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PERFORMANCE, SOME PHYSIOLOGICAL AND IMMUNOLOGICAL RESPONSES TO HEAT STRESS IN BROILER CHICKENS FED ON DIETS CONTAINING BETAINE AND/OR SODIUM BICARBONATE

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ABSTRACT

An experiment was conducted to study the performance, some physiological and immunological responses to heat stress in broiler chickens fed on diets containing 1% betaine and/or 0.5% sodium bicarbonate. A total number of 180 broiler chickens at one-day of age were used. Birds were divided to 4 equal groups that were randomly allotted to one of the following four treatments 1) basel diet supplemented with 0.5% sodium bicarbonate, 2) basel diet supplemented with 0.5% sodium bicarbonate and 1% betaine, 3) basel diet supplemented with 1% betaine, and 4) basel diet without any supplements served as control. The birds were subjected to high ambient temperature (40°C±1°C) for 6 hrs per day from the 25th day up to the end of the experimental period (49 days of age).

The results could be summarized as follows:

- Significant (P<0.01) increases in final body weight and total body weight gain were detected in the birds fed diet supplemented with 1% betaine compared with the control group.
- A significant (P<0.001) improvement in feed conversion was observed in the birds fed diet supplemented with 0.5% sodium bicarbonate compared with the control group.
- A significant decrease (P<0.01) in water consumption was observed in the experimental group fed diet supplemented with 1% betaine compared with the control group.
- Significant decreases (P<0.01) in rectal temperature and blood pH were detected for birds fed diet supplemented with 0.5% sodium bicarbonate and 1% betaine and the birds fed diet supplemented with 1% betaine compared with the control group.
- Significant increase (P<0.01 and P<0.05) in bursa of fabricius and adrenal gland weight index was observed in all experimental groups fed supplemental diets compared with the control group.
- Significant increases (P<0.001 and P<0.05) in antibody titer and T4, T3 levels were observed in the group of birds fed diet supplemented with 0.5% sodium bicarbonate and 1% betaine compared with the control group.
- Significant decreases (P<0.05 and P<0.001) in H/L ratio, cholesterol, AST, ALT, total protein, albumin and globulin levels were observed in the experimental groups fed diets supplemented with 0.5% sodium bicarbonate and 1% betaine and the diet supplemented with 1% betaine compared with the control group.

INTRODUCTION

High environmental temperature is always problem. It has been considered as one of the most important factors affecting poultry production.

Therefore, heat stress became a major concern of broiler industry because of the resulting decreased growth, increased mortality, and poor body weight performance (Eberhart and Washburn, 1993 and Berrong and Washburn, 1998). This reduction of efficiency was partly explained by decreased metabolic utilization of nutrients, increased heat production, reduced protein retention and enhanced lipid deposition (Aïn Baziz *et al.*, 1996 and Geraert *et al.*, 1996).

Prolonged periods of elevated temperature increased morbidity and mortality of broiler chickens especially after the age of 4 weeks (Deaton *et al.*, 1978 and McDougald and Mcquistion, 1980).

Mortality due to heat stress is a problem in broiler. Economic losses attributable to heat prostration are especially large because they usually occur shortly before the broilers are marketable (Zhou *et al.*, 1997).

Heat stress caused many biochemical and physiological changes such as: shift in acid-base balance, hyperthermia, increased demand of O_2 and production of Co_2, increased production of free radical and corticosterone (Mebta and Shingari, 1999). Changes in acid-base status could affect water and mineral balance and metabolism of protein, fat and carbohydrate (May *et al.*, 1986 ; Hood *et al.*, 1990 and Takagi and Block, 1991). Blood alkalosis reduces both feed consumption and growth rate of chicks and increases feed cost of the gain (Jovanovic *et al.*, 1995).

Diets have been altered to reduced these problems via reducing the heat increment of the diet with fat supplementation (Daghir, 1988) or improving the amino acid balance (Hus-Jennchung *et al.*, 1998) or extravitamin and / or trace minerals premix supplementation (Deyhim and Teeter, 1991).

Numerous compounds have been added to broiler feed and water in attempts to help alleviate the adverse effects of heat stress. Many compounds have been directed at correcting the acid-base imbalances of the blood, primarily toward counteracting the pH rise of respiratory alkalosis (Whiting *et al.*, 1991).

