am – Pulse rate during cool period of the day; SEM – Standard error of mean

Conclusion and Applications

Based on the findings of this study:

1. Supplements of Vitamins C and E had no significant effect on most of growth performance characteristics of the broiler chicken except their feed conversion ratio with chickens not fed having the highest feed conversion ratio
2. There were significant, positive and low correlations among physiological traits of broiler chicken fed Vitamins C and E.
3. There were significant effects of Vitamins C and E on physiological traits of the chicken.
4. Vitamin C supplement was most effective in suppressing thermo-physiological responses of the broiler chicken.
5. The output of this study revealed that the use of Vitamin C and E can be adopted to ameliorate heat stress in broiler chickens particularly during the hot periods of day as well as during dry season when the environmental will be high.

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