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Synergistic Effect of Electrolytes and Ascorbic Acid on Performance and Physiological Response of Broiler Birds in Hot Humid Tropics

Bukola Christiana Majekodunmi, Olugbenga Adeniran Ogunwole*, Olujide Adedamola Sokunbi

Department of Animal Science, University of Ibadan, Ibadan, Nigeria

Abstract The study was aimed at determining the synergy of electrolytes (ammonium chloride, sodium bicarbonate, calcium chloride) and ascorbic acid water supplementation on performance and selected physiological response of broiler birds reared during hot period (March-April) in Ibadan, South West Nigeria. Two hundred and forty, one-day old Arbor Acre broiler chickens were randomly allotted to eight treatments: Treatment 1(control- without any supplementation), Treatment 2 (0.5% ammonium chloride), Treatment 3 (0.5% sodium bicarbonate), Treatment 4 (0.5% calcium chloride), Treatment 5 (300ppm ascorbic acid), Treatment 6 (0.5% ammonium chloride + 300ppm ascorbic acid), Treatment 7 (0.5% sodium bicarbonate + 300ppm ascorbic acid), Treatment 8 (0.5% calcium chloride + 300ppm Ascorbic acid). Each treatment was in triplicate of 10 birds each. The design of the experiment was a completely randomized design. Feed intake (FI), weight gain (WG) and feed conversion ratio (FCR) were similar ($p>0.05$) among treatments. Significant ($p>0.05$) variations were observed in the relative weights of lung, gizzard and intestine among treatments. Rectal temperature ranging from 41.89 to 41.98 ^{o}C and respiratory rate of 64.93 to 75.43 breath/minute across treatments were not significantly different ($p>0.05$). Mortality (%) was significantly higher ($p < 0.05$) for birds on T1 (20.0), T7 (13.3) and T2 (13.3) with the lowest value recorded for birds on T4 (3.3) while birds on treatments 3, 5, 6 and 8 each recorded 10% mortality. Combination of electrolytes and ascorbic acid did not confer any beneficial effect compared to when any of the electrolytes or ascorbic acid was used solely.

Keywords Heat stressed broiler chickens, Vitamin-Mineral synergy, Supplemental nutrients, Organs weight, Physiological response

1. Introduction

High ambient temperature accompanied with high humidity that characterises the tropics and sub tropic areas of the world has been identified as a major problem affecting performance and physiological attributes of chickens [1, 2]. Broilers respond to high temperature by increasing respiratory rate [3], body temperature [4], water consumption [5] and decreasing feed consumption [6].

Several therapeutic agents have been suggested to alleviate negative effects of environmental temperature on performance of poultry [7-10]. There has been reported alteration in ascorbic acid endogenous synthesis and utilization in poultry under high environmental temperature which became inadequate for optimum performance [11].

Ascorbic acid and electrolytes supplementation have been observed to improve performance of broilers reared in a hot environment [12-15]. Combinations of vitamins and electrolytes supplementation of drinking water are often employed in the poultry industry as a prophylaxis for stress-induced morbidity and heat-stress mortality. Most reports are limited to the use of these nutrients solely [16] with less emphasis on the effects on performance and physiological response when combined [15, 17, 18]. This study was therefore undertaken to evaluate the synergy of electrolytes (ammonium chloride, sodium bicarbonate and calcium chloride) and ascorbic acid water supplementation on performance characteristics and selected physiological responses of heat stressed broiler chickens.