Some compounds, such as the sodium bicarbonate, ascorbic acid (Mebta and Shingari, 1999), NH_4Cl, betaine (Trimethylglycine) and KCL have been used in attempts to reduce the deleterious effects of heat stress.

A number of studies have reported beneficial responses to sodium bicarbonate ($NaHCo_3$) added to the diet or to drinking water (Teeter *et al.*, 1985 ; Branton *et al.*, 1986 ; Gorman and Balnave, 1994 and Hayat *et al.*, 1999). Balnave and Oliva (1991), working with finishing broilers at high temperatures (30°C), found that diets supplemented with 16.8 g $NaHCo_3$ /kg or drinking water supplemented with 5.6 g $NaHCo_3$ /L produced a significant improvement in bird production response.

Moreover, Gorman (1992) evaluated the performance of finishing broilers (3-6 weeks of age) at high temperature (32°C). He found that dietary supplementation with sodium bicarbonate stimulated water and feed intakes and improved weight gain.

Ghazalah *et al.* (1998) found that the addition of either 1% $NaHCo_3$ or 2% of a mixture of $NaHCo_3$ and NH_4Cl (50:50) to broiler chick diets gave

the highest performance and economic efficiency of production compared to the control diet. While, Latshaw and Turner, 1991 ; Grizzle *et al.*, 1992 and Roberts *et al.*, 1995 found no significant effect.

Other studies used betaine to counter the negative effect of heat stress in poultry. Betaine is tertiary amine formed by the oxidation of choline (Kidd *et al.*, 1997). It is present in most living organisms and is concentrated in some plants like sugar beet, from which it can be extracted (Virtanen, 1995). Betaine has an osmoprotective effect by accumulating in cells and cell organelles exposed to osmotic and ionic stress, replacing inorganic ions and protecting enzymes and cell membranes from ionic inactivation (Rudolph *et al.*, 1986 ; Petronini *et al.*, 1992 and Ko *et al.*, 1994).

The use and evaluation of betaine (Trimethylglycine) as a feed additive for animals has increased in last years. It has been used for pigs (Smith *et al.*, 1994 ; Matthews *et al.*, 1995), chicks (Saunderson and Mackinlay, 1990 ; Virtanen *et al.*, 1996 ; Remus and Virtanen, 1996 and Zimmermann *et al.*, 1996), and salmon (Virtanen *et al.*, 1989). Some studies indicated that feed efficiency was more improved by betaine than by choline (Abel *et al.*, 1985; and Schutte *et al.*, 1997). In poultry, the methylation properties of betaine may also be important during lipid metabolism by reducing and redistributing carcass fat (Saunderson and Mackinlay, 1990). Supplemented betaine may be advantageous during certain physiologically challenging conditions, including the high metabolic demand of rapid growth, disease and osmotic stress in different cell types, because betaine is a labile donor of methyl groups (Kidd *et al.*, 1997).

The objective of this study was to determine the possibility of using dietary betaine (Trimethylglycine) and sodium bicarbonate ($NaHCo_3$) to improve broiler performance, physiological and immunological responses during exposure to a high ambient temperature.

MATERIALS AND METHODS

Birds and diets:

The present study was carried out using 180 one-day old unsexed commercial Hubbard broiler chicks. The chicks were randomly divided into twelve groups of 15 birds. Groups of chicks were allocated to four diet treatments with three replicates for each treatment. The chicks were floor reared on a deep litter system (10 birds/m^2), provided with clean feeders and waterers, and kept under standard hygienic management conditions, and feed and water were offered *ad libitum*.

The birds were fed on a commercial starter and finisher rations to supply the required levels of protein and energy as recommended by NRC (1994), the ingredient percentage and calculated chemical composition of each diet (A.O.A.C., 1980) are presented in Table 1.

The experimental treatments were the addition of 0.5% sodium bicarbonate ($NaHCo_3$); the addition of 0.5% sodium bicarbonate plus 1.0% betaine (Trimethylglycine) ; the addition 1.0% betaine (Trimethylglycine), and the control was the basal diet without any supplements (control).

Table (1): Physical and chemical composition of the basal diets.

