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Effects of High Environmental Temperatures on the Electrolyte Status of Thai Indigenous, Thai Indigenous Crossbred and Broiler Chickens

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Abstract: The purpose of this experiment was to study the effects of high environmental temperatures on the electrolyte status of three breeds of chickens: Thai Indigenous Chickens (TIC), Thai Indigenous Crossbred Chickens (TICC) and Broiler Chickens (BC). Male and female TIC, TICC and BC were maintained at the environmental temperature ranges of 26±2°C and cyclic 38±2°C. Sodium (Na^+), chloride (Cl^-) and potassium (K^+) were investigated on days 1, 7, 14, 21 and 28 of the experimental period. The results revealed the following information: On day 7, plasma Na^+ of male BC at 38±2°C was significantly higher than that of male BC at 26±2 °C ($p<0.05$). On day 14, plasma Na^+ of male TIC and BC at 26±2°C was significantly higher than that of male TIC and BC at 38±2°C ($p<0.05$). On day 28, plasma Cl^- of male TIC and BC at 38±2°C was significantly higher than that of male TIC and BC at 26±2°C ($p<0.05$). On day 28, at 38±2°C, plasma Cl^- of male TIC was significantly higher than male TICC and male and female BC ($p<0.05$). On days 1, plasma K^+ of TIC, TICC and BC at 38±2°C was significantly higher than that of TIC, TICC and BC at 26±2°C ($p<0.05$). On day 7, plasma K^+ of TIC and TICC at 38±2°C was significantly higher than that of TIC and TICC at 26±2°C ($p<0.05$). On day 14, plasma K^+ of male BC at 38±2°C was significantly lower than that of male BC at 26±2°C ($p<0.05$). On days 21, plasma K^+ of female TICC at 38±2°C was higher than female TICC at 26±2°C ($p<0.05$). On day 28, plasma K^+ of male TIC and TICC at 38±2°C was significantly higher than that of TIC and TICC at 26±2°C ($p<0.05$). This experiment showed that time, breeding and environmental temperature have an influence on the electrolyte status of TIC, TICC and BC. Under heat stress, TIC preserved the electrolyte in their body better than the TICC and BC, respectively.

Key words: Heat stress, electrolyte, Thai indigenous chickens, Thai indigenous chickens crossbred, broilers

INTRODUCTION

Potassium (K^+), chloride (Cl^-) and the strong ion sodium (Na^+), have the greatest impact on the acid-base balance of blood and tissue (Boerges *et al*., 2003a). The lack of a proper acid-base balance leads to a metabolic imbalance (Moghaddam *et al*., 2005). Under high environmental temperature and humidity conditions, body temperature and respiratory rate increase, which lowers blood CO_2 levels and changes the acid-base balance, resulting in respiratory alkalosis. Generally, electrolyte balances in the body are maintained within strict limits; under thermoneutrality, birds theoretically have an optimal internal electrolyte balance (Boerges *et al*., 2003b). When chickens were under heat stress, plasma concentrations of Na^+, K^+ (Deyhim and Teeter, 1995; Boeges *et al*., 2004) and Cl^- decreased (Boeges *et al*., 2004).

During the summer season in Thailand, environmental temperatures frequently reach 36-40°C, which is a dangerous zone for broilers. However, Thai Indigenous Chickens (TIC), the wild birds that have been domesticated in the rural villages of Thailand over a long period of time, have become accustomed to these high environmental temperatures. TIC though, have a lower productive performance than broilers, so breeders have improved their production by crossbreeding them with chickens imported from overseas. These Thai Indigenous Chicken Crossbreds (TICC) are a crossbreed of ½ TIC (cock) and ¼ Rhode Island Red and ¼ Plymouth Rock (hen). TICC have a higher productive performance than TIC. The purpose of this experiment was to study the effects of chronic high environmental temperatures on the electrolyte status of TIC, TICC and broilers (BC). Results from this preliminary study would provide fundamental knowledge for improving poultry production by identifying a heat tolerant genetic resource for poultry production in tropical regions.

MATERIALS AND METHODS

Twenty four TIC (12 males; 12 females), 28 days old; twenty four TICC (12 males; 12 females), 70 days old and twenty four BC (12 males; 12 females), 84 days old, one

kilograms of weight each and infectious disease-free, were obtained from a commercial farm near Mahasarakham University. The experiments were performed during April-July, 2005 and begun after a 7 day adaptation period. The chicks were fed a standard ration *ad libitum* with continuous light and water supplies. The relative humidity was 65%. The experimental design was a split-split-plot design in CRD. The m ain plot was at two temperatures settings i.e., 26±2°C (continuous temperature) and 38±2°C (cyclic temperature; 26±2, -38±2, -26±2°C). The chickens were maintained at 38±2°C for 8 h/day. The sub plot was 2×3 factorial i.e., sex (male and female) and 3 breeds of chicken (TIC, TICC and BC). Six TIC, six TICC and six BC were maintained at each environmental temperature. On day 1, 7, 14, 21 and 28 of the experimental period, blood samples (via wing vein:0.75 mL) were collected and transferred to tubes containing EDTA as an anticoagulant (Ritchie *et al*., 1994). Plasma Na^+, Cl^- and K^+ were analyzed by using a KODAK EKTACHEM analyzer (Kodak Ektachem®; Eastman Kodak Company, Rochester, New York).

