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THE ROLE OF VITAMIN C AND ELECTROLYTES ON ALLEVIATING THE NEGATIVE EFFECTS OF HEAT STRESS ON BROILER CHICKS

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ABSTRACT

The current study was conducted to investigate the role of electrolytes and vitamin C on eleminating the side effects of acute heat stress on the economical and physiological parameters in broiler chicks. Four hundred Hubbard broiler chicks at four weeks of age were devided into four groups. Groups 1 and 2 received tap water while groups 3 and 4 received water treated with electrolytes (2 g/L Sodium bicarbonate plus 2 g / L Potassium chloride) and vitamin C (1 g/L) respectively for 24 hr daily. First group served as a control and the other groups exposed to 4 hr heat stress (39 ± 1°C) / day at 30 days of age for 3 days. The data showed that high environmental temperature induced significant elevation in body temperature, respiration rate, corticosterone, water consumption and mortality rate compared to the control. Triiodothyronine (T_3) was significantly suppressed under heat stress condition compared to the control. Vitamin C and electrolytes treatment had no significant effects on body weight or weight gain compared to the control, while tap water treatment had significantly lowest body weight than the control. Addition of electolytes increased significantly water consumption than other groups. Moreover, water treatments (vit.C or electrolytes) reduced the mortality rate and suppressed the eleviation in body temperature and respiration rate significantly under high environmental temperature compared to the control. Vitamin C or electrolytes treatment had no significant effect on the suppression of T_3 induced by heat stress, but vit.C neutralized the effect of heat stress on the corticosterone level and retarned back to the normal level. The present data concluded that vitamin C and electrolytes ameliorated the negative effects of heat stress and enhanced the chicks performance under stress condition.
Keywords: broiler – heat stress – vitamin C – electrolytes.

INTRODUCTION

Heat stress is one of the most critical problems for poultry production in many regions of the world. Heat stress occurs when birds have difficulty in balancing heat production and heat loss when exposed to heat stress. When broiler chicks were exposed to high environmental temperature (35°C) for a short time, 4hrs (Yahav *et al,* 1997) or for long time, 16 days (Cooper and Washburn, 1998), body temperature increased significantly compared to the control. Once body temperature exceeds 42°C under heat load, the respiration rate reaches a peak of a bout 150 to 260 bearth per minute (Mushtaq *et al*, 2005) However, panting is associated with excessive loss of carbon dioxide (CO_2) which reduces the partial pressure of CO_2 in the blood. In turn, there is an increase in plasma PH and bicarbonate resulting in respiratory alkalosis (Belay *et al*, 1990). Further- more, heat stress could induce economical damage. High environmental temperature reduces growth rate, body weight (Yaclin *et al,* 1997), and survivability of broiler chickens

(Cheng *et al,* 1993) and thus decreases profitability. In addition, heat stress is associated with low triiodothyronin (T_3) concentration (Yahav and Mc Murtry, 2001), and high concentration of corticosterone (Abbas *et al,* 2007). High environmental temperature is associated with high blood PH. Correction of blood PH can be achieved by excreting bicarbonate (HCO_3^-) via urine to lower blood bicarbonate (Mushtaq *et al,* 2005). Bicarbonates are anions that must be excreted with cations such as sodium (Na) or potassium (K), in the urine. Thus K and Na can be depleted from the body. Belay *et al* , (1990) showed that a respiratory alkalosis associated with heat stress was related to negative balance of key minerals (K+Na) that control plasma PH and body volume as well as optimum osmotic relationships.

Although all birds can synthesize vitamin C, synthesis is inadequate under stressfull conditions (Mc Dowell, 1989). Vitamin C has been demonstrated to enhance antioxidant activity (Jacob 1995).

The current study was planned to investigate the role of vitamin C and electrolytes on alleviating the negative effects of heat stress in broiler chicks.

MATERIALS AND METHODS

Birds Mangement

One-day-old broiler chicks (Hubbard) were used in the current study. At the first day of recieving chicks, they were wingbanded, weighed to the nearst gram, and housed on floor pens. The intial brooding temperature was 32°C and was reduced grodually by 2°C per week untill it reached 24°C at fourth week.

Feed and water were provided ad libitum. All chicks were fed a commercial broiler starter ration (23% CP and 2950 Kcal/Kg ME) for four weeks of age, then fed a commercial grower ration (21% CP and 3150 Kcal/Kg ME) for the next three weeks.