Ingredients	Percentage	
	Starter (1-28 days)	Finisher (28-49 days)
Physical composition:		
Yellow corn	63	72
Soybean meal 44% CP	27	18
Broiler protein conc.*	10	10
Calculated analysis:		
ME (kcal/kg)**	2980	3091
Crude protein %	22.6	19.2
Crude fiber %	3.5	3.0
Ether extract %	3.3	3.5
Calcium %	0.88	0.87
Total phosphorus %	0.66	0.65
Methionine %**	0.48	0.44
Lysine %**	1.19	0.97
Methionine + cystine %**	0.65	0.62

***broiler protein concentrate mixture: composed of meat meal, fish meal, sodium chloride, dicalcium phosphate, DL methionine, Limestone, vitamin and mineral premix, and antioxidant. It contains 52% CP, 2200 kcal ME/kg, 6.9% ether extract, 2% CF, 8% Ca, 3.3 % av. P. ; 2% methionine, 3% lysine and 2.4% methionine + cystine.**
****calculated analysis was based on the analysis tables of poultry NRC (1994).**

At 25th day of age, birds were exposed to extra heat sources to raise the ambient temperature up to 40°C±1°C for 6 hr per day (from 10 a.m. to 16 p.m.) until the end of the experimental period (49 day of age).

The tested parameters:

Growth performance:

The body weight and feed consumption were weekly recorded, the feed efficiency and body weight gain were calculated for the different groups.

Bird's thermoregulation measurements such as water consumption (per 6 h) and rectal temperature were recorded during exposing birds to heat stress.

The immune response:

The immune response was evaluated by measuring humoral immunity through haemagglutination inhibition (HI) test against Newcastle disease (Majjabe and Hitchner, 1977) at 21st day and 35th day of age. At the end of experiment, cellular immunity was tested through differential leucocytic count to determine heterophil / lymphocyte (H/L) ratio (Schalm *et al.*, 1973). Also, spleen and bursa of fabricius weight, as they considered the immune responsible organs, also thyroid gland, adrenal gland, and liver weight were measured.

Lymphoid organs and other internal organs weight index: were calculated for bursa, spleen, liver, thyroid and adrenal gland according to Montgomery *et al.* (1985) as follows:

$$\frac{\text{Organ weight}}{\text{Body weight}} \times 10000$$

Blood biochemistry:

At the end of the experiment (7 weeks of age), 8 birds of each treatment were slaughtered to obtained two blood samples one for the quantitative determination of aspartate transaminase, (AST) and alanine transaminases, (ALT) (Reitman and Frankel, 1957), total serum protein, (TP) (Doumas, 1975), serum albumin (Doumas *et al.*, 1971), serum uric acid (UA) (Caraway, 1963), total serum cholesterol (Watson, 1960), serum thyroxine, (T4) and serum triiodothyronine, (T3) (Passing and Bablok, 1983), whereas the other blood sample was collected for pH determination and HCT%. Haematocrit percentage (HCT %) measured by caulter counter model CBC 5PN 4235629, Hialeah, Florida, USA.

Statistical analysis:

The obtained data were statistically analyzed using ANOVA-test (SPSS, 1986). Differences between means were judged according to Duncan's multiple range test (1955).

RESULTS AND DISCUSSION

Growth performance:

Effects of treatments on final body weight, body weight gain, feed consumption, feed conversion and water consumption of heat-stressed chicks are presented in Table 2. The results show that there are significant differences in final body weight and body weight gain between the treated groups of chicks and the control group. The birds fed on a diet supplemented with 0.5% sodium bicarbonate ($NaHCo_3$) plus 1.0% betaine under heat stress were significantly higher ($P<0.01$) in final body weight and body weight gain than those fed on the basel diet (control group). A similar trend was observed for total feed consumption where the highest value was recorded with 0.5% $NaHCo_3$ plus1% betaine group. Concerning the feed conversion, it could be noticed that $NaHCo_3$ groups gave the best results followed by betaine groups. Birds fed with a combination of $NaHCo_3$ and betaine gave less results but were better than the control birds. This means that both $NaHCo_3$ and betaine play a role in food metabolism and increase the food utilization when used alone. Haydon and West (1990) suggested that the improvement resultsed form $CaCo_3$ or $NaHCo_3$ supplementation to heat stressed animals, was probably due to increased blood buffering capacity. The results obtained for adding $NaHCo_3$ are in agreement with results outlined by Hooge (2000) who stated that the use of $NaHCo_3$ improved the performance of broiler chickens during heat stress as Na replenish some of the Na lost in urine, and bicarbonate is carbon dioxide generating buffers that restores some of the Co_2 (lost while panting) and after cool down broilers may develop metabolic acidosis in tissues and bicarbonate serves to buffer this post stress effect. Also, Gorman (1992) found that dietary supplementation with sodium bicarbonate stimulated water and feed intake and improved weight gain.