All data were analyzed using the ANOVA procedure of Statistical Analysis System (1990). Means were separated by Duncan's multiple range tests. The level of significance was determined at $p<0.05$.

RESULTS AND DISCUSSION

On days 1, 7, 14, 21 and 28 of experimental period, when the TIC, TICC and BC were maintained at 26±2°C and 38±2°C, their plasma Na^+, K^+ and Cl^- were determined. The results are shown in Table 1-3, respectively.

On day 7, plasma Na^+ of male BC at 38±2°C was higher than that of male BC at 26±2°C. These occurrences explain that during the initial period of heat exposure, male TIC and BC maintained at the higher temperatures responded by decreasing the period of time between their consumption of water and increasing their loss of water through accelerated wet dropping. The documents which support this hypothesis are reported by Aengwanich *et al*. (2003) and Aengwanich and Simaraks (2004); they found that when chickens are under heat

Table 1: Plasma Na^+ of male and female TIC, TICC and BC maintained at 26±2 and 38±2°C, on days 1, 7, 14, 21 and 28 of experimental period

		Environmental temperature at 26±2°C						Environmental temperature at 38±2°C						
		TIC		TICC		BC		TIC		TICC		BC		
Parameter	Days	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	SEM
Plasma Na^+	1	141.50	144.50	142.67	140.50	153.50	143.67	147.33	150.00	145.50	143.33	146.50	145.00	0.87
(mg dL^{-1})	7	138.17^{ab}	139.67^{ab}	139.50^{ab}	140.00^{ab}	131.50^{c}	135.33^{bc}	142.50^{a}	142.67^{a}	135.83^{bc}	138.83^{ab}	137.50^{ab}	136.17^{bc}	0.49
	14	145.83^{a}	144.83^{ab}	139.50^{bc}	142.33^{abc}	137.83^{c}	139.83^{bc}	138.00^{c}	140.50^{abc}	136.67^{c}	137.00^{c}	130.67^{d}	137.00^{c}	0.53
	21	137.33	141.33	142.00	132.67	138.83	136.67	142.33	141.83	138.33	138.50	134.00	135.67	0.70
	28	142.17	141.00	142.50	143.33	135.17	140.17	144.67	146.00	142.33	139.83	139.00	139.33	0.57

$^{a, b, c \text{ and } d}$within row mean with no common superscript differ significantly ($p<0.05$). SEM = Standard Error of the Mean

Table 2: Plasma K^+ of male and female TIC, TICC and BC maintained at 26±2 and 38±2°C, on days 1, 7, 14, 21 and 28 of experimental period

		Environmental temperature at 26±2°C						Environmental temperature at 38±2°C						
		TIC		TICC		BC		TIC		TICC		BC		
Parameter	Days	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	SEM
Plasma K^+	1	4.60^{de}	4.43^{de}	4.60^{de}	4.40^{de}	4.27^{e}	4.75^{cd}	5.43^{ab}	5.08^{bc}	5.48^{ab}	5.62^{a}	5.50^{ab}	5.77^{a}	0.039
(mmol L^{-1})	7	4.52^{ef}	4.23^{f}	4.82^{cde}	4.58^{def}	5.20^{abc}	5.00^{abc}	5.35^{a}	4.95^{abcd}	5.25^{ab}	5.20^{abc}	5.17^{abc}	4.92^{bcde}	0.037
	14	4.75^{bc}	4.55^{c}	5.10^{abc}	4.65^{bc}	5.57^{a}	5.20^{ab}	4.93^{bc}	4.65^{bc}	5.05^{abc}	4.71^{bc}	4.85^{bc}	4.73^{bc}	0.015
	21	4.33^{d}	4.73^{cd}	4.92^{abc}	4.47^{cd}	5.03^{abc}	5.05^{abc}	4.67^{cd}	4.80^{bcd}	5.40^{a}	5.37^{ab}	4.97^{abc}	5.03^{abc}	0.050
	28	4.62^{cd}	4.35^{d}	4.50^{cd}	4.35^{d}	4.85^{bcd}	4.70^{bcd}	5.75^{a}	5.02^{bcd}	5.73^{a}	5.07^{abcd}	5.18^{abc}	5.42^{ab}	0.063

$^{a, b, c \text{ and } d}$within row, mean with no common superscript differ significantly ($p<0.05$). SEM = Standard Error of the Mean

