COMPARATIVE EFFICACY OF DIFFERENT SUPPLEMENTS WITH DRINKING WATER USED TO ALLEVIATE BODY TEMPERATURE OF HEAT-STRESSED BROILER CHICKENS

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ABSTRACT

A total of 425 one day old, unsexed, Hubbard classic broiler chicks strain were reared on floor for 6 weeks (WK) to evaluate the efficacy of different supplements to reduce body temperature (Tb) of heat-stressed broiler chickens. Birds were given water and diet *ad libitum*. At 21 day of age, 375 birds were almost equal weights chosen, randomly divided into 5 groups, 3 replicates of 25 birds each. Treatment groups were; without supplementation (T1,control), supplementation 400 (T2) and 550 (T3) mg betaine / liter drinking water (DK), mixture of KCl, $NaHCO_3$,vitamin C and salicylic acid by 450, 450, 50 and 50 mg / liter DK respectively (T4) and 150 mg vitamin C / liter DK (T5). Temperature and relative humidity were recorded in 600, 1400, 1800 and 2400 hours daily. Birds were received 24 hours light a day, also all routine management and medications were applied. Results revealed that in most treatment groups, Tb was significantly ($P < 0.01$) increased in hot period of the day (1400h and 1800h) in comparison with moderate period (600h and 2400h) and the difference was higher in control treatment1 group (T1) at 4, 5, 6 WK of age and their average. A significant ($P < 0.05$) decrease was found in Tb of T5 in comparison with T1 during all times of the day, whereas occurred only during hot period (1400h and 1800h) in T2, T3 and T4 at 4, 5, 6 WK of age and their average. The average of Tb of all treatment groups for 4, 5, and 6 WK of age illustrated a significant decrease in moderate ($P < 0.05$) and hot periods of the day ($P < 0.01$) in comparison with T1, in addition to temperature difference was greater in hot period than moderate period. It can be concluded that all supplements used in this trial, expressed their efficacy in reducing Tb of heat-stressed birds, in particular during hot period of the day, however vitamin C was the most potent.

Key words: Body temperature, broiler, heat stress, betaine, vitamin C, KCl.
****Part of Ph.D work for the second author.**

الفعالية المقارنة لمختلف الاضافات الى ماء الشرب المستخدمة في تلطيف درجة حرارة جسم فروج اللحم المجهد حرارياً

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المستخلص

أستخدم 425 فروج لحم ،بعمر يوم، غير مجنسه، عرق هبرد التجاري. ربيت على فرشه لمدة 6 أسابيع وذلك لتقييم فعالية بعض المضافات لخفض درجة حرارة فروج اللحم المجهد حراريا. قدم للطيور الغذاء والماء بصورة حره. انتخب 375 طير متجانس الوزن الى حد ما، وزعت عشوائيا على خمسة مجاميع بثلاثة مكررات كل مكرر يضم 25 طير. شملت المعاملات: بدون أضافه (السيطره T1)، أظافة 400(T2) و 550 (T3) ملغرام بيتين/ لتر ماء شرب، مزيج KCl، NaHCO3، فيتامين C وحامض السلسيلك بكميات 450، 450، 50، و 50 ملغرام/ لتر ماء شرب على التوالي(T4) و150 ملغرام فيتامين C /لتر ماء شرب (T5). سجلت درجات الحراره والرطوبه في القاعه في الاوقات 600، 1400، 1800، و2400 ساعه يوميا. أستلمت الافراخ 24 ساعه أضاءه يوميا وطبقت جميع الاجراءات الروتينيه في التربيه والرعاية الصحيه. أظهرت النتائج ارتفاع درجة حرارة جسم معظم طيور المعاملات معنوياً ($P < 0.01$) في الفترة الحاره من اليوم(1400h –1800h) مقارنة بالفتره المعتدله (600h–2400h) وكان الفرق اعظم في معاملة السيطره لكل من الاسابيع 4، 5، 6 ومعدلاتها. وظهر أنخفاض معنوي في درجة حرارة T5 مقارنة مع معاملة السيطره T1 خلال كل اوقات اليوم، بينما حدث ذلك فقط في الفترة الحاره في المعاملات T2، T3 و T4 للاسابيع 4، 5، 6 ومعدلاتها. أظهر معدل درجة حرارة جسم طيور جميع المعاملات التجريبيه للاسابيع 4، 5، و6 من عمر الطيور انخفاضا معنويا في الفتره المعتدله ($P < 0.05$) والحاره ($P < 0.01$) من اليوم مقارنة مع درجة حرارة جسم طيور معاملة السيطره (T1) وكان الفرق في درجة الحراره أعظم في الفترة الحاره من الفترة المعتدله. يمكن الاستنتاج ان جميع المضافات المستخدمه في التجربه عبرت عن امتلاكها الفعاليه في خفض درجة حرارة جسم فروج اللحم المجهد حراريا خصوصا في الفترة الحارة من اليوم وأظهر فيتامين C الفعاليه الاقوى.