Experimental Design

At 4 weeks of age, 400 chicks were divided randomly into 4 equal groups. Groups 1 and 2 received tap water, while groups 3 and 4 received treated water by 2g $NaHCO_3$ + 2g KCl per liter and 1g vitamin C per liter respectively for 7 days. At 30 days of age, all groups, except group 1 that served as a control, exposed to 4h heat stress (39 ± 1°C) for 3 days.

Growth Performance

Body weight, weight gain, water consumption, and mortality rate were measured weekly from the fourth to seventh weeks of age.

Physiological Measurments:

A) Body temperature and Respiration rate

Body temperature and respiration rate were monitored on each of 5 birds chosen randomly whithin each group. The measurements were taken two times daily during the heat stress exposure, just before the heat exposure and then 10 minutes before the treatment ends. Body temperature was measured using an electric thermometer with a probe inserted into the cloca and kept there for 1 minute before the temperature was recorded. The respiration rate was measured by counting the thoracic movement for 1 minute.

B) Hormones and Blood picture

Blood samples (3ml) were collected from wing vein of 5 birds from each group just before and after every singl day of heat stress. Two third of the blood samples were centrifuged at 3000 rpm for 20 min, and plasma was stored at -20°C for hormone measurment, while the last one third of the blood sample was used to measure the blood hemoglobin (Hb), hematocrite (Ht) and PH. The amount of Hb was determined by hemoglobinometer (Alfred, 1961).

The hematocrite was measured using microhematocrite method of Johnson (1955). Blood PH was measured using PH meter (Fragel-model 3050).

Corticosterone and Triiodothyronine (T_3) concentrations were determined by radio- immuno assay (RIA) kits (Dingnostic Products Co-operation Los Angeles, USA).

Statistical analysis:

Data were analyzed using one-way analysis of variance,where treatment was the factor effecting the traits. Significant differences among experimental treatments were seperated using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

The effects of heat stress, vit.C, and electrolytes on body weight and growth rate are shown in Tables 1 and 2. Heat stress suppressed body weight and growth rate compared to the control at 5 weeks of age. Furthermore, the effect of heat stress on body weight extended untill the marketing age. The current data are in agreement with Yaclin *et al.* (1997), Cooper and Washburn (1998), and Yahav and Plavnik (1999). With respect of the effects of vit.C & electrolytes on body weight and growth rate under heat stress condition, our results showed that vit.C and electrolytes significantly alleviate the negative effect of heat stress. Furthermore, the effects of vit.C and electrolyte continue untill the marketing age. Similar results were observed by Blaha *et al.* (2000), Karimi *et al.* (2000), and Decuypere *et al.* (2000), who reported that vit.C and electrolytes improved body weight and growth rate under heat stress conditions.

Table (1): Effect of heat stress and anti-stressors on body weight (g) of broiler chicks at different ages.

Age (week)	Heat stress			Control
	Electrolyte	Vit.C	Tap water	
4	858±13.26	852±12.54	851±15.64	857±13.41
5	1174±21.15^{ab}	1170±23.61^{ab}	1139±23.11^{b}	1193±22.42^{a}
6	1553±26.12^{ab}	1551±28.31^{ab}	1531±30.16^{b}	1580±32.14^{a}
7	1947±33.26^{ab}	1945±36.15^{ab}	1930±39.54^{b}	1982±40.22^{a}

a,b Means, within rows, followed by different superscripts differ significantly (P ≤0.05).

Table (2): Effect of heat stress and anti-stressors on weight gain (g) of broiler chicks at different ages.

Age (week)	Heat stress			Control
	Electrolyte	Vit.C	Tap water	
4-5	316 ± 13.15^{ab}	318 ± 11.92^{ab}	288 ± 14.61^{b}	336 ± 12.62^{a}
5-6	379 ± 18.24	381 ± 16.35	382 ± 20.11	387 ± 20.90
6-7	394 ± 21.16	394 ± 23.66	399 ± 22.75	402 ± 26.81

a,b Means, within rows, followed by different superscripts differ significantly ($P \leq 0.05$).

The effects of heat stress, vit.C and electrolyte on water consumption is shown in Table(3). The heat stress increased the water consumtion significantly compared to the control at 5 wks of age and the effect extended untill 6 wks of age. This result is in agreement with Whiting *et al.* (1991), who found that high environmental temperature increases the water consumption. Regarding the effect of vit.C and electrolyte on water consumption under heat stress condition, our data revealed that those treatments elevated water consumption. Smith and Teeter (1993) and Belay and Teeter (1993) reported the same results when they used similar treatment.