2. Materials and Methods

2.1. Experimental Birds and Management

The study was carried out at the Teaching and Research Farm of the University of Ibadan, Ibadan which is located between latitudes 60°10" and 90°10" north of the equator and longitudes 30° and 60° of the Greenwich during hot dry season (March to April, 2012). Two hundred and forty,

* Corresponding author:
droaogunwole@gmail.com (Olugbenga Adeniran Ogunwole)
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one-day old Arbor Acre chickens were used for the seven weeks experiment. After one week of brooding, birds were weighed and randomly allotted to eight treatments. Each treatment was replicated three times with ten birds per replicate in a completely randomized design. Ambient temperature and humidity of the poultry house were recorded daily at 8, 13 and 20 hours using DeltraTrak Thermo Hygrometer (Model Number 13307) Formulated broiler starter and finishers' diets containing 3162 Kcal/Kg ME and 22.68% CP; 3256 Kcal/Kg ME and 20% CP respectively, were offered to birds ad libitum. Composition of experimental diets is shown in Table 1. Clean drinking water, sourced from the deep well, was provided ad libitum from day 21 to day 47 of the experiment. The seven drinking water treatments were used as Treatment 1(control- without any supplementation), Treatment 2 (0.5% ammonium chloride), Treatment 3 (0.5% sodium bicarbonate), Treatment 4 (0.5% calcium chloride), Treatment 5 (300ppm ascorbic acid), Treatment 6 (0.5% ammonium chloride + 300ppm ascorbic acid), Treatment 7 (0.5% sodium bicarbonate + 300ppm ascorbic acid), Treatment 8 (0.5% calcium chloride + 300ppm ascorbic acid). Recommended vaccination and other medicaments were administered [19].

Table 1. Ingredient and Nutrient Composition of Diets Fed to Birds Given Supplemental Electrolytes and Ascorbic Acid

Feed ingredients (%)	Starter diet (1-4 weeks)	Finisher diet (5:7 weeks)
Maize	53.70	56.00
Wheat offal	2.51	2.21
Soybean meal	38.20	30.00
Palm kernel meal	-	4.50
Palm oil	2.50	4.00
Oyster shell	0.80	1.00
Dicalcium phosphate	1.50	1.50
Common salt	0.25	0.25
Methionine	0.16	0.16
Lysine	0.07	0.07
Broiler premix	0.25	0.25
Avatec	0.06	0.06
Calculated nutrient composition (%)		
Crude Protein	22.68	20.00
Metabolizable Energy (Kcal/kg)	3162.00	3256.24
Calcium	0.90	0.97
Phosphorus	0.56	0.51
Calorie:Protein Ratio	139.4:1	162.8:1

1kg of broiler premix contains:
Vitamin A-10,000,000 IU; Vitamin D3-2,000,000; Vitamin E-20,000 IU ;Vitamin K-2,250mg; Thiamine B1-1,750mg; Riboflavin B2- 5,000mg; Pyridoxine B6-2,750mg; Niacin-27,500mg; Vitamin B12-15mg; Pantothenic acid- 7,500mg; Folic acid-7500mg; Biotin-50mg; Choline chloride-400g; Antioxidant-125g; Magnesium-80g; Zinc-50mg; Iron-20g; Copper-5g; Iodine-1.2g; Selenium-200mg; Cobalt-200mg

2.2. Data Collection on Broiler Performance

A weighed quantity of feed was offered ad libitum to each experimental unit throughout the week. At the end of each week, the residual feed was collected, weighed to calculate weekly feed consumption per pen and the feed intake was corrected for morality. Individual body weight was obtained at the beginning of the experiment. Thereafter, weekly body weight was recorded per pen basis. At the end of each week, average weekly body weight gain was calculated. Weekly feed conversion ratio (FCR) was calculated as grams of feed consumed to produce one gram of live weight. Water consumption per pen basis was recorded by offering known quantity of water and taking refusal daily. Weekly water intake per bird was calculated by dividing the total intake by the total number of birds in the respective pen. Record of mortality was maintained throughout the experimental period. At week 7, five birds from each replicate were sacrificed. Liver, gizzard, heart, proventriculus, intestine, abdominal fat were harvested, weighed and were related to percent live weight of the broiler chickens.