Regarding the effect of betaine, similar results were obtained by Abel *et al.* (1985) and Schutte *et al.* (1997), who reported that feed efficiency was more improved by betaine than choline. Also, Kidd *et al.* (1997) reported that supplemental betaine may be advantageous during certain physiologically challenging conditions, including the high metabolic demand of rapid growth, disease and osmotic stress in different cell types, because betaine is a labile donor of methyl groups.

As shown in Table 2, water consumption decreased significantly ($P<0.01$) during heat exposure when birds were fed on diet supplemented with betaine compared to other treatments. This result indicates that betaine is an osmolyte, which helps the bird retain water more efficiently ; retaining water allows more energy for growth. Moreover, Bagnasco *et al.* (1989) reported that betaine accumulation in the renal medulla cells allows the cells to tolerate osmotic stress.

Table (2): Mean±SE of growth performance and water consumption of broiler chickens subjected to high ambient temperature in the different experimental diet groups.

Traits \ Treatments	$NaHCo_3$	$NaHCo_3$ + betaine	Betaine	Control	Sig.
Initial body weight (g) at 7 d of age	102.80±1.01	105.36±1.68	105.67±1.12	101.88±1.43	NS
Final body weight (g) at 49 d of age	1602.48±13.39^{ab}	1624.16±25.72^{a}	1560.11±19.19^{bc}	1534.18±20.34^{c}	**
Body weight gain (g)	1499.68±12.79^{ab}	1518.80±24.16^{a}	1454.44±18.28^{bc}	1432.32±19.32^{c}	**
Total feed consumed (g)	3579.52±20.66^{b}	3950.80±27.27^{a}	3637.14±11.73^{b}	3900.57±25.95^{a}	***
Average feed conversion	2.39±0.021^{c}	2.62±0.046^{b}	2.51±0.033^{b}	2.74±0.049^{a}	***
Water consumption ml/bird/6 hr	261.90±6.58^{a}	258.09±2.98^{a}	232.37±5.99^{b}	259.52±8.71^{a}	**

a, b and c : means in the row with different superscripts vary significantly compared to control.

**** P<0.01 *** P<0.001 NS not significant**

Results presented in Table (3) indicate that adding sodium bicarbonate alone or combined with betaine to the diets decreased rectal temperature of heat-stressed chicks compared with the control; less decrease in rectal temperature was obtained by adding betaine alone. These results are in agreement with those obtained by Smith and Teeter (1989); Balnave and Gorman (1993) ; Ahmed and Maghraby (1995) and Soutyrine *et al.* (1998), who found that adding $NaHCo_3$ to broiler diet or drinking water reduced body temperature of broiler chicks under heat stress conditions.

Table (3): Means±SE of rectal temperature and blood pH of broiler chickens subjected to high ambient temperature in the different experimental diet groups at 49 day of age.

Traits \ Treatments	$NaHCo_3$	$NaHCo_3$ + betaine	Betaine	Control	Sig.
Rectal temperature (°C)	41.83±0.29^{bc}	41.43±0.14^{c}	42.07±0.07^{b}	42.70±0.07^{a}	**
Blood pH	7.36±0.025^{a}	7.27±0.027^{b}	7.25±0.029^{b}	7.38±0.005^{a}	**

a, b and c : means in the row with different superscripts vary significantly compared to control.