Table (3):Effect of heat stress and anti-stressors on water consumption (ml/day/bird) of broiler chicks at different ages.

Age (week)	Heat stress			Control
	Electrolyte	Vit.C	Tap water	
5	571.8 ± 4.59^{a}	423.9 ± 4.57^{b}	417.6 ± 4.55^{b}	227.2 ± 4.57^{c}
6	340.9 ± 4.68^{a}	310.7 ± 4.72^{b}	319.4 ± 4.51^{b}	317.6 ± 4.62^{b}
7	422.2 ± 5.26	416.9 ± 5.32	421.9 ± 5.12	424.3 ± 5.16

a-c Means, within rows, followed by different superscripts differ significantly ($P \leq 0.05$).

Heat stress had sever effect on mortality rate as shown in Table (4). Heat stress elevated mortality rate by 16% compared to the control during heat treatment. The result could be due to sudden death sendrom (Cheng *et al.*, 1993), or increasing the temperature of the hypothalmus (Pinshow *et al.*, 1982). However vit.C reduced the mortality rate to 5% versus 3% in electrolyte treatment compared to heat treatment that received tap water. The alleviating effects of vit.C or electrolyte on the mortality rate could be due to reduce formation of prostaglandin or proinflommatory cytokines (Nava *et al.*, 1997).

Table (4): Effect of heat stress and anti-stressors on the mortality rate in broiler chicks during heat treatment.

Age (days)	Heat stress			Control
	Electrolyte	Vit.C	Tap water	
30	1.66	3.33	6.66	0.0
31	1.69	1.72	5.35	0.0
32	0.0	0.0	3.77	0.0

Heat stress increased body temperature and respiration rate significantly compared to the control during heat treatment. Even though, vitamin C and electrolyte treatments alleviated the effects of heat stress significantly regarding body temperature and respiration rate, but it was significantly higher compared to the control (Table 5). The beneficial effect of vit.C and electrolyte could be due to enhance water consumption which in turn reduced the elevation in body temperature and respiration rate (Smith and Teeter, 1993)

Table (5):Effect of heat stress and anti-stressors on respiration rate and body temperature (°C) of broiler chicks during heat treatment.

		Age (days)					
		30		31		32	
		B.H.	A.H.	B.H.	A.H.	B.H.	A.H.
Respiration rate	E	58.1 ± 0.58^{c}	170.6 ± 0.71^{b}	57.8 ± 0.53^{d}	160.7 ± 0.95^{c}	58.2 ± 0.62^{c}	155.9 ± 0.69^{b}
	V	58.7 ± 0.53^{c}	172.3 ± 0.76^{b}	58.4 ± 0.60^{d}	166.8 ± 0.86^{b}	59.4 ± 0.51^{c}	157.1 ± 0.86^{b}
	T	59.8 ± 0.54^{c}	196.6 ± 0.91^{a}	59.2 ± 0.58^{d}	188.9 ± 0.79^{a}	60.0 ± 0.49^{c}	176.6 ± 0.82^{a}
	C	59.1 ± 0.51^{c}	59.6 ± 0.56^{c}	60.1 ± 0.61^{d}	59.8 ± 0.58^{d}	59.2 ± 0.54^{c}	59.6 ± 0.59^{c}
Body temperature	E	40.75 ± 0.16^{c}	42.77 ± 0.24^{b}	40.74 ± 0.14^{c}	42.54 ± 0.21^{b}	40.74 ± 0.12^{c}	42.43 ± 0.24^{b}
	V	40.73 ± 0.12^{c}	42.85 ± 0.26^{b}	40.72 ± 0.12^{c}	42.67 ± 0.22^{b}	40.73 ± 0.14^{c}	42.52 ± 0.26^{b}
	T	40.86 ± 0.13^{c}	43.66 ± 0.27^{a}	40.83 ± 0.16^{c}	43.36 ± 0.26^{a}	40.81 ± 0.12^{c}	43.31 ± 0.26^{a}
	C	40.82 ± 0.11^{c}	40.84 ± 0.12^{c}	40.81 ± 0.12^{c}	40.83 ± 0.14^{c}	40.78 ± 0.11^{c}	40.79 ± 0.13^{c}

$^{a-d}$ **Means, within rows, followed by different superscripts differ significantly (P ≤0.05).**
B.H.= befor heat stress A.H.=after heat stres
E = Electrolyte V = Vitamin C T = Tap water C = Control

Heat treatment increased corticosterone concentration significantly compared to the control as shown in Table (6).