2.3. Physiological Measurement

The rectal temperature (RT) of three birds randomly selected out of each replicate was taken with a digital thermometer by rectal probe (0.1℃ accuracy) as previously described [20]. Respiratory rate (RR) of the birds was taken as the number of breaths per minute. Rectal temperature and the respiratory rate were monitored thrice weekly while the weekly average was calculated for each pen.

2.4. Statistical Analyses

All data obtained were analysed using one way analysis of variance (ANOVA) with SAS statistical analysis software program [21]. Treatment means were compared using the Duncan option of the same software.

3. Results

The ambient temperature range of 28.91 to 34.20℃ and the relative humidity values of 51.25 to 84.74% were obtained in the poultry house during the experimental period. The performance characteristics of heat stressed broiler chickens given water supplemented with electrolytes, ascorbic acid or combination at the starter phase (week 1 to 4) is presented in Table 2. Significant variations ($p < 0.05$) were observed in the feed intake (FI) and weight gain (WG) at the starter phase among treatments. Birds on T7 (sodium bicarbonate + ascorbic acid) had higher FI and WG which differ significantly ($p < 0.05$) from those on treatments 1, 4 and 6. However, feed conversion ratio (FCR) showed no significant variations among treatments.

The performance characteristics of the experimental birds at the finisher phase (week 5 to 7) are shown in Table 3. There were no significant ($p > 0.05$) variations in the WG and FCR at the finisher phase of this experiment. However,

FI was significantly ($p<0.05$) higher for birds on T7 compared with those on T8 (Calcium chloride + ascorbic acid). The results of the average FCR shown in Figure 1 however revealed that birds on treatments 2, 3, 4, 5, 6, 7 and 8 had lower FCR compared with those in the control group. Effect of the treatments on the water intake of the experimental birds is shown in Figure 2. It was observed that water intake increased with electrolytes supplementation. Results of the organs weight of birds given water supplemented with electrolytes, ascorbic acid or combination are presented in Table 4. No significant difference ($p > 0.05$) was observed in the live weight which ranged from 1.47 to 1.66kg. Significant variations ($p < 0.05$) were observed in the relative weight of the lung, gizzard and intestine. Mortality (%) significantly ($p < 0.05$) varied among treatments which were 13.3, 13.3, 10.0, 3.3 10.0, 10.0, 20.0 and 10.0 for birds on treatments 1, 2, 3, 4, 5, 6, 7 and 8 respectively. The effect of supplemental ascorbic acid, electrolytes or combination in drinking water during high temperature period on RT and RR of broiler chickens is shown in Table 6. Rectal temperatures (41.89 to 41.98℃) were not significantly different ($p > 0.05$) among treatments. The RR which ranged from 64.93 to 75.43 (breath/minute) were also not significantly ($p > 0.05$) influenced by the treatments.

Table 2. Performance Characteristic of Heat Stressed Broiler Chickens Given Water Supplemented with Electrolytes, Ascorbic Acid or Combination at the Starter Phase

Parameters	T1	T2	T3	T4	T5	T6	T7	T8	SEM
Feed intake (g/day)	369.00^{b}	395.33^{ab}	444.33^{ab}	382.00^{b}	398.67^{ab}	374.67^{b}	462.67^{a}	397.33^{ab}	14.56
Weight gain (g)	231.67^{c}	268.33^{bc}	328.33^{ab}	263.33^{bc}	255.00^{bc}	265.00^{bc}	350.00^{a}	260.00^{bc}	13.48
FCR	1.59	1.47	1.35	1.45	1.56	1.41	1.32	1.53	0.05

ab: means on the same row with different superscripts are significantly different($p<0.05$)T1- Control, T2- Ammonium chloride, T3-Sodium bicarbonate, T4-Calcium chloride, T5-Ascorbic acid, T6- Ammonium chloride + Ascorbic acid, T7- Sodium bicarbonate + Ascorbic acid, T8- Calcium chloride + Ascorbic acid, SEM-Standard error of mean. , FCR- Feed conversion ratio

Table 3. Performance Characteristic of Heat Stressed Broiler Chickens at the Finisher Phase

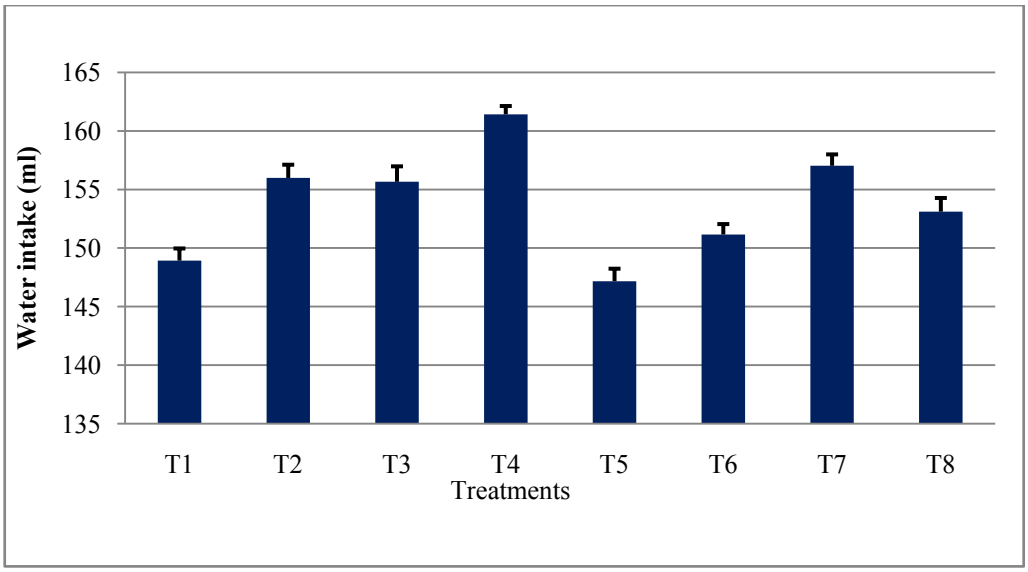
Parameters	T1	T2	T3	T4	T5	T6	T7	T8	SEM
Feed intake (g/day)	1872.20^{ab}	2034.40^{ab}	1812.30^{ab}	1899.30^{ab}	1915.80^{ab}	1840.80^{ab}	2215.20^{a}	1716.80^{b}	76.03
Weight gain (g)	782.00	878.07	702.86	816.30	783.15	747.55	830.00	758.29	29.94
FCR	2.39	2.32	2.58	2.33	2.45	2.46	2.67	2.26	0.09

a,b: means on the same row with different superscripts are significantly different($p<0.05$)T1- Control, T2- Ammonium chloride, T3-Sodium bicarbonate, T4-Calcium chloride, T5-Ascorbic acid, T6- Ammonium chloride + Ascorbic acid, T7- Sodium bicarbonate + Ascorbic acid, T8- Calcium chloride + Ascorbic acid, SEM-Standard error of mean. , FCR- Feed conversion ratio

Table 4. Organs Weight of Heat Stressed Broiler Birds Given Water Supplemented With Electrolytes, Ascorbic Acid or Combination

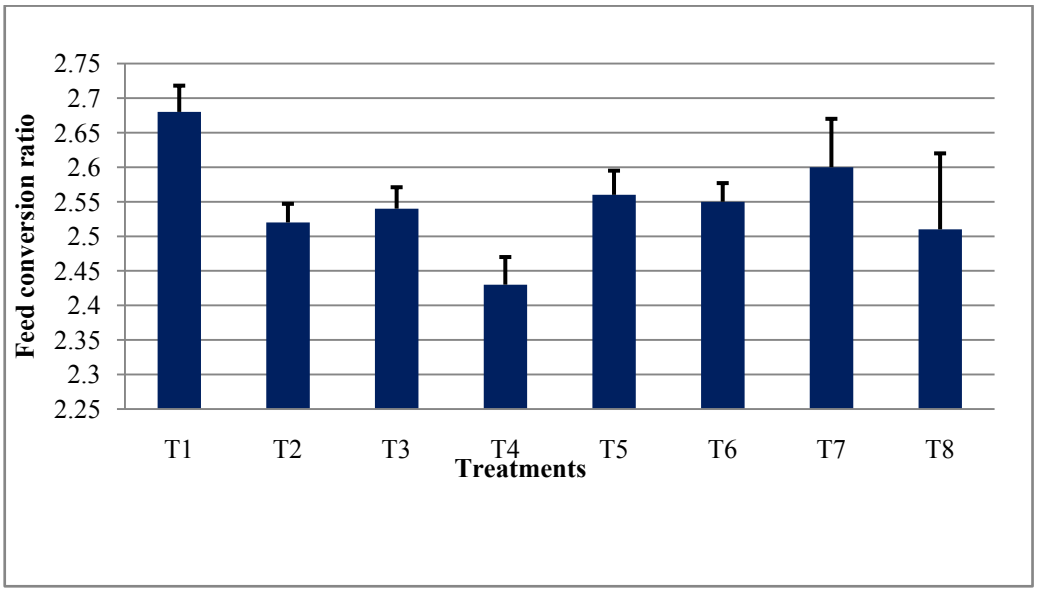
Organs	T1	T2	T3	T4	T5	T6	T7	T8	SEM
Live weight (kg)	1.66	1.51	1.65	1.62	1.52	1.47	1.58	1.57	0.33
Kidney (%)	0.52	0.69	0.54	0.63	0.66	0.66	0.53	0.66	0.03
Heart (%)	0.45	0.51	0.47	0.44	0.40	0.43	0.43	0.44	0.01
Lung (%)	0.49^{ab}	0.59^{a}	0.53^{ab}	0.52^{ab}	0.47^{b}	0.47^{b}	0.52^{ab}	0.49^{ab}	0.01
Liver (%)	2.35	2.42	2.32	2.33	2.54	2.40	2.52	2.13	0.06
Proventriculus (%)	0.56	0.64	0.59	0.58	0.69	0.60	0.62	0.57	0.02
Gizzard (%)	2.44^{ab}	2.71^{a}	2.14^{b}	2.48^{ab}	2.60^{ab}	2.25^{ab}	2.56^{ab}	2.57^{ab}	0.05
Intestine (%)	5.87^{b}	7.52^{a}	6.33^{ab}	5.99^{b}	6.61^{ab}	6.03^{ab}	6.04^{ab}	5.59^{b}	0.16
Crop (%)	0.37	0.52	0.51	0.74	0.56	0.49	0.40	0.57	0.04
Pancreas (%)	0.24	0.26	0.26	0.23	0.28	0.25	0.28	0.25	0.01
Abdominal fat (%)	1.55	1.48	1.21	1.32	1.58	1.33	1.43	1.18	0.08

abc: means on the same row with different superscripts are significantly different($p<0.05$) SEM - Standard error of mean. T1- Control, T2- Ammonium chloride, T3-Sodium bicarbonate, T4 – Calcium chloride, T5- Ascorbic acid, T6 -Ammonium chloride + Ascorbic acid, T7- Sodium bicarbonate + Ascorbic acid, T8- Calcium chloride + Ascorbic acid



T1- Control, T2- Ammonium chloride, T3-Sodium bicarbonate, T4 – Calcium chloride, T5- Ascorbic acid, T6 -Ammonium chloride + Ascorbic acid, T7- Sodium bicarbonate + Ascorbic acid, T8- Calcium chloride + Ascorbic acid

Figure 1. Average Water Intake (ml) of Heat Stressed Broiler Chickens Given Electrolytes, Ascorbic Acid or Combination