كلمات مفتاحية: درجة حرارة الجسم، فروج اللحم، الاجهاد الحراري، البيتين، فيتامين C، البوتاسيوم.
***جزء من اطروحة دكتوراه للباحث الثاني.**

INTRODUCTION

Increase global temperature during last two decades above common levels is one of the most important problems facing life, in particular drastic decrease in productivity of plant and animals. Iraq is located within arid and semiarid zones that is characterized by high temperature, which reaches 50 C^o average during long summer and low relative humidity. High environmental temperature causes economic losses in animal sector **(**34**)**. Iraqi poultry production suffers of this dilemma, therefore the performance being always lower than standards. High temperatures cause an increase in body temperature of birds, which lead birds to be heat stressed, low immunity and productivity, and high mortality (22). Body temperature (Tb) is the most physiological trait used to evaluate the responsiveness to heat stress, which birds try to keep in normal range (14, 18). Many researches have been conducted to alleviate the negative effects of heat stress **(**2**,** 25, 30)**,** such as using betaine as supplement with diet or drinking water **(**20**)**. Betaine has two main important physiological functions, as a donor of methyl group and osmotic regulator of cells, therefore betaine can persist liquid equilibrium inside cells under heat stress conditions **(**20**,** 19**)**. Betaine and vitamin C supplementation with diet or water decreased body temperature of birds exposed to heat stress (8, 36**).** It is well known that salicylic acid as a tranquilizer works, in particular during hot times to reduce Tb of heat-stressed broilers **(**1**)**. Electrolytes are essential for maintaining physiological functions during heat stress conditions, which result in increased excretion of potassium through urine, hence resulting in decreased plasma potassium (3; 25). Therefore, potassium levels should be increased for birds reared in high temperature conditions. Birds regulate mainly heat loss through water evaporation in high temperature conditions and this may lead to arise respiratory alkalosis **(**12, 27). Heat exposed birds may exhibit reduced levels of plasma carbon dioxide and bicarbonate **(**9**)** and may affect the blood pH and induce in the birds a nutritional requirement for bicarbonate **(**35**).** one-fourth of the broiler US companies use either $NaHCO_3$ or $NaHCO_3$•$NaCO_3$•$2H_2O$ (sodium sesquicarbonate) during summer season **(**16**)**. Acetylsalicylic acid (aspirin) is a potent antipyretic drug that has shown to lower the Tb of heat-stressed chickens, However, Stilborn *et al.* **(**33**)** found that, dietary supplementation of aspirin provided a little benefit to heat stressed broilers. McDaniel and Parker (29) found that inclusion of acetyl salicylic acid at 0.15% in the male broiler breeder diet did not decrease the Tb. Al-hassani (4) pointed out a supplementation mixture of KCl, $NaHCO_3$, vitamin C and salicylic acid with drinking water increased heat resistance of broiler chickens. Poultry have the ability to synthesize vitamin C, but this ability is inadequate under stress conditions, such as high environmental temperatures. Therefore, supplementation of vitamin C in water appears necessary during heat stress **(**31**).** The vitamin C helps to control the increase in Tb and plasma corticosterone concentration. There are several reports which demonstrated that supplemental vitamin C reduces rectal temperatures in heat-stressed birds **(**7, 26). This study was conducted to evaluate the efficacy of betaine, vitamin C and combined supplementation of vitamin C, salicylic acid, $NaHCO_3$, and KCl supplemented in drinking water in reducing Tb of heat-exposed broiler chickens.

MATERIALS AND METHODS

A total of 425 day old, unsexed, Hubbard classic broiler chicks strain, 40 grams weight average were reared on shave wood litter to the end of 6 weeks (WK). Birds were given water and diet *ad libitum.* Starter and finisher diets were given (table 1). At 21 day of age, all birds were weighed, 375 birds were almost equal weights chosen, randomly divided into 5 groups, 3 replicates of 25 birds each.Treatment groups were; without supplementation (T1,control), supplementation 400 (T2) and 550 (T3) mg betaine / drinking water (DK), mixture of KCl, NaHCO3,vitamin C and salicylic acid by 450, 450, 50 and 50 mg / DK respectively (T4) and 150 mg vitamin C / DK (T5). Temperature and relative humidity were recorded inside House four times daily 600, 1400, 1800 and 2400 hours by three thermometers and hygrometers located in the beginning, middle and end of house (table 2). Birds were received 24 hours light a day, also all routine management and medications were applied. Rectal temperature was recorded at the last day of each 4, 5, and 6 WK by one decimal digital thermometer (Digital, W. Germany) by inserting probe for 6 cm inside bird's rectum.. A complete random design was used and a significant differences ($P < 0.05$ and $P < 0.001$) was tested by Duncan Multiple Range Test (17). Data were statistically analyzed according to ready statistical analysis system **(**31**).**

Table 1. Composition of experimental diets for the starter (0-21 days) and Finisher (22-42 days) phases

Ingredients	Stazdxdrter (%)	Finisher (%)
corn	50	54.5
wheat	12	12
Soybean meal(1)	30	23
Protein concent.(2)	5	5
Sunflower oil	1	3.5
limestone	1	1
DiCalcium Phosphate	0.7	0.7
Nacl	0.3	0.3
total	100.0	100.0
Calculated chemical analysis (3)		
Me (kcal/kg diet)	2911	3130.65
Crude protein %	22.21	19.23
Lysine %	1.14	0.91
Arginine %	1.10	0.90
Methionine %	0.51	0.42
Methionine+cystine %	0.72	0.63
Choline mg/kg	1325	1250
Total calcium %	1.11	0.88
Available p %	0.56	0.48
Potassium mg/kg	0.77	0.60
Sodium %	0.14	0.14
Chloride%	0.15	0.15
Fiber %	3.61	3.20
Fat %	4.04	6.54
C/P ratio	131.09	162.80

1- Contains 48 % CP and 2230 Kcal / Kg metabolizable energy.

2-Contains 40 % CP, 5 % fat, 2 % fiber, 6.5 % Ca, 4 % available P, 3.85 %, Lysine, 3.7 % methionine, 4 % ME with mixture of vitamins and Microelements supplemented to fulfill birds requirements.

3-According to NRC, 1994.

RESULTS AND DISCUSSIONS

House temperature and relative humidity were recorded at 4, 5, 6 weeks (WK) of age and their average indicated that birds were being exposed to daily high cyclic temperature and heat stress (Table2). In most treatment groups, broiler body temperature (Tb) was significantly ($P < 0.01$) increased in hot period of the day (1400h and 1800h) in comparison with moderate period (600h and 2400h) and the difference was higher in control treatment1 group (T1) than the rest treatment groups at 4, 5, 6 WK of age and their average (Tables 3, 4, 5 and figure 1). A significant ($P < 0.05$) decrease was found in Tb of T5 in comparison with T1 during all times of the day, whereas occurred only during hot period (1400h and 1800h) in T2, T3 and T4 at 4, 5, 6 WK of age and their average (Tables 3, 4, 5 and figure 1).The average of Tb of all treatment groups (T2, T3, T4 and T5) for 4, 5, and 6WK of age illustrated a significant decrease in moderate (600h and 2400h) ($P < 0.05$) and hot periods of the day (1400h and 1800h) ($P < 0.01$) in comparison with T1, in addition to temperature difference was greater in hot period than moderate period (figure2). Results obtained have emphasized most previous studies, that betaine has a role in alleviating Tb of heat-stressed chickens through its osmotic functions, which decrease dehydration by fluids retaining inside body, which assists thermal dissipation through evaporation **(**37**),** as well as betaine donates three methyl (CH_3) groups, which promote protein metabolism without expends much energy and Tb increase, in addition to need to methyl groups is increased during stress conditions (20). Deyhim and Teeter (15) indicated that supplementing KCl increased water consumption over control. Belay and Teeter (10) showed that supplementing 0.75% KCl with the DW of heat-stressed broilers increased water consumption, non-sensible (evaporative) heat loss and apparent respiration efficiency, that all these processes have led to decrease Tb. The Tb response to KCl supplemented in DW is probably due to the fact that an elevation of plasma potassium has been shown to cause vasodilation (24). The K^+ ions have vasodilating property, coupled with the increased the water intake, which leads to much fluid retention in the peripheral vascular volume during heat stress conditions. Supplementation electrolytes with DW or diet generally increase water consumption of heat-stressed chickens, that helps to keep Tb within normal range (11). Sever heat stress great increases the secretion of catecholamine hormones from medulla of adrenal gland and the sympathetic nervous system in both poultry and mammals. It has been reported that during heat stress, the decrease in adrenal ascorbic acid (vitamin C) concentration coincided with adrenocortical insufficiency. It can be illustrated that the role of Vitamin C in maintaining Tb of heat-stressed birds either through decreases heat load by lowering heat production or increases heat loss from the body to the environment (13**)**. In addition to, vitamin C plays crucial role in resistance of stressor factors through synthesis and regulation central stress hormones secretion, epinephrine, norepinephrine and corticosterone **(**21), which finally result in decrease Tb and respiratory rate **(**23). It can be concluded that the heat-stressed broiler chickens responded positively to betaine, vitamin C, mixture of KCl, NaHCO3,vitamin C and salicylic acid supplemented with drinking water throughout the periods of heat stress as evidenced by reducing Tb, particularly during hot hours (1400-1800h) of the day in comparison with T1 (control)birds. Group T5 (150 mg vitamin C / L drinking water) was the most efficient among the rest treatment groups.