Table (6):Effect of heat stress and anti-stressors on hemoglobin (g/100ml blood), hematocrit /(%) and blood PH of broiler chicks during heat treatment.

		Age (days)					
		30		31		32	
		B.H.	A.H.	B.H.	A.H.	B.H.	A.H.
Hemoglobin (g/100ml blood)	E	9.48 ± 0.11^{a}	6.47 ± 0.12^{c}	9.46 ± 0.09^{a}	6.92 ± 0.13^{c}	9.45±0.1[illegible]^{a}	8.02 ± 0.17^{c}
	V	9.55 ± 0.21^{a}	7.31 ± 0.14^{b}	9.59 ± 0.11^{a}	7.01 ± 0.20^{c}	9.51 ± 0.17^{a}	8.31 ± 0.11^{b}
	T	9.59 ± 0.12^{a}	7.45 ± 0.09^{b}	9.57 ± 0.21^{a}	7.38 ± 0.10^{b}	9.49 ± 0.11^{a}	8.36 ± 0.21^{b}
	C	9.58 ± 0.10^{a}	9.56 ± 0.11^{a}	9.58 ± 0.14^{a}	9.56 ± 0.12^{a}	9.59 ± 0.13^{a}	9.57 ± 0.15^{a}
Hematocrite (%)	E	31.26 ± 0.24^{a}	22.09 ± 0.32^{b}	31.50 ± 0.22^{a}	23.86 ± 0.31^{b}	31.99 ± 0.17^{a}	25.16 ± 0.24^{b}
	V	32.41 ± 0.19^{a}	23.65 ± 0.48^{b}	32.30 ± 0.26^{a}	24.27 ± 0.32^{b}	32.90 ± 0.12^{a}	25.81 ± 0.61^{b}
	T	31.63 ± 0.28^{a}	22.42 ± 0.65^{b}	33.20 ± 0.19^{a}	23.61 ± 0.41^{b}	33.51 ± 0.27^{a}	26.72 ± 0.43^{b}
	C	32.41 ± 0.34^{a}	31.26 ± 0.21^{a}	31.54 ± 0.27^{a}	32.16 ± 0.21^{a}	30.97 ± 0.31^{a}	31.51 ± 0.36^{a}
Blood PH	E	7.49 ± 0.03^{c}	7.58 ± 0.02^{b}	7.48 ± 0.03^{c}	7.58 ± 0.02^{b}	7.49 ± 0.02^{c}	7.58 ± 0.02^{b}
	V	7.50 ± 0.02^{c}	7.68 ± 0.01^{a}	7.49 ± 0.02^{c}	7.69 ± 0.02^{a}	7.47 ± 0.02^{c}	7.69 ± 0.01^{a}
	T	7.47 ± 0.01^{c}	7.69 ± 0.02^{a}	7.47 ± 0.02^{c}	7.71 ± 0.01^{a}	7.47 ± 0.01^{c}	7.70 ± 0.02^{a}
	C	7.48 ± 0.02^{c}	7.51 ± 0.01^{c}	7.49 ± 0.03^{c}	7.47 ± 0.02^{c}	7.50 ± 0.01^{c}	7.48 ± 0.01^{c}

a,c Means, within rows, followed by different superscripts differ significantly (P ≤0.05).
B.H.= befor heat stress A.H.= after heat stress
E = Electrolyte V = Vitamin C T = Tap water C = Control

Furthermore, vit.C suppressed the elevation of corticosterone level induced by heat treatment. But electrolyte treatment had no significant effect on corticosterone level under heat stress treatment. The result could be due to producing pro-inflommatory cytokines (IL-1, IL-6, and TNFα) under heat stress as reported by Abbas (2007).

On the other hand, heat treatment suppressed the thyroid hormone level (Table 7). Moreover, vit.C and electrolyte treatment had no significant effect on T_3 level compared to the heat treatment group, but it was significantly higher compared to the control.

Table (7):Effect of heat stress and anti-stressors on plasma T_3 and corticosterone concentrations (ng/dl) of broiler chicks during heat treatment.

		Age (days)					
		30		31		32	
		B.H.	A.H.	B.H.	A.H.	B.H.	A.H.
Plasma T_3 (ng/dl)	E	149.11 ± 0.92^a	82.16 ± 0.63^b	156.71 ± 0.97^a	88.61 ± 0.95^b	151.62 ± 0.98^a	91.18 ± 1.06^b
	V	147.36 ± 0.84^a	78.15 ± 0.72^b	156.11 ± 0.95^a	86.11 ± 0.88^b	146.9 ± 0.97^a	88.62 ± 1.07^b
	T	143.41 ± 0.88^a	76.12 ± 0.91^b	154.92 ± 0.83^a	82.63 ± 0.93^b	149.66 ± 0.90^a	86.12 ± 1.12^b
	C	146.06 ± 0.61^a	145.62 ± 0.77^a	150.26 ± 0.91^a	151.61 ± 0.88^a	148.11 ± 1.12^a	147.61 ± 1.02^a
Plasma corticosterone (ng/dl)	E	5.41 ± 0.73^b	8.83 ± 0.75^a	4.86 ± 0.91^b	6.98 ± 0.73^a	4.62 ± 0.61^b	6.91 ± 0.57^a
	V	4.73 ± 0.86^b	5.92 ± 0.66^b	4.11 ± 0.63^b	5.11 ± 0.66^b	4.16 ± 0.73^b	6.59 ± 0.73^a
	T	5.66 ± 0.82^b	9.92 ± 0.94^a	5.51 ± 0.72^b	7.92 ± 0.81^a	5.22 ± 0.63^b	7.41 ± 0.72^a
	C	5.82 ± 0.73^b	6.41 ± 0.82^b	5.61 ± 0.65^b	5.82 ± 0.81^b	4.82 ± 0.82^b	5.21 ± 0.70^b

[a,b] Means, within rows, followed by different superscripts differ significantly ($P \leq 0.05$).
B.H.= befor heat stress A.H.= after heat stress
E = Electrolyte V = Vitamin C T = Tap water C = Control

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دور فيتامين C و الإلكتروليتات في تخفيف التأثيرات السلبية للإجهاد الحراري في بدارى التسمين

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أجريت هذه الدراسة لإيضاح تأثير الإلكتروليتات و فيتامين C على خفض التأثيرات الجانبية للإجهاد الحراري الحاد على الصفات الإقتصادية و الفسيولوجية لكتاكيت التسمين .

تم تقسيم ٤٠٠ كتكوت تسمين هبرد إلى أربعة مجموعات على نهاية الأسبوع الرابع من العمر. المجموعة الأولى و الثانية أعطيت ماء عادي بينما المجموعة الثالثة و الرابعة أعطيت الماء مع إلكتروليتات (٢ جم/ لتر بيكربونات صوديوم + ٢ جم/ لتر كلوريد بوتاسيوم) و فيتامين C (١ جم/ لتر) على التوالي لمدة ٢٤ ساعة يوميا. المجموعة الأولى إستخدمت ككنترول و المجاميع الأخرى عرضت إلى ٤ ساعات إجهاد حراري (٣٩ ± ١°م) يوميا عند عمر ٣٠ يوم و لمدة ٣ أيام .

أوضحت النتائج الآتي :

١- درجة الحرارة العالية أدت إلى زيادة معنوية لدرجة حرارة الجسم و معدل التنفس و الكورتيكوستيرون و كمية الماء المستهلك و معدل النفوق مقارنة بالكنترول .

٢- إفراز التراي أيودو ثيرونين (T_3) إنخفض معنويا تحت ظروف الإجهاد الحراري مقارنة بالكنترول .

٣- المعاملة بفيتامين C و الإلكتروليتات ليس لها تأثيرات معنوية على وزن الجسم أو الوزن النهائي مقارنة بالكنترول . بينما معاملة الماء العادي كانت أقل معنويا في وزن الجسم عن الكنترول .

٤- إضافة الإلكتروليتات أدت إلى زيادة معنوية في كمية الغذاء المستهلك عن باقي المجاميع .

٥- إضافة فيتامين C أو الإلكتروليتات إلى الماء قلل نسبة النفوق و قلل من إرتفاع حرارة الجسم و معدل التنفس معنويا تحت درجات الحرارة العالية مقارنة بالكنترول .

٦- المعاملة بفيتامين C أو الإلكتروليتات لم يكن لها تاثير معنوي على خفض T_3 المصاحب للإجهاد الحراري بينما فيتامين C عادلت تأثير الإجهاد الحراري على مستوى الكورتيكوستيرون و أعاده إلى المستوى الطبيعي.

أوضحت النتائج أن إضافة فيتامين C و الإلكتروليتات حسنت التأثيرات السلبية للإجهاد الحراري و رفعت أداء الكتاكيت تحت ظروف الإجهاد .