Table 3: Plasma Cl^- of male and female TIC, TICC and BC maintained at 26±2 and 38±2°C, on days 1, 7, 14, 21 and 28 of experimental period

		Environmental temperature at 26±2°C						Environmental temperature at 38±2°C						
		TIC		TICC		BC		TIC		TICC		BC		
Parameter	Days	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	SEM
Plasma Cl^-	1	106.33	107.83	109.67	105.00	117.50	107.00	112.67	110.83	108.17	108.83	109.67	109.17	0.87
(mmol L^{-1})	7	104.67	104.00	103.33	104.00	92.50	95.50	108.83	108.83	101.50	105.00	105.00	101.17	0.49
	14	109.67^{ab}	110.17^{a}	104.67^{abcd}	106.17^{abc}	97.83^{de}	103.00^{bcde}	103.83^{abcde}	103.67^{abcde}	102.17^{cde}	103.00^{bcde}	97.67^{e}	103.50^{abcde}	0.53
	21	103.83	108.33	105.17	103.67	101.00	101.33	107.00	107.00	105.67	105.17	103.83	101.17	0.70
	28	105.33^{bc}	105.17^{bc}	106.00^{abc}	103.67^{c}	97.33^{d}	101.67^{cd}	111.17^{a}	109.83^{ab}	104.67^{bc}	105.5^{abc}	104.67^{bc}	104.83^{bc}	0.57

$^{a, b, c \text{ and } d}$within row, mean with no common superscript differ significantly ($p<0.05$). SEM = Standard Error of the Mean

stress, their kidneys, which adapt to heat stress by increasing the secretion of urine, help reduce their body temperature, therefore, plasma sodium rose. These findings were opposite with the report of Boeges *et al.* (2004) and Deyhim and Teerter (1995). They found that when broilers were under heat stressful environments, their plasma Na^+ decreased. On day 14, plasma Na^+ of male TIC and BC at 26±2°C was higher than that of male TIC and female BC at 38±2°C. This was accord with the report of Deyhim and Teerter (1995) and Boeges *et al.* (2004).

On day 28, plasma Cl^- of male TIC and BC at 38±2°C was higher than that of male TIC and BC at 26±2°C. This occurrence was in contrast with the report of Boeges *et al.* (2004), they found that when broilers were under heat stress, plasma Cl^- decreased and at 38±2°C, plasma Cl^- of male TIC was higher than male TICC and male and female BC. This occurrence indicated that TIC preserved Cl^- in their body better than TICC and BC.

On day 1, plasma K^+ of TIC, TICC and BC at 38±2°C was higher than that of TIC, TICC and BC at 26±2°C. On day 7, plasma K^+ of TIC and TICC at 38±2°C was significantly higher than that of TIC and TICC at 26±2°C. This increase explains that under heat stress TIC, TICC and BC only lose water through wet dropping, resulting in an increase in their plasma K^+. This is in contrast to a report by Deyhim and Teeter (1995); they found that when broilers are under heat stress, their plasma K^+ decreases. On day 14, plasma K^+ of male BC at 38±2°C was lower than that of male BC at 26±2°C. This occurrence explain that when chickens were maintained under prolonged high environmental temperatures, they adapted to the condition (Aengwanich *et al.*, 2003) by increasing their consumption of water to reduce their body temperature (Deeb and Cahaner, 2002). This was in according to the document of Xin *et al.* (2002), which indicated that when the house air temperature increased from 4.4 to 37.8°C, daily water use increased from 182 to 590 mL/bird. Therefore, on day 14, the plasma K^+ of the chickens maintained at 26±2°C was higher than that of chickens at 38±2°C because their blood volume had increased (hemodilution). On day 21, plasma K^+ of female TICC at 38±2°C was significantly higher than female TICC at 26±2°C and on day 28, plasma K^+ of male TIC and TICC at 38±2°C was higher than that of TIC and TICC at 26±2°C. These phenomenons showed that time, breeding and sex influence plasma K^+.

CONCLUSION

During the initial period of heat exposure, the plasma Na^+ of all chickens maintained at the high environmental temperatures was higher than that of chickens at thermoneutral. At high environmental temperature, plasma Na^+ of TIC was higher than TICC and BC. Plasma Cl^- of chickens at the high environmental temperature was higher than chickens at thermoneutral. The pattern of plasma Na^+ and Cl^- of chickens under heat stress were similar. The plasma K^+ of the TIC, TICC and BC at high environmental temperature was increased. The major cause of increasing level of plasma electrolyte in chickens under heat stress was dehydration. The results of this present study clearly demonstrate that time, breed, sex and environmental temperature have an effect on the electrolyte status of chickens and the plasma electrolyte of the TIC changes to a lesser degree than that of the TICC and BC when they are under heat stress.

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