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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Effect of Supplemental Electrolytes and Ascorbic Acid on the Performance and Carcass Characteristics of Broiler Raised During High Temperature Period in Nigeria

B.C. Majekodunmi, O.A. Ogunwole and O.A. Sokunbi
Physiology Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria

Abstract: The effect of supplementing drinking water with sodium chloride, sodium bicarbonate, calcium chloride and ascorbic acid on feed intake, weight gain, Feed Conversion Ratio (FCR), visceral and immunological organs of broilers reared under natural heat stress was undertaken. A total of 200 day-1 Arbor acre strain chickens were randomly divided into five treatments. Each treatment was in quadruplicate of ten chickens each. Treatment 1 (T1) was the control with water without any supplement while treatments T2, T3, T4 and T5 had their water supplemented with 0.5% ammonium chloride, sodium bicarbonate, calcium chloride and 300ppm ascorbic acid respectively. The design of the experiment was a completely randomized design. Birds given salts (T2, T3 and T4) had lower feed intake (721.5 g, 732.6 g and 730.30 g respectively) compared with their counterparts on Treatments 1 and 5 (735.30 g and 733.10 g respectively) Birds on T3 had significantly improved ($p<0.05$) weight gain (331.56 g) and lower FCR (2.22). The FCR generally decreased in birds given salts. The visceral and immunological organs were not significantly affected ($p>0.05$) by the treatment except birds on T4 which recorded significantly lower ($p<0.05$) relative weight of intestine (2.93%), higher weight of bursa of fabricus (0.19%). Conclusively, (0.5%) salts supplementation in water had positive effect on the performance of heat stressed broiler in this experiment.

Key words: Heat stress, supplemental salts, broiler performance, feed conversion ratio, immunological organs, ascorbic acids, visceral organs

INTRODUCTION

Poultry is one of the most efficient industries producing food for human consumption. However, the output of this industry is threatened by climatic, social and physical stressors (Dreiling *et al.*, 1991). Evident climate change arising from increasing global warming underscored the need to appreciate the likely effects of climate on the performance of animals particularly poultry.

Poultry house temperature and humidity are components of microclimate which have significant effect on the productivity, health and consequently on the profitability of poultry production. Poultry, like mammals are homeothermic. They have an external comfort zone of around 18-22°C while their internal environment remains relatively constant (Charles, 2002). Gray *et al.* (2003) demonstrated that broiler subjected to high temperature exhibit many behavioural and physiological responses which allow them to reestablish heat balance with their environment. Among these responses are; spreading of wings away from the body to promote cooling by reducing insulation, crouching near cool surface and resting more during the hot periods. Within the body, there is peripheral vasodilation resulting in an increased non-evaporative heat loss (Macari *et al.*, 1994) and increase in blood glucose concentration as a direct response to greater catecholamine and glucocorticoid secretion (Borges *et al.*, 2003).

High ambient temperature is highly undesirable in broiler production. Its effect is always much greater when coupled with high humidity as water losses its ability to evaporate. Reduced feed intake, growth rate, feed conversion and survivability are immediate consequences of rearing broilers in a hot humid environment (Geraert, 1998).

Different therapeutic agents have been proposed as possible therapies to mitigate the consequence of heat stress on the performance of broiler. These include ascorbic acid (Cier *et al.*, 1992), vitamins B-complex (Bashir *et al.*, 1998), vitamin E (Williams, 1996), acetylsalicylic acid (Stilborn *et al.*, 1988), sodium chloride (Smith, 1994), potassium chloride, potassium carbonate, ammonium chloride (Teeter and Smith, 1986) and sodium bicarbonate (Branton *et al.*, 1986).

In Nigeria, however, the utilization of electrolytes in ameliorating the adverse effect of heat stress in broiler is not adequately documented. This study therefore was conducted to evaluate the effect of selected electrolytes and ascorbic acid supplementation in drinking water on the performance visceral and immunological organs of broiler exposed to heat stress.

MATERIALS AND METHODS

The study was carried out at the Teaching and Research Farm of the University of Ibadan, Ibadan which is located

Corresponding Author: O.A. Ogunwole, Physiology Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria

Table 1: Gross composition of experimental diets

Feed ingredients (%)	Starter diet	Finisher diet
Maize	52.00	52.00
Wheat offals	7.73	7.73
Soybean meal	35.00	30.00
Palm kernel meal	-	4.50
Palm oil	2.50	3.00
$CaCO_3$/Oyster shell	0.50	0.50
Dicalcium phosphate	1.50	1.50
Salt	0.25	0.25
Methionine	0.15	0.15
Lysine	0.06	0.06
Broiler premix*	0.25	0.25
Avatec	0.06	0.06
Total	100.00	100.00
Calculated analysis		
Crude Protein	22.97	19.06
Metabolizable energy kcal/kg	3007.70	3018.90
Calorie: Protein Ratio	136.4:1	152.8:1

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

between latitudes 6010" and 9010" North of the equator and longitudes 30 and 60 of the Greenwich for a period of seven weeks.

A total of 200 day-1 old Arbor acre strain broiler chicks were used for the experiment. After one week of brooding, they were weighed and randomly allotted to five treatments. Each treatment was replicated four times with ten birds per replicate in a Completely Randomized Design (CRD). Ambient temperature and humidity of the poultry house were recorded daily at 8, 13 and 20 hrs using thermo hygrometer.

Broiler starters and finishers' diets containing 3000 kcal/kg ME, 23% CP and 3000 kcal/kg ME and 19% CP respectively were formulated and were offered *ad libitum* to the birds throughout the course of the experiment. The composition of the experimental diets is shown in Table 1. Clean water in which test electrolytes or ascorbic acid has been added was provided *ad libitum*. Treatment 1(control) was without any electrolytes or vitamin, Treatment 2 (0.5% ammonium chloride), Treatment 3 (0.5% sodium bicarbonate), Treatment 4 (0.5% calcium chloride), Treatment 5 (300 ppm ascorbic acid).

The quantity of feed consumed per bird daily was recorded for each treatment by subtracting the leftover from the quantity of feed offered. Weekly and overall FCR were determined by dividing the appropriate feed intake with average weight gained. At week 7, five birds from each replicate were slaughtered. Liver, gizzard, heart, proventriculus, intestine, abdominal fat, adrenal gland, thymus, spleen and bursa of fabricus were harvested, weighed and were related to percentage body weight of the broiler chickens.

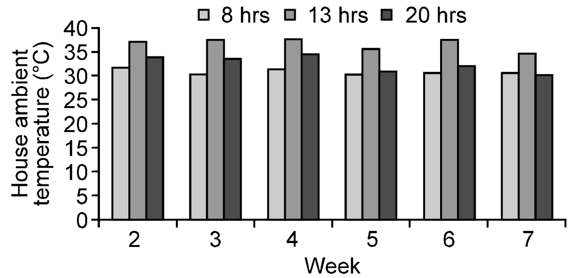

Fig. 1: Weekly poultry house ambient temperature

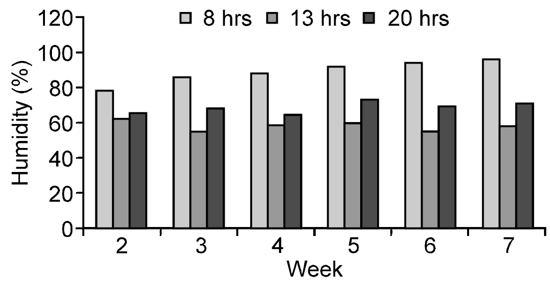

Fig. 2: Weekly poultry house humidity

Statistical analysis: Data generated were analyzed using General Linear Model (GLM) of SAS software (SAS, 1999). Treatment means were compared by Duncan Option of the software.

RESULTS AND DISCUSSION

Figure 1 and 2 shows the average weekly experimental house temperature and humidity. The recorded ambient temperature during in the period indicated a range (30.90-36.73°C) well above the thermo neutral zone (18-22°C) for broiler (Charles, 2002) indicating a perpetual exposure of birds to heat stress. Behavioural responses such as panting, crouching near cool surfaces and wide spreading of the wings were thus observed during the experimental period. According to Gray *et al.* (2003), panting would normally be expected to occur when the ambient temperature is near or above 30°C.

A range of 58.48-89.24% relative humidity was observed which was quite high. High humidity above 60% has been reported to impair the heat transmission from body core to peripheral at 35°C but facilitate it at 30°C in broiler chickens of 4-week age (Lin *et al.*, 2006). These prevailing weather conditions indicated that birds were subjected to moderately high temperature and humified environments.

Feed intake: As shown in Table 2, FJ increased with age. Significant differences ($p<0.05$) were only observed in week 2, 3 and 4. During week 5 and 6, Treatment 1 had the highest (851.88 g and 974.50 g respectively) feed intake which slightly dropped in week 7 when Treatment 5 had the highest (997.50 g) feed intake.

Table 2: Weekly feed intake of heat stressed broiler given electrolytes and ascorbic acid

Treatment	2nd week	3rd week	4th week	5th week	6th week	7th week
1	327.50[a]	470.73[b]	826.90[abc]	851.88	974.50	960.50
2	346.88[a]	490.13[b]	756.88[c]	801.25	951.50	982.08
3	331.88[a]	503.75[ab]	760.63[a]	841.88	971.25	986.25
4	247.50[b]	561.50[a]	788.88[ab]	847.50	963.88	972.50
5	337.50[a]	485.13[b]	795.58[a]	817.93	965.00	997.50
SEM	6.36	3.65	6.52	17.49	14.69	22.31

[abc]Means in the same column 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

Table 3: Weekly weight gain of heat stressed broiler given electrolytes and ascorbic acid

Treatment	2nd week	3rd week	4th week	5th week	6th week	7th week
1	146.25[ab]	259.38[b]	350.00	356.25	340.00[ab]	497.50
2	161.25[a]	277.50[ab]	335.00	332.50	342.00[ab]	494.25
3	149.38[ab]	291.25[a]	341.25	332.50	393.75[a]	481.25
4	146.88[ab]	270.00[ab]	347.50	380.00	327.00[b]	461.25
5	144.50[b]	275.00[ab]	373.75	313.75	363.75[ab]	465.00
SEM	2.38	4.03	6.54	15.55	13.64	18.45

[abc]Means in the same column 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

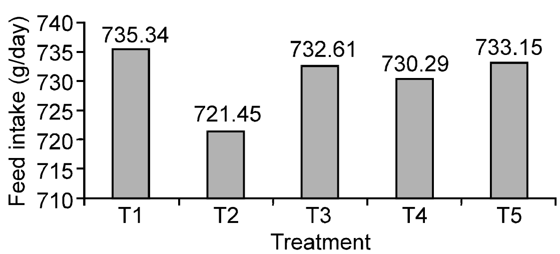

Fig. 3: Average feed intake of heat stressed broiler given salts and ascorbic acid. T1 - Control, T2 - Ammonium chloride, T3 - Sodium bicarbonate, T4 - Calcium chloride, T5 - Ascorbic acid

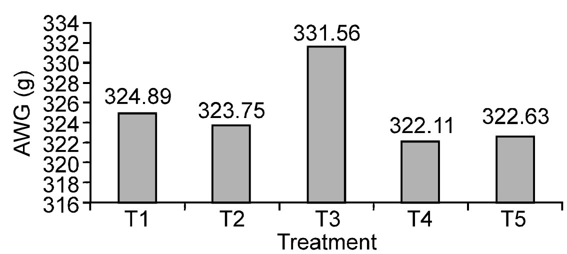

Fig. 4: Overall weight gain (g) of heat stressed broiler given salts and ascorbic acid. T1 - Control, T2 - Ammonium chloride, T3 - Sodium bicarbonate, T4 - Calcium chloride, T5 - Ascorbic acid. AWG - Average Weight Gain

Figure 3 shows the overall FI of each treatment throughout the experimental period. Birds on Treatment 1(control) had the highest FI followed by those on Treatment 5 (Ascorbic acid). Birds on treatments 2, 3 and 4 (i.e. birds that were given electrolytes) had lower FI compared with their counterpart on treatments 1 and 5. This implied that salts inclusion in water did not increase the FI of heat stressed broiler contrary to the report of Teeter (1994) that potassium chloride supplement (0.5%) in drinking water enhanced the feed consumption of broilers.

Body weight gain: Table 3 shows the weekly weight gain of birds. Significant variations ($p<0.05$) were observed in weeks 2, 3 and 6. The weekly weight gain of birds steadily increased from week 2 to week 4 after which a decline was observed in week 5 and 6 and later increased in week 7. In week 4, the highest weight gain (373.75 g) was recorded for birds on treatment 5 while birds on treatment 1 had the highest weight gain (497.50 g) in week 7.

Figure 4 shows the overall average weight gain throughout the experimental period. Birds on treatment 3 supplemented with 0.5% sodium bicarbonate solution exhibited a better weight gain than birds on other treatments. This result agreed with the earlier observation in broiler (Teeter *et al.*, 1985) and turkey (Balnave and Gorman, 1993). This marked improvement might be due to bicarbonate anion provision as heat exposed birds may exhibit reduced level of plasma carbon dioxide and bicarbonate that may affect the blood pH. Thus the provision of bicarbonate for birds in treatment 3 may offset the induced nutritional as well as physiological requirement for bicarbonate (Teeter *et al.*, 1985).

Feed Conversion Ratio (FCR): Table 4 shows the values obtained for weekly FCR. Significant differences ($p<0.05$) were observed in week 2 and 3. In week 2, birds on treatment 4 had the best FCR (1.71) which was significantly different from those obtained for other treatments though, reverse was the case in week 3.

Figure 5 shows the overall average feed FCR of each treatment throughout the experimental period. FCR is a reflection of the quality of feed and the ability of the

Table 4: Weekly feed conversion ratio of heat stressed broiler given electrolytes and ascorbic acid

Treatment	2nd week	3rd week	4th week	5th week	6th week	7th week
1	2.25[a]	1.82[b]	2.36	2.40	2.87	1.98
2	2.15[a]	1.77[b]	2.26	2.47	2.81	2.00
3	2.22[a]	1.73[b]	2.24	2.59	2.49	2.05
4	1.71[b]	2.09[a]	2.29	2.24	2.96	2.13
5	2.34[a]	1.76[b]	2.14	2.68	2.68	2.21
SEM	0.06	0.03	0.05	0.09	0.18	0.08

[abc]Means in the same column 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

Table 5: Visceral and immunological organs of heat stressed broiler given electrolytes and ascorbic acid solution

Organs	T1	T2	T3	T4	T5	SEM
Live weight (kg)	2.36	2.27	2.29	2.31	2.35	31.990
Kidney (%)	0.58	0.53	0.54	0.54	0.57	0.006
Heart (%)	0.38	0.35	0.33	0.37	0.34	0.009
Lung (%)	0.43	0.42	0.39	0.43	0.46	0.008
Liver (%)	1.48	1.47	1.42	1.46	1.58	0.019
Spleen (%)	0.07	0.08	0.08	0.09	0.07	0.030
Thymus (%)	0.14	0.14	0.15	0.14	0.13	0.008
Adrenal gland (Left) (%)	0.0034	0.0029	0.0097	0.0029	0.0067	0.0009
Adrenal gland (right) (%)	0.0025	0.0024	0.0025	0.0028	0.0030	0.0000
Bursa of fabricus (%)	0.12[b]	0.13[b]	0.13[b]	0.19[a]	0.10[b]	0.006
Proventriculus (%)	0.35	0.29	0.33	0.32	0.32	0.008
Gizzard (%)	1.87	1.71	1.73	1.93	1.70	0.036
Intestine (%)	3.39[a]	3.09[ab]	3.19[ab]	2.93[b]	3.17[ab]	0.047
Crop (%)	0.67	0.61	0.62	0.68	0.63	0.017
Pancreas (%)	0.16	0.15	0.17	0.16	0.16	0.003
Abdominal fat	2.09	2.25	1.93	1.79	2.12	0.080

[ab]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

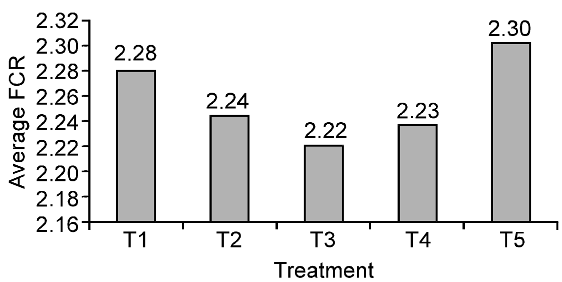

Fig. 5: Overall feed conversion ratio of heat stressed broiler given salts and ascorbic acid. T1 - Control, T2 - Ammonium chloride, T3 - Sodium bicarbonate, T4 - Calcium chloride, T5 - Ascorbic acid. FCR - Feed conversion ratio

animal to digest and utilize it. As shown in the figure, birds on treatments supplemented with electrolyte solution, exhibited better FCR than those on treatments 1(control i.e. no supplementation) and 5 (ascorbic acid supplementation).

It can then be inferred that improvement in FCR of birds on Treatments 3, 2 and 4 was due to ammonium chloride, sodium bicarbonate and calcium chloride supplementation respectively which agreed with earlier reports (Keskin and Durgan, 1997; Lopez and Austic, 1993) of improvement in FCR after electrolytes supplementation.

Results of visceral and immunological organs are shown in Table 5. There were no observed significant differences ($p>0.05$) in the live weight at the end of the study. Live weight ranged from 2.27 to 2.36 kg. However, on the average, birds on treatments 4, 5 and 1(control) had higher numerical weight than those on other treatments. Significant variations ($p<0.05$) were only observed in the relative weights of bursa of fabricous and intestine of birds on Treatment 4 which had lower ($p<0.05$) relative weight of intestine (2.93%) and higher ($p<0.05$) weight of bursa of fabricous (0.19%) which significantly differ from other treatments. The reduction in the intestinal weight observed in this study is in agreement with the findings of Mitchell and Carlisle (1992), Dibner *et al.* (1996) and Howard *et al.* (2004). They all reported reduction in both wet and dry weight of intestine of birds raised under high environmental temperature. Intestine is a metabolically active organ (Spratt *et al.*, 1990) and its development has been noted to be affected by many factors especially stress (Mitchell and Carlisle, 1992). On the other hand, increased bursa of fabricous weight observed in this study is contrary to the observation of Guyton and Hall (1997) who reported that heat stress increased cortisol secretion which in turn caused atrophy of lymphoid tissue. Puvadolpirod and Thaxton (2000) also reported regression of lymphoid organs as an important response of chicken to chronic stress. Reduction in the weight of bursa and its ratio to body weight was also reported by Lecui *et al.* (1998).

According to Cazaban and Yannick (2011), bursa of fabricous appearance, size and weight can be evocative of some physiological disorders such as stress and disease. There is no standard of size for a given age in a given breed as it is known to be affected by a variety of factors such as age, breed, sex and rearing conditions. Hypertrophied bursa of fabricous is suggested to be an indication of early infection by infectious bursa disease virus which is on the process to get atrophied (i.e turning into chronic stage) or already in a recovery process. More also, difference in the average bursa/body ratio can be noticed between males and females: most of the time, the bursa/body ratio in males is lower than in females, this is probably linked to the heavier body weight in males. Either of the aforementioned explanation could be responsible for the increased relative weight of bursa of fabricous recorded for birds on treatment 4 in this study.

Conclusions and applications: Under the condition of the present study, ascorbic acid in water of heat stressed broilers increased survivability but did not positively affect the body weight and feed conversion ratio. However, higher concentration of ascorbic acid in water for broiler should be further studied. Broilers responded positively to sodium bicarbonate supplementation in water with regard to the body weight, feed conversion ratio and survivability. The dietary water supplementation with electrolytes and or ascorbic acid should be considered during heat stress because of their potential positive economic impact.

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