Table 2. Means of house temperature (̊C) and relative humidity (RH %) recorded during 600, 1400, 1800 and 2400 h of day for 4, 5 and 6 weeks of broiler age

weeks	600h		1400h		1800h		2400h	
	C^0	RH	C^0	RH	C^0	RH	C^0	RH
4	24.5	67.5	33.0	57.0	35.5	45.0	30.0	38.5
5	26.0	64.0	35.5	38.0	37.0	34.0	33.0	39.5
6	29.0	59.0	36.5	50.0	38.5	45.0	33.5	55.0
M *	26.5	63.5	35.0	48.3	37.0	41.3	32.2	44.3

*M = Average of 4,5 and 6 weeks

Table 3. Effect of supplementation betaine, mixture of $NaHCO_3$, KCl, salicylic acid and vit.C and vit. C alone with drinking water on body temperature of heat- stressed broiler chickens, 4 weeks old during 600, 1400, 1800 and 2400 h of day.

Treatments	600h	1400h	1800h	2400h
T_1	^{A} 40.87 ± 0.06^{c}	^{A}41.60 ± 0.10^{ab}	^{A} 41.70 ± 0.05^{a}	^{A}41.30 ± 0.15^{b}
T_2	^{AB} 40.70 ± 0.05^{b}	^{B}41.10 ± 0.15^{a}	^{B}41.30 ± 0.08^{a}	^{AB}40.95 ± 0.11^{ab}
T_3	^{AB} 40.60 ± 0.11^{b}	^{B}41.12 ± 0.06^{a}	^{B}41.30 ± 0.15^{a}	^{BC}40.70 ± 0.07^{b}
T_4	^{AB} 40.83 ± 0.07^{bc}	^{B}41.20 ± 0.05^{a}	^{B}41.35 ± 0.02^{ab}	^{AB}40.92 ± 0.13^{c}
T_5	^{B} 40.58 ± 0.07^{b}	^{B}41.00 ± 0.05^{a}	^{B}40.90 ± 0.07^{a}	^{C}40.45 ± 0.11^{b}

Table 4. Effect of supplementation betaine , mixture of $NaHCO_3$, KCl, salicylic acid and vit.C and vit. C alone with drinking water on body temperature of heat- stressed broiler chickens, 5 weeks old during 600, 1400, 1800 and 2400 h of day

Treatments	600h	1400h	1800h	2400h
T_1	^{A} 40.72 ± 0.06^{a}	^{A}41.78 ± 0.06^{a}	^{A} 41.57 ± 0.05^{a}	^{A}40.97 ± 0.03^{b}
T_2	^{A} 40.68 ± 0.11$^{a b}$	^{B}41.13 ± 0.14^{a}	^{B}40.90 ± 0.10^{ab}	^{B}40.58 ± 0.09^{b}
T_3	^{A} 40.67 ± 0.10^{b}	^{B}41.00 ± 0.10^{a}	^{C}40.48 ± 0.05^{bC}	^{B}40.30 ± 0.11^{C}
T_4	^{A}40.70 ± 0.05^{bc}	^{B}41.10 ± 0.08^{a}	^{B}40.90 ± 0.02^{ab}	^{AB}40.63 ± 0.06^{c}
T_5	^{B} 40.37 ± 0.04^{bc}	^{C}41.65 ± 0.08^{a}	^{C}40.55 ± 0.05^{ab}	^{B} 40.35 ± 0.02^{C}