T1- Control, T2- Ammonium chloride, T3-Sodium bicarbonate, T4 – Calcium chloride, T5- Ascorbic acid, T6 -Ammonium chloride + Ascorbic acid, T7- Sodium bicarbonate + Ascorbic acid, T8- Calcium chloride + Ascorbic acid

Figure 2. Average Feed Conversion Ratio (FCR) of Heat Stressed Broiler Chickens Given Water Supplemented With Electrolytes, Ascorbic Acid or Combination

Table 5. Rectal Temperature and Respiratory rate of broiler birds given water supplemented with electrolytes, ascorbic acid or combination during high temperature period

Parameters	T1	T2	T3	T4	T5	T6	T7	T8	SEM
Rectal temperature (^{o}C)	41.96	41.93	41.98	41.89	41.91	41.91	41.98	41.98	0.04
Respiratory rate (breath/minute)	70.57	70.77	69.07	69.53	69.57	68.07	75.43	64.93	2.63

T1- Control, T2- Ammonium chloride, T3-Sodium bicarbonate, T4-Calcium chloride, T5-Ascorbic acid, T6- Ammonium chloride + Ascorbic acid, T7-Sodium bicarbonate + Ascorbic acid, T8- Calcium chloride + Ascorbic acid, SEM-Standard error of mean.