**** P<0.01**

Effect of sodium bicarbonate and / or betaine on blood pH of heat-stressed chicks is presented in Table (3). The results show that the addition of betaine to broiler diets alone or combined with $NaHCo_3$ decreased blood pH ($P<0.01$) of heat-stressed chicks. Adding $NaHCo_3$ alone had no effect on blood pH. This results seem to agree with those obtained by Rudolph *et al.* (1986) ; Peteronini *et al.* (1992) ; Ko *et al.* (1994) and Kidd *et al.* (1997) who reported that betaine has an osmoprotective effect by accumulating in cells and cell organelles exposed to osmotic and ionic stress, replacing inorganic ions and protecting enzymes and cell membranes from ionic inactivation.

Data for lymphoid and other internal organs weight index are presented in Table (4). Results indicate that, adding $NaHCo_3$ and / or betaine to heat-stressed chicks' diets increased the weight index of bursa of fabricius and adrenal gland. This confirms the hypothesis that diet supplementation with $NaHCo_3$ and / or betaine attenuated the deleterious effect of heat stress and gave the hens the ability to resist heat, because the bursa of fabricius has an important duty in humeral immunity or antibody formation. On the other hand, there were no significant differences in spleen, liver and thyroid gland weight index among the different experimental treatments.

Table (4): Means±SE of lymphoid and other internal organs weight index[1] of broiler chickens subjected to high ambient temperature in the different experimental diet groups at 49 day of age.

Traits \ Treatments	$NaHCo_3$	$NaHCo_3$ + betaine	Betaine	Control	Sig.
Bursa of fabricius	15.28±0.70[a]	16.43±0.76[a]	14.60±1.55[a]	8.20±0.37[b]	***
Spleen	14.12±2.68	15.93±1.30	16.69±0.94	16.38±1.69	NS
Liver	263.16±38.64	287.69±37.77	265.17±3.07	282.68±5.45	NS
Thyroid gland	2.22±0.34	1.38±0.06	2.49±1.39	2.27±0.43	NS
Adrenal gland	4.72±0.47[a]	4.69±0.73[a]	4.60±0.15[a]	2.76±0.35[b]	*

1: Internal organs weight index = organ weight/ body weight x 10000
a and b: means in the row with different superscripts vary significantly compared to control.
* P<0.05 *** P<0.001 NS not significant

The results of immune response parameters are presented in Table (5). Humeral immune response as represented in haemagglutination inhibition (HI) titers against Newcastle disease virus vaccination, indicated that adding $NaHCo_3$ and/or betaine to heat-stressed chicks' diets increased the level of antibody titer ($P<0.001$) at 35th day of age; the best results were obtained when a combination of $NaHCo_3$ and betaine was added. This confirms the hypothesis that diet supplementation with sodium bicarbonate and betaine attenuated the deleterious effect of heat stress and gave hens the ability to resist heat. Kidd *et al.* (1997) reported that supplemental betaine may be advantageous during certain physiologically challenging conditions, including the high metabolic demand of rapid growth, disease and osmotic stress in different cell types, because betaine is a labile donor of methyl groups.

Table (5): Means±SE of haemagglutination inhibition (HI) titers, heterophil / lymphocyte ratio (H/L) and hematocrit percentage (HCT %) of broiler chickens subjected to high ambient temperature in the different experimental diet groups.

Traits \ Treatments	$NaHCo_3$	$NaHCo_3$ + betaine	Betaine	Control	Sig.
HI at 21 day of age	5.75±0.25	5.50±0.65	6.00±1.00	5.25±0.25	NS
HI at 35 day of age	6.00±0.41^{b}	7.25±0.25^{a}	5.75±0.25^{b}	4.33±0.33^{c}	***
H/L ratio	1.02±0.02^{ab}	0.938±0.02^{b}	0.928±0.03^{b}	1.13±0.11^{a}	*
HCT %	28.61±0.83	28.84±0.69	26.33±0.64	27.11±0.68	NS

a, b and c: means in the row with different superscripts vary significantly compared to control.

** P<0.05 *** P<0.001 NS not significant*

Regarding the cellular immune response, the results demonstrated reduction in H/L ratio in heat-stressed chicks fed on diets supplementation with sodium bicarbonate and betaine or betaine alone. The increase in blood lymphocyte and decrease in blood heterophile number may be attributed to the decrease in blood corticosteroid level. There were no significant differences in hematocrit percentage (HCT %) among the different experimental treatments.

