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Effect of water electrolyte supplementation on performance, serum and haematological indices of broiler chickens under heat-stressed condition

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Target Audience: *Farmers, Researchers and Policy makers*

Abstract

In a study to assess the effect of electrolyte supplementation on performance of broiler chicken, 192 day-old Abor Acre broiler chicks were randomly allotted to 4 treatments: T1 – un-supplemented water, T2 - 0.5% NaCl, T3 - 0.5% KCl and T4 - 0.5% $NaHCO_3$, with 6 replicates each in a completely randomized design. Initial weight, final weight, weight gain, feed intake were recorded and feed conversion computed. Mortality was recorded when observed. Ambient temperature and relative humidity were monitored daily. At the end of day 28, rectal temperature of each bird was recorded weekly for 3 weeks using a digital thermometer. At day 42, blood (5mls) was collected for haematological indices and plasma separated for the determination of Cl, Na, K, Ca, P, Mg, HCO_3. Data obtained were analyzed and means separation determined by least significant differences ($p<0.05$) using the SAS Institute statistical software. Under heat stress, 0.5% KCl and 0.5%NaCl supplementation in water reduced rectal temperature, increased body weight, improved FCR, and reduced blood pH. Electrolyte supplementation also influenced red blood cell count as well as serum levels of sodium, potassium and bicarbonate. Supplementing KCl and NaCl in drinking water may be a means to improve productivity of broiler under high temperature and humidity conditions.

Keywords: Electrolytes, broiler chicken, performance, heat stress

Description of Problem

High temperature is a major limitation to growth and meat yield of broilers raised in tropical countries of the world (1). Reduced feed intake, growth rate, feed conversion, survivability, dressing yield and increased rectal temperature are the immediate consequences of rearing broilers in a hot humid environment. Depleted performance and decreased profitability of broilers are aggravated when high temperature is associated with high humidity. Numerous compounds have been added to broiler feed and water in attempts to help to alleviate the adverse effects of heat stress. Under heat stress conditions, the concentration of Cl ions in the blood increases whereas concentration of Na and K decreases causing blood acidification that resulted in low blood electrolyte balance and increased blood Cl contents (2, 3). Responses of birds to hot environments are in part mediated through changes in circulatory levels of hormones, glucose, electrolysis and leucocytes and the function of organs (4, 5). To minimize heat load, birds will reduce feed intake and increase evaporative heat loss. This will cause loss of CO_2 but it will induce an increase in blood pH. As the heat load increases, the resulting increase in the body temperature will lead to tissue damage and release of intracellular components into the circulation (6). Most heat stressed studies were carried out using dietary electrolytes balance (DEB) inclusion as a means of heat dissipation. Therefore, water electrolytes supplementation needed to be given priority, as birds tend to reduce the feed intake and thus increase water intake during high ambient temperature.

The study was envisaged to evaluate the effect of water electrolyte supplementation on growth performance, serum and haematological indices of Abor acre broilers under heat-stressed condition.

Materials and Methods

This research was carried out at the Poultry unit of the Teaching and Research Farm, University of Ibadan, Nigeria. A total of one hundred and ninety two (192) 1 Day old Abor Acre broiler chicks were allotted to 4 experimental treatments replicated 6 times with each replicate having eight (8) birds in a completely randomized design (CRD). Each bird was tagged and weighed. The experimental period was divided into two phases that is starter (day 1 to 21) and finisher (day 22 to 42) according to the recommendation of Abor Acre management guides. The starter ration was fed for the first 3 weeks after which a finisher ration was introduced until the end of the trial (Table 1). Feed was provided on *ad libitum basis*. Solutions were mixed and filled as needed in 2 litres quantities on a weight and volume basis. Ten grams of feed grade of the solution were added to 2 litres water in line with recommendation of electrolyte-water mixture: T1 – un-supplemented water, T2 - 0.5% NaCl, T3 - 0.5% KCl and T4 - 0.5% $NaHCO_3$.

Data Collection

Data on feed intake (FI), body weight gain (BWG) and feed conversion ratio (FG) was recorded weekly. Water intake (WI) was recorded on a daily basis. Environmental temperature and relative humidity were recorded every 4 hours (Table 2). At the end of day 28, rectal temperature of each bird was recorded weekly for 3 weeks using a digital thermometer. At day 42, blood (5mls) was collected from the jugular vein into ethylene diamine tetra acetic acid (EDTA) coated vacutainer for immediate pH monitoring. Blood plasma was separated by centrifugation of blood samples at 2,000 x g for 15 min (3) and was analyzed for mineral (Cl, Na, K, Ca, P, Mg, HCO) contents. The packed cell volume (PCV) and haemoglobin were determined using the micro haematocrit method and cyanmethehemoglobin method respectively as described (7). Erythrocyte count (RBC) and leukocyte count (WBC) were determined using improved Neubauer haemocytometer after the appropriate dilution (8). Differential leukocyte counts were determined by scanning Giemsa's stained slides in the classic manner (8). Data was subjected to analysis of variance, with means separations determined by least significant differences ($p<0.05$) using the SAS Institute statistical software.

Table 1: Gross Composition of Experimental Diets

Ingredients	Starter	Finisher
Maize	58.00	56.50
Groundnut cake	33.00	9.50
Soya bean meal	4.60	-
Wheat bran	-	10.00
Full fat soya	3.00	20.00
Fish meal 72	0.50	0.30
Oyster shell	0.50	1.00
Di-calcium phosphate	2.50	1.95
Salt	0.25	0.25
DL-Methionine	0.15	0.15
L-Lysine	0.25	0.10
Broiler premix[1]	0.25	0.25
Total	100	100
Calculated analysis		
Metabolizable energy (kcal/kg)	3005.3	3000.3
Crude protein (%)	23.11	19.72
Crude fiber (%)	3.82	3.79
Ether extract (%)	3.86	5.51
Calcium	1.02	1.12
Available phosphorus	0.55	0.45

[1]Provided per kg of Diet: Selenium-250 µg; Vitamin A-8,250 IU; Vitamin D3-2,750 IU; Vitamin A-17.9 IU; Menadione- 1.1 mg; Vitamin B12-12 µg; Biotin-41 µg; Choline-447 mg; Folic acid-1.4 mg; Niacin-41.3 mg; Pantothenic acid-11 mg; Pyridoxine-1.1mg; Riboflavin-5.5 mg; Thiamine-1.4 mg; Iron-282 mg; Magnesium-125 mg

Table 2: Mean Ambient Temperature and Relative Humidity from Weeks 4 To 6

	Temperature(C)			Humidity (%)		
Week	Minimum	Maximum	Mean	Minimum	Maximum	Mean
4	28.70	31.20	29.95	70.10	76.20	73.30
5	29.70	31.0	30.35	72.30	78.40	75.35
6	29.80	35.60	32.70	75.30	83.60	79.45

Results and Discussion

There were significant differences ($p<0.05$) observed for weight gain, FCR and water intake (Table 3). Electrolyte supplemented birds had significantly higher weight gain (Control – 1630.0; NaCl – 1683.3; KCl – 1687.7 and NaHCO3 – 1651.4) and lower FCR (Control – 1.93; NaCl –1.83; KCl – 1.80 and NaHCO3 – 1.82) than control broilers. Water intake values (Table 4) were highest and lowest in birds on 0.5% NaCl and control birds respectively. The results of the study (Table 5) also revealed significant differences ($p<0.05$) for serum levels of Na, K and HCO_3. Sodium levels were highest on 0.5% $NaHCO_3$and lowest for control birds. However, 0.5% KCl resulted in the highest value for K while control and 0.5%NaCl gave the lowest values. In this study, non-supplemented birds had poorer performance than electrolyte supplemented birds, when birds were exposed to heat stress. Weight gain was lower and FCR was higher without electrolyte supplementation. This agrees with the previous findings (9), whereby electrolyte supplementation was observed to improve weight gain under high ambient temperatures. Similarly, KCl supplementation has also been reported to increase the BW gain and survivability in chickens to varying degrees (10). This also agrees with previous findings by (11), who demonstrated that chronic exposure to temperatures of 32°C from periods of 14 to 28 days of age as well as 27 to 41 days of age impaired performance in broiler chickens. However, the significant differences observed in the weight gain of this study was in line with a review (12) which estimates that broiler performance is optimal in a temperature range of approximately 18-22°C. Temperatures beyond this point that approach the upper critical temperature can affect performance.

Table 3: Performance of Heat Stressed Broilers Supplemented with Electrolytes in drinking water

Parameters	Week	Control 0%	0.5%NaCl	0.5%KCl	0.5%$NaHCO_3$	SEM	Sig.
Initial weight (g)		53.20	53.00	52.23	53.60	0.78	ns
Feed intake (g)		3147.00	3079.00	3044.00	3007.00	53.20	ns
Final weight (g)		1683.00	1737.00	1740.00	1657.00	74.20	ns
Weight gain (g)		1630^{b}	1683.8^{a}	1687.77^{a}	1651.4^{a}	39.32	**
FCR		1.931^{a}	1.8286^{b}	1.804^{b}	1.821^{b}	0.07	**
Water intake (ml)	4	216.7^{c}	326.8^{a}	273.4^{ab}	240.5^{b}	2.45	**
	5	242.5^{b}	324.8^{a}	325.7^{ab}	334.8^{ab}	2.65	**
	6	260.1^{b}	324.3^{a}	321.6^{a}	306.5^{ab}	2.73	**

^{abc}mean in a row with different superscripts are significantly different ($p<0.05$)
NS=P>0.05, **=P<0.05, SEM= Standard error of mean

Table 4: Serum Biochemistry of Heat stressed Broilers Supplemented with Electrolytes in Drinking Water

Salts	Control	0.5%NaCl	0.5%KCl	0.5%$NaHCO_3$	SEM	Sig
Na (mEq/L)	169.07^{c}	177.50^{b}	208.96^{ab}	223.51^{a}	11.39	**
K (mEq/L)	3.48^{b}	3.49^{b}	4.52^{a}	4.16^{ab}	0.23	**
Cl (mg/dl)	95.58	102.16	114.14	115.50	8.57	NS
Ca (mg/dl)	9.46	9.45	10.42	11.13	0.65	NS
HCO_3	15.57^{b}	14.29^{b}	18.39^{a}	19.19^{a}	0.78	**

^{abc}mean in a row with different superscripts are significantly different ($p<0.05$)
NS=P>0.05, **=P<0.05, SEM= Standard Error Mean
Keys: NS means no significant difference

Table 5: Effects of Electrolytes Supplementation on Rectal Temperature, Mortality Rate and Blood pH Of Broilers Raised under Heat Stress

		Treatments				SEM	sig
Variables	Week	Control	0.5%NaCl	0.5%KCl	0.5%$NaHCO_3$		
Rectal temperature (C)	4	41.32^{a}	41.17^{b}	41.15^{b}	41.20^{ab}	0.13	**
	5	41.37^{a}	41.16^{b}	41.13^{b}	41.25^{a}	0.19	**
	6	41.24^{a}	41.21^{a}	41.00^{b}	41.22^{a}	0.21	**
Blood Ph		7.39^{a}	7.34^{ab}	7.30^{b}	7.36^{ab}	0.48	**

^{a,ab,bc}mean values in the same column bearing different superscripts are significantly different.
NS=P>0.05, **=P<0.05, SEM= Standard Error Mean
NS means no significant difference

In this study, mortality was highest during the last two weeks of the experiment in both control and 0.5% $NaHCO_3$. This reflects the increasing heat problems with increasing body weight. This is in agreement with (13, 14), who observed that light birds generally respond better to heat than heavy birds. High level of NaCl in broiler diets has been noted to increase the risk of Sudden Death Syndrome (15) and ascites (16) under moderate climatic conditions.

Presented in Table 4 is the effect of electrolyte supplemen-tation on rectal temperature, mortality and blood pH of broiler chicken exposed to heat stress. Significant differences ($p<0.05$) were observed for rectal temperatures at weeks 4, 5 and 6. Non-supplemented birds had the highest temperature, while birds on 0.5% KCl had the lowest temperature. Also blood pH and mortality were significantly influenced by electrolyte supplementation. Heat stress resulted in lowered Na^+, Cl^-, Ca^{2+}, and K^+ levels, while increasing blood HCO_3 in birds with electrolyte supplementation. Similar effects were noted in broiler chickens at 34°C over a 6-h period, although the decrease in Ca observed in this case was not significant (17). It can be expected that serum HCO_3 in control treatment increased during the heat stress as birds displayed visibly increased panting during that period in order to facilitate evaporative cooling and can lead to an increase in blood pH (18). Lower K^+ concentrations observed in the control group may have been due to increased excretion due to respiratory alkalosis. During respiratory alkalosis, there is reduced competition between H^+ and K^+ ions for urinary excretion, thus resulting in the increased excretion of K^+ (18). However control birds had similar HCO_3 levels with birds on 0.5% KCl, which had more blood CO_2 that may have been incorporated into bicarbonate to neutralize excess acid. However, bicarbonate levels did not significantly differ between the two other treatment groups, which may be due to the fact that birds are efficient at re-absorption of filtered bicarbonate during acidosis (19). Serum Cl and HCO_3 concentrations vary inversely, in order to maintain the proper total anion strength needed to compliment the blood Na, so as Cl goes up HCO_3 goes down and vice versa.

Table 6: Haematological Indices of Heat stressed Broilers Supplemented with Electrolytes in Drinking Water

Variables	Treatments				SEM	Sig
	Control	0.5% NaCl	0.5% KCl	0.5%$NaHCO_3$		
PCV (%)	26.83	28.83	25.17	27.83	2.26	NS
Hb (g/dl)	8.90	9.70	8.63	9.25	0.75	NS
RBC (10^6ul)	3.25^b	4.12^a	3.15^b	3.53^{ab}	0.22	**
WBC (10^3ul)	20.93	20.83	23.59	20.57	2.09	NS
Lymp %	67.50	63.50	66.83	65.83	2.76	NS
Hetero%	25.50	30.17	22.83	28.17	3.00	NS
Mono %	2.17	3.50	3.50	3.33	0.60	NS
Eios %	4.17^a	2.17^b	3.33^{ab}	2.50^{ab}	0.55	**
Baso %	0.50	0.17	0.17	0.17	0.18	NS
Plateletx(10^9)	198.67	204.33	243.33	190.50	22.40	NS

^{abc}mean in a row with different superscripts are significantly different ($p<0.05$)
NS=P>0.05, **=P<0.05, SEM= Standard Error Mean
Keys: NS means no significant difference, ** means significant difference

In this report, electrolyte supplementation influenced rectal temperature (Table 5). This was not consistent with (20) who reported lower body temperature of birds supplemented with electrolytes. Also, (Table 4) water supplemented with 0.5% KCl reduced blood pH by the 42nd day in the present study. However, 0.5% NaHCO3 did not reduce the alkaline blood pH to a level considered as favourable (21) for physiological functions of a bird. The results from this study suggested that 0.5% NaCl reduces the alkalotic pH as compared with 0.5% KCl. In general, hyperthermia induced hyperventilation and associated respiratory alkalosis, which lead to increased blood partial pressure of CO_2 (22). Apparently, KCl inclusion might not affect blood pH considerably because it contains both positive (K^+) and negative (Cl^-) ions. However, the reduction in blood pH in this study was in agreement with previous report (3) where there was decrease in blood pH during heat stress with 0.5% KCl supplementation. Likewise, work done (9) showed a linear increase in BW gain, while no effect on blood pH was observed at 0.05, 0.10, and 0.15 K^+ and KCl supplementation in drinking water. One possible reason for low pH with 0.5%KCl in this study might be acidogenic effect of Cl^- and maintenance of blood electrolyte balance due to increased blood k^+ contents (3).

There were no significant differences (p>0.05) observed for all the haematological indices assessed except red blood cells and eiosenophils counts (Table 6). It was observed that values for RBC was highest and lowest for birds on 0.5%NaCl and control respectively, while EOS values were highest for control and lowest at 0.5%NaCl. Changes in red blood cell and eiosonophils concentrations may have been caused by hemodilution, a mechanism allowing for evaporative water loss without compromising plasma volume in the body (23).

Conclusion and Applications

1. Under tropical summer condition, KCl and NaCl supplementation in drinking water were more effective on body temperature and body weight modulation of broilers than that of $NaHCO_3$ supplementation.
2. The concentration of 0.5% KCl and 0.5%NaCl reduced body temperature, increased body weight, improved FCR, and reduced blood pH to almost normal blood pH.
3. KCl and NaCl supplementation also produced expected haematological indices and enhanced serum biochemistry.
4. Potassium chloride and NaCl in drinking water may be a means to improve productivity of broilers under high temperature and humidity conditions. Therefore, interaction between these salts at higher levels of concentration and economic aspect should be further studied.

References

1. Hulet, R., Gladys, G., Hill, D., Meijerhof, R. and El-Shiekh, T. (2007). Influence of egg shell temperature and broiler breeder flock age on posthatch growth performance and carcass characteristics. *Poult. Sci.* 86:408-412 24
2. Belay, T. and Teeter, R. G. (1993).Broiler water balance and thermobalance during thermoneutral

and high ambient temperature exposure. *Poultry Sci*. 72, 116-124.

3. Ahmad, T., Sarwar, M., Nisac, M. U., Haq, A. U. and Hasan, Z. U. (2005). Influence of varying sources of dietary electrolytes on the performance of broilers reared in a high temperature environment. *Animal Feed Science Technology*,120:277–298.
4. Smith, M. O. (1994). Effect of electrolytes and lighting regimen on growth of heat distressed broilers. *Poultry Science*, 73:350-353
5. Mitchell, M. A. and Kettlewell, P. J. (1988).Physiological stress and welfare of broiler in transit solution not problems. *Poultry Science Journal*, 77:1803-1814
6. Whitehead, C. C. and Keller, I. (2003). An update on ascorbic acid in poultry. *World Poultry Science Journal* 59:161-184
7. Mitruka, B. M. and Rawnsley, H. M. (1977). Clinical biochemical and haematological reference values in normal experinmental animal. New York mass publishing.
8. Schalm, O. W., Jane, N. C. and Carol, E. J. (1975). Veterinary haematology. 3rd. edition. Lca and Febiger Philadelphia.
9. Ait-Boulashen, J., Garlich, D. and Edens, F. W. (1995). Potassium chloride improves the thermotolerance of chickens exposed to acute heat stress. *Poultry Science*, 74:78-79.
10. Teeter, R. G. and Smith, M. O. (1986). High chronic ambient temperature stress effects on broiler acid-base balance and their response to supplemental ammonium chloride, potassium chloride, and potassium carbonate. *Poultry Science*, 65:1777-1781.
11. Geraert, P. A., Padilha, J. C. F. and Guillaumin, S. (1996). Metabolic and endocrine changes induced by chronic heat exposure in broiler chickens: Growth performance, body composition and energy retention. *British Journal of Nutrition* 75:195-204.
12. Charles, D. R. (2002). Responses to the thermal environment. In: Charles, D.R. and Walker, A.W. (eds) Poultry Environment Problems, a guide to solutions. Nottingham University Press, UK, P.1–16.
13. Meltzer, A. (1978). Acclimatization to ambient temperature and its nutrition consequences. *World's Poultry Science Journal* 43:33-44.
14. Molero, C. (2007). Nutritional solutions to heat stress. *International Poultry Production*, 15 (5):27-29.
15. Grashorn, M. (1994).Investigation of the aetiology and pathology of sudden death syndrome in meat type chickens. *Arch. Geflügelk*. 58:243-244.
16. Shlosberg, A., Bellaiche, M., Zeitlin, N., Yaacobi, M. and Cahaner, A. (1996). Haematocrit values and mortality from ascites in cold-stressed broiler from parents selected by haematocrit. *Poultry Science*, 75:1-5.
17. Mujahid, A., Akiba, Y. and Toyomizu, M. (2009). Progressive changes in the physiological responses of heat-stressed broiler chickens. *Journal of Poultry Science*, 46:163-167.
18. Borges, S. A., Fischer da Silva, A.V. and Maiorka, A. (2007). Acid-base

balance in broilers. *World's Poultry Science. Assoc*. 63:73-81.

19. Toyomizu, M., Tokuda, M., Mujahid, A. and Akiba, Y. (2005). Progressive alteration to core temperature, respiration and blood acid-base balance in broiler chickens exposed to acute heat stress. *Journal of Poultry Science* 42:110-118.
20. Borges, S. A., Fischer da Silva, A. V., Ariki, J., Hooge, D. M. and Cummings, K. R. (2003). Dietary electrolyte balance for broiler chickens under moderately high ambient temperatures and relative humidities. *Poultry Science*, 82:301–308.
21. Hurwitz, S., Cohen, I., Bar, A. and Bornstein, S. (1973). Sodium and chloride requirements of the chick: Relationship to acid- base balance. *Poultry Science*, 52:903–909.
22. Borges, S. A., Fischer da Silva, A. V., Ariki, J., Hooge, D. M. and Cummings, K. R. (2003b). Dietary electrolyte balance for broiler chickens exposed to thermoneutral or heat-stress environments. *Poultry Science*, 82:482–435.
23. Borges, S.A., Fischer Da Silva, A. V., Meira, A.D.A., Moura, T., Maiorka, A. and Ostrensky, A. (2004).Electrolyte balance in broiler growing diets. *International Journal of Poultry Science*, 3:623-628.