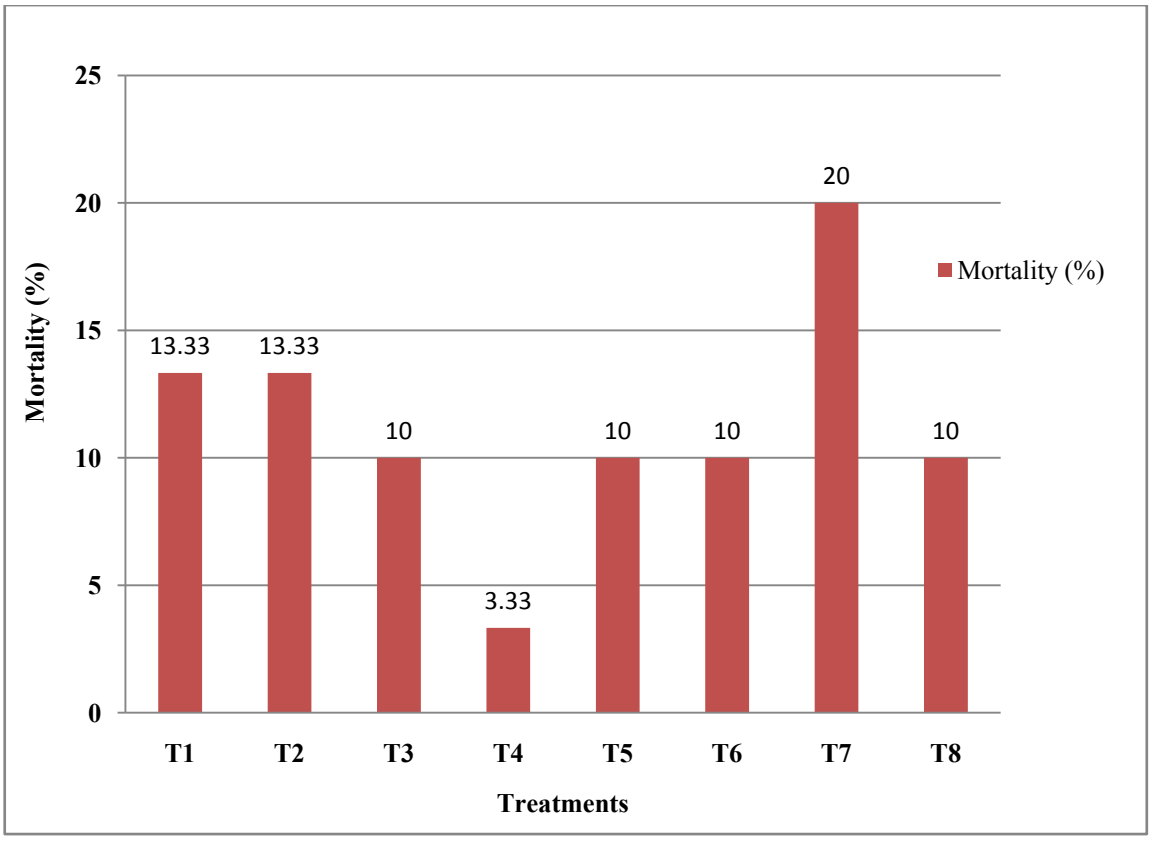


Figure 3. Mortality (%) of Heat Stressed Broiler Birds Given Supplemental Electrolytes and Ascorbic Acid

4. Discussion

In the present study, body weights of the experimental birds were lower than those expected at 49 days of age demonstrating the adverse effects of high ambient temperatures coupled with high humidity experienced by birds throughout the experimental period. The average daily temperature values indicated a range above the thermoneutral zone (18-22℃) for broiler chickens [22] and 18-24℃ for tropical broiler birds [23]. This temperature effect coupled with the recorded high humidity value reduced the feed intake and body weight gain. The observed poor performance of birds in terms of feed intake and weight gain was consistent with earlier reports [12, 14, 24, 25] that supplementation of Vitamin C and electrolytes together in feed or water did not change feed intake. The result however contradicted earlier findings [10, 26, 27] that supplementation of Vitamin C and electrolyte in drinking water or feed at 500-3150 ppm and 300-350 meq/kg increased feed intake. The reduced performance explained the proposition that heat stressed birds' reduced feed consumption to lower the thermogenic effect associated with nutrient absorption, assimilation and utilization [28]. In addition, reduced blood flow to the gastrointestinal tract during heat induced peripheral vasodilation may impair nutrient absorption [29]. The observed FCR and water intake in this experiment agreed with earlier findings [11, 30] that no significant effect of ascorbic acid on FCR was obtained as a result of supplementation of water with ascorbic acid. Also report revealed no improvements in the weight gain, FCR, and survival of heat stressed broiler birds given water supplemented with sodium bicarbonate [31]. However, numerical improvement observed in terms of FCR and water intake of birds to water supplemented with these mitigating agents agreed with other reports [9, 32, 33] in experiments carried out in conditions of high ambient temperature of 41℃.

No significant difference ($p > 0.05$) was noticed in water intake among treatment groups. Nevertheless, water intake increased with the inclusion of electrolytes. The results of this study agreed with the reports [10, 25, 34] on increased water intake in birds given water supplemented with electrolytes. This observation also conformed to the earlier findings [14] that water intake of heat stressed birds increased when given water supplemented with sodium bicarbonate.

Lack of response in the RT in this experiment was supported by reports [11, 35, 36] on the lack of any significant effect of supplemental electrolytes and vitamin C on the RT of broiler birds maintained at 22℃ or exposed to temperature 43℃ despite report that supplemental ascorbic acid reduced RT in heat stressed birds [37]. This study also failed to show any positive effects of the treatments on the RR of the birds contrary to our previous findings [14] in which the treatments reduced the RR of birds. In addition, it disagreed with the reports [37, 38] observations on reduction in panting rate in heat stressed chickens given ascorbic and electrolytes respectively. In the extensive reviews [39-42] on

the subject of heat stress and performance characteristics, it was concluded that differences in response depend on ambient temperature, age of bird, length of exposure to high temperature and management due to method of ascorbic acid preparation, type of ascorbic acid used and the vitamin's innate instability could explain the variability in the results obtained in this experiment compared to others.

5. Conclusions

The electrolytes and ascorbic acid had positive effect on the feed conversion ratio while electrolytes supplementation improved water intake. However, the outcome of this study in terms of synergy established that combination of electrolytes and ascorbic acid did not have a beneficial effect over the individual effect of electrolytes or ascorbic acid.

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