The results of serum thyroxine (T4) and serum triiodothyronine (T3) levels of heat-stressed chicks are presented in Table (6). Serum T4 and T3 concentrations were higher (P<0.05) in heat-stressed chicks fed on diets with sodium bicarbonate and betaine than those fed the control diet or diets with *$NaHCo_3$ or betaine alone. Thyroid gland is involved in control of growth* and development and exerts primary control of metabolic rate, any treatments like heat stress that changes metabolic rate affect thyroid activity (May and McNaughton, 1980). It is well known that, heat stress-induced reduction in plasma T3 concentration could be interpreted through thermal inhibition of the hypothalamus and pituitary which results in a decline of TSH release and in turn thyroid hormones secretion (Sturike, 1986).

Table (6): Means±SE of serum thyroxine (T4) and triiodothyronine (T3) levels of broiler chickens subjected to high ambient temperature in the different experimental diet groups at 49 day of age.

Traits \ Treatments	$NaHCo_3$	$NaHCo_3$ + betaine	Betaine	Control	Sig.
T4 (µg/dL)	6.60±0.17^{b}	9.50±1.08^{a}	8.00±0.49^{ab}	6.53±0.36^{b}	*
T3 (ng/dL)	136.58±16.15^{b}	176.90±6.19^{a}	135.63±14.46^{b}	114.27±6.52^{b}	*

a and b : means in the row with different superscripts vary significantly compared to control.

* P<0.05 *** P<0.001

These results indicate that bird's heat tolerance improve as birds fed diets with sodium bicarbonate and betaine by increasing thyroid activity.

Results in Table (7) indicated that adding betaine alone or combined with sodium bicarbonate to heat-stressed chicks increased (P<0.001) the

levels of total protein, albumin and globulin. It is clear that betaine with $NaHCo_3$ gave higher albumin and globulin values followed by betaine alone. This may be related to the accumulated betaine protects the cells from osmotic stress and allows them to continue regular metabolic activities in conditions that would normally inactivate the cell (Rudolph *et al.*, 1986; Petronini *et al.*, 1992 and Ko *et al.*, 1994).

Table (7): Means±SE of serum protein and cholesterol levels of broiler chickens subjected to high ambient temperature in the different experimental diet groups at 49 day of age.

Traits \ Treatments	$NaHCo_3$	$NaHCo_3$ + betaine	Betaine	Control	Sig.
Total protein (g/dL)	2.74 ± 0.03^{c}	3.96 ± 0.12^{a}	3.42 ± 0.14^{b}	2.54 ± 0.13^{c}	***
Albumin (g/dL)	1.19 ± 0.04^{c}	1.88 ± 0.05^{a}	1.59 ± 0.07^{b}	1.21 ± 0.06^{c}	***
Globulin (g/dL)	1.54 ± 0.02^{c}	2.08 ± 0.08^{a}	1.83 ± 0.08^{b}	1.34 ± 0.08^{c}	***
A/G ratio	0.77 ± 0.03^{b}	0.91 ± 0.02^{a}	0.87 ± 0.03^{a}	0.91 ± 0.04^{a}	*
Cholesterol (mg/dL)	152.50 ± 0.65^{b}	144.75 ± 1.70^{b}	111.67 ± 1.67^{c}	174.75 ± 9.87^{a}	***

a, b and c : means in the row with different superscripts vary significantly compared to control.
* P<0.05 *** P<0.001

Cholesterol level was lowest (P<0.001) when heat stressed chicken were fed on diet with betaine alone, followed by those fed on diet with betaine and $NaHCo_3$ and those fed on diet with $NaHCo_3$ alone.

The findings obtained were in agreement with those of Saunderson and Mackinlay (1990) who reported that in poultry, the methylation properties of betaine may be important during lipid metabolism by reducing and redistributing carcass fat. Moreover, Schutte *et al.* (1997) reported that betaine may interact with the lipid metabolism by stimulating the oxidative catabolism of fatty acid via its role in carnithine synthesis, thus offering a potential for reduced carcass fatness in commercial production. Liver function data represented as aspartate amino transferases (AST) and alanine amino transferases (ALT) levels kidney function represented by serum uric acid are presented in Table (o). Presented data show that adding betaine alone or combined with sodium bicarbonate to heat-stressed chicks' diets decreased (P<0.001, P<0.01) the activities of AST and ALT enzymes. The decrease of enzyme activity reflects healthy, nonpathologecal and non-toxic effect on liver.

Table (8): Means±SE of Liver and kidney function efficiency of broiler chickens subjected to high ambient temperature in the different experimental diet groups at 49 day of age.

Traits \ Treatments	$NaHCo_3$	$NaHCo_3$ + betaine	Betaine	Control	Sig.
Serum AST (U/L) (GOT)	37.75 ± 0.48^{a}	26.50 ± 1.71^{c}	30.00 ± 0.58^{b}	37.50 ± 0.65^{a}	***
Serum ALT (U/L) (GPT)	2.25 ± 0.14^{b}	1.38 ± 0.24^{c}	1.75 ± 0.14^{bc}	3.50 ± 0.29^{a}	***
Serum uric acid (mg/dL)	5.50±0.05	5.47±0.06	5.53±0.06	5.45±0.02	NS

A, b and c: means in the row with different superscripts vary significantly compared to control.
*** P<0.001 NS Not significant

The kidney function efficiency test represented by serum uric acid (UA) demonstrated nonsignificant differences among the different treatments. It could be concluded that adding betaine and sodium bicarbonate to heat-stressed chicks' diets may help reduce the negative effects of heat stress on them.

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الأداء الأنتاجى وبعض الاستجابات الفسيولوجية والمناعية للاجهاد الحرارى فى دجاج التسمين المغذاة على علائق محتوية على البيتايين وبيكربونات الصوديوم كلاً على حده أو معاً.

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أجريت هذه الدراسة على عدد ١٨٠ كتكوت تسمين هبرد عمر يوم ، ربيت هذه الكتاكيت على الارض ، وتم توزيعها على أربعة مجاميع تجريبية وقسمت كل مجموعة (معاملة) الى ثلاثة مكررات بكل مكرر ١٥ كتكوت ، وذلك بغرض دراسة كفاءة أداء الكتاكيت والاستجابة الفسيولوجية والمناعية لهم تحت ظروف الاجهاد الحرارى عندما نضيف الى العليقة البيتايين وبيكربونات الصوديوم وكانت المعاملات كالاتى:

١- المعاملة الاولى : العليقة الاساسية + ٠,٥% بيكربونات صوديوم
٢- المعاملة الثانية: العليقة الاساسية + ٠,٥% بيكربونات صوديوم + ١% بتيائين
٣- المعاملة الثالثة: العليقة الاساسية + ١% بتيائين
٤- المعاملة الرابعة: العليقة الاساسية فقط بدون اى اضافات (مجموعة المقارنة)

وتم تعريض الطيور الى درجة حرارة ٤٠ ثم±١ م لمدة ٦ ساعات يوميا من الساعة العاشرة صباحا وحتى الساعة الرابعة بعد الظهر وهى ساعات الذروة وذلك عند عمر ٢٥ يوم حتى نهاية التجربة عند عمر ٤٩ يوم.

وتم دراسة معدل النمو والكفاءة الغذائية ومعدل استهلاك الماء ودرجة حرارة الجسم وpH الدم ووزن بعض الاعضاء والغدد الداخلية ومستوى الاجسام المضادة لمرض النيوكاسل بجسم الطائر ونسبة خلايا H/L ونسبة الهيماتوكريت – تركيز البروتين الكلى – الالبيومين والجلوبيولين فى الدم وتركيز الكولسترول وهرمون الثيروكسين والتراى ايودوثيرونين فى الدم وتركيز انزيمات الكبد AST, ALT وتركيز حمض اليوريك فى الدم.

ويمكن تلخيص النتائج كالاتى:

- زاد وزن الطيور عند عمر ٤٩ يوم وكذلك معدل النمو معنويا عند مستوى ٠,٠١ للمجموعة المضاف اليها ١% بيتايين بالمقارنة بمجموعة المقارنة (الكنترول).
- حدث تحسن للكفاءة الغذائية معنويا عند مستوى ٠,٠٠١ وللمجموعة المضاف اليها ٠,٥% بيكربونات صوديوم مقارنة بالمجموعة الكنترول.
- قل استهلاك الماء وكذلك درجة حرارة الجسم و pH الدم معنويا عند مستوى ٠,٠١ للمجموعة المضاف اليