APRW -20

Response of Heat-Stressed Broiler Chicks to Varying Dietary Electrolyte Balance at Pre-Starter and Starter Phases

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Abstract
Heat stress in the tropics is a limitation to production efficiency of broiler chickens (BC), as early chick mortality is aggravated by sharp fluctuations in brooding temperature, high relative humidity and environmental temperatures. The balance of acid-base in broilers could be enhanced by supplementing diets or water of BC under heat stress with electrolytes. However, information on the ideal dietary electrolyte balance (DEB) of BC under heat stress at pre-starter and starter phases is scanty. Therefore, a study was carried out using a total of 300, one-day-old Arbor Acre chicks that were randomly allotted to six dietary treatments [210 (T_1), 240 (T_2), 270 (T_3), 300 (T_4), 330 (T_5) and 360 (T_6)] mEq/Kg DEB, in a completely randomized design. Birds were reared at pre-starter phase (PSP) of 0–14 days and starter phase (SP) of 14 - 21 days, under the temperature-humidity index of 24.97 - 35.19. Feed intake (FI, g/bird), body weight (BW, g/bird), body weight gain (BWG, g/bird), feed conversion ratio (FCR), and mortality (%) were monitored. Data were analysed using descriptive statistics and ANOVA at α0.05. Birds on T_3 had lower FI (409.28 ± 34.79) compared to T_5 (460.82 ± 31.94), but did not differ significantly from birds on T_1 (443.16 ± 18.18), T_2 (437.20 ± 25.61), T_4 (426.17 ± 19.59), and T_6 (431.66 ± 45.24) at PSP. The BW and BWG of chicks were not significantly affected at PSP and SP. The FCR of birds on T_3 was significantly improved at PSP (1.38 ± 0.09) and SP (1.30 ± 0.04). A dietary electrolyte balance of 270 mEq/kg improved performance of pre-starter and starter chicks.

Keywords: Dietary electrolyte balance, broiler chicks, heat stress

Introduction
Metabolic activities and fast-growing rate of broiler chicks pose difficulty in coping with heat stress that is prevalent in the tropics because exposure to heat stress for long period suppresses the immune system and alter body chemistry. The effects of high ambient temperatures and relative humidity have been observed in the poultry industry, as production efficiency is reduced in improved strains of broiler chicks fed diets supplemented with different additives (Ahmad *et al*., 2006). Under heat stress, broiler chick losses homeostatic balance because the accumulated heat from the environment and metabolic activities could not be dissipated (Belay *et al.,* 1992). The first two weeks of life of broilers correspond to about 17% of their rearing period in days, and 8 to 10% as a percentage of final weight gain (Lilburn, 1998). This is the period of fastest bone, muscle and immune system development. When broiler growth is compromised, with consequent weight loss soon after hatching, performance is impaired until slaughter (Vieira and Moran, 1998). Rodrigo *et al.* (2011) reported that another factor that should be considered at the starting phase of broiler rearing is initial weight, considering that breeder age influences broiler weight. Each extra gram in hatchling weight is equivalent, on average, to 9 additional grams at slaughter (Stringhini *et al*., 2003). Belay *et al.* (1992) reported that the increase in broiler growth rate increases their body heat production and this situation demands an efficient means to economically improve the thermo-tolerance of broiler chickens in hot climates without affecting their productivity.

The objective of this study was to determine the dietary electrolyte balance that would improve the performance of pre-starter and starter chicks.

Materials and Methods
The protocol for this experiment was reviewed and approved by the Institutional Animal Care and Use Committee; and the Agricultural Biochemistry and Nutrition Unit of the Department of Animal Science, University of Ibadan, Nigeria. A total of 300, one day- old Arbor Acre broiler chicks were randomly allotted to six treatments (mEq/Kg: 210 (T_1), 240 (T_2), 270 (T_3), 300 (T_4), 330 (T_5), 360 (T_6) DEB) with five replicate groups in a Completely Randomized Design (CRD). The DEB was calculated using the equations derived from preliminary research findings of the authors. The derived equations were based on the following assumptions for an ideal DEB.

1. The DEB equation is dependent on mineral sources.
2. The DEB equation must be able to hold other macro ions at a constant, whose excess or deficiency could constitute an imbalance.

3. Other macro ions are held at a constant under recommended value ranges for broiler chickens.

The derived equation of DEB is

$$\sum DEB = \sum (Na^{+} + K^{+}) - \sum Cl^{-} \ldots [y]\,[c]$$

Where [y] = mineral sources

[c] = other macro ions (Ca, Mg, P, S etc) held constant.

Aggregate DEB = Inherent DEB in rations + DEB in Electrolyte sources.

Maximum and minimum average ambient temperature and relative humidity of the pen were monitored on a daily basis using a digital hydro thermometer. Assay was conducted in each diet for sodium and potassium (Flame spectrophotometer), and chloride (titration) (Lacroix *et al.*, 1970) as shown in Table 1.

Table 1: Analyzed nutrients in experimental diets fed to broiler chicks at pre-starter and starter phases

Periods	Nutrients (%)	Diets (mEq/kg)					
		210	240	270	300	330	360
	Crude protein	22.90	22.95	23.10	22.93	22.79	22.89
	Crude fat	5.29	5.26	5.44	5.54	5.46	5.66
	Calcium	10.09	10.16	10.36	10.06	10.20	10.25
0 - 21 d	Phosphorus	8.02	8.03	8.09	8.12	8.13	8.16
	Sodium	1.40	2.20	2.92	3.63	4.33	5.05
	Potassium	8.16	8.65	9.18	9.73	10.21	10.66
	Chloride	2.32	2.81	3.27	3.75	4.28	4.77

Data obtained were subjected to descriptive statistic and analysis of variance using SAS package (2012). Means for treatments in the analysis of variance were compared using Duncan Multiple Range Test and based on probability level of 0.05.

Results and discussion

At prestarter phase, significant ($p<0.05$) differences in feed and dry matter intake of birds fed different DEB were observed. Birds on 330 mEq/Kg DEB had higher ($p<0.05$) feed (460.82) and dry matter (431.70) intake compared to birds on 270 (FI: 409.28; DM: 377.77) mEq/Kg DEB. There were no significant ($p>0.05$) differences observed in feed intake and DM intake of birds fed DEB treatments of 210, 240, 300 and 360 mEq/Kg at pre-starter phase. However, at 14 to 21 days, feed intake of birds was not affected ($P>0.05$) by different DEB treatments. This result has shown that birds `appetite was not enhanced by dietary electrolyte balance at starter phase.

The result disagrees with that reported by Borges *et al.* (2003) stating that regardless of ambient temperatures, increasing DEB stimulated feed intake, which may possibly be due to increasing Na^{+} levels in diets (0.15 to 0.45%). Mongin (1981) reported that optimal chick growth performance, when fed purified diets, was achieved using DEB ($Na^{+}+K^{+}- Cl^{-}$) of around 250 mEq/kg with a relation (K+Cl)/Na > 1. An optimal electrolyte balance was found for feeds containing from 250 to 300 mEq/kg. The body weight (BW) of birds on different dietary treatments was not affected at pre-starter and starter phases. The body weight gain (BWG) of birds fed different DEB showed no significant ($P>0.05$) differences at pre-starter and starter phases (Table 2). This result agrees with the findings of Rondon *et al.* (2001) and Murakami *et al.* (2001) who established with modern broiler strains and practical diets, an optimal DEB for the starter phase to be between 246 and 315 mEq/Kg. Birds on 270 (1.38), 240 (1.48), 300 (1.43) and 360 (1.51) had lower ($p<0.05$) FCR compared to 330 (1.55), and 210 (1.56) mEq/kg DEB at 14 – 21 d. Birds on 270 mEq/Kg DEB had the highest ($p<0.05$) gain to feed ratio compared to other dietary treatments, while birds on 210 mEq/Kg DEB had the lowest gain to feed ratio. Borges *et al.* (2002) reported that increase in DEB (40 to 340) caused a quadratic effect on weight gain and feed: gain, and a linear increase in feed intake. However, the ideal DEB observed was between 246 and 277 mEq/kg in overall results. Borges *et al.* (2003) noticed that DEB 240 mEq/kg gave the best body weight gain and feed conversion ratio versus DEB 0, 120, and 360 mEq/kg, in broiler raised during summer season (max. 31°C, min. 23°C; RH 75.5%).

Conclusion

The results of this study have shown that an aggregate dietary electroyte balance of 270 mEq/kg is ideal for improving the performance of broiler chicks at pre-starter and starter phases.

Table 2::Effect of varying dietary electrolyte balance on performance of heat-stressed broiler chicks at prestarter and starter phases

Periods	DEB mEq / Kg	Mean F. I (g)	DMI (g/bird)	BW (g/bird)	BWG (g)	FCR (g/g)	Gain: Feed	Mortality (%)
	210	443.16[ab]	412.63[ab]	319.60	283.40	1.56[a]	0.64[b]	0.00
	240	437.20[ab]	405.07[ab]	331.24	294.66	1.48[ab]	0.67[ab]	0.00
0 – 14 d	270	409.28[b]	377.77[b]	332.16	295.80	1.38[b]	0.73[a]	0.00
	300	426.17[ab]	388.58[b]	339.39	303.17	1.43[ab]	0.71[ab]	2.00
	330	460.82[a]	431.70[a]	333.40	297.10	1.55[a]	0.65[ab]	0.00
	360	431.66[ab]	388.32[b]	320.14	284.54	1.51[ab]	0.66[ab]	0.00
SEM		13.72	12.59	10.99	10.96	0.05	0.03	0.82
P value		0.20	0.06	0.77	0.78	0.11	0.14	0.44
	210	424.00	394.79	629.14	309.54	1.38[ab]	0.73[ab]	-
	240	420.70	389.78	659.80	328.56	1.29[ab]	0.78[ab]	-
14 – 21 d	270	441.00	407.04	673.44	341.28	1.30[ab]	0.77[ab]	-
	300	445.89	406.56	656.50	317.11	1.43[a]	0.71[b]	-
	330	419.00	392.52	679.68	346.28	1.21[b]	0.83[a]	-
	360	423.00	380.53	625.78	304.64	1.39[ab]	0.73[ab]	-
SEM		3.97	11.45	14.66	14.43	0.06	0.03	-
P value		0.53	0.56	0.08	0.26	0.18	0.16	-

[abc]Means for treatments within a column with no common superscript showed significant ($P< 0.05$) differences using DMRT; F.I-Feed intake, DM- dry matter, BW- body weight, BWG- Body weight gain, FCR-Feed conversion ratio, DEB-Dietary electrolyte balance, p-value- Probability value, SEM- Standard error of mean.

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