Table 5. Effect of supplementation betaine , mixture of $NaHCO_3$, KCl, salicylic acid and vit.C and vit.C alone with drinking water on body temperature of heat- stressed broiler chickens, 6 weeks old during 600, 1400, 1800 and 2400 h of day

Treatments	600h	1400h	1800h	2400h
T_1	^{A}41.20 ± 0.02^{c}	^{A}42.09 ± 0.09^{a}	^{A} 42.06 ± 0.03^{a}	^{A}41.50 ± 0.07^{b}
T_2	^{A}41.07 ± 0.11^{b}	^{B}41.40 ± 0.07^{a}	^{B}41.43 ± 0.06^{a}	^{BC}41.03 ± 0.03^{b}
T_3	^{B}40.70 ± 0.02^{b}	^{C}41.09 ± 0.04^{a}	^{C}41.10 ± 0.05^{a}	^{C}40.83 ± 0.04^{b}
T_4	^{A}41.03 ± 0.03^{b}	^{B}41.47 ± 0.10^{a}	^{B}41.55 ± 0.05^{a}	^{B}41.14 ± 0.07^{b}
T_5	^{B} 40.45 ± 0.12^{ab}	^{D}0.75 ± 0.10^{ab}	^{D}40.90 ± 0.07^{a}	^{D} 40.50 ± 015^{ab}

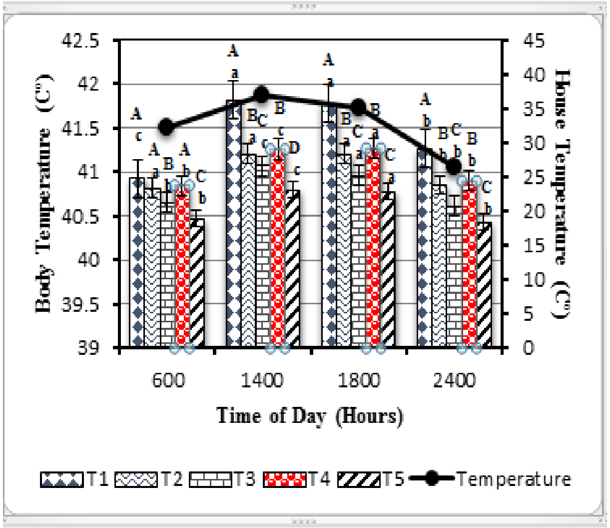

Figure 1- Average heat-stressed broiler body temperature for 4, 5, and 6 weeks of age. Superscripts of different capital and small litters mean significant (p < 0.05) difference between treatments within same time (h) and between times of day respectively. Standard error bars included

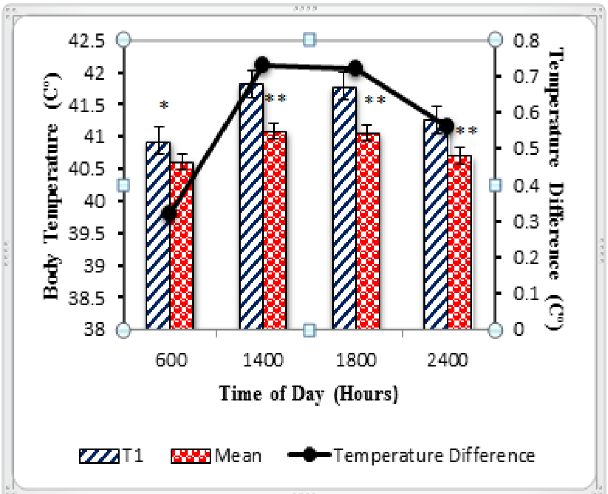

Figure 2- Illustrate body temperature of heat – stressed broiler chickens of control group and average for 4, 5 and 6 weeks of age for treatment groups, and their difference (-●-) time of day (h). * and ** mean significantly (P < 0.05) and (P <0.01) different within time respectively. Standard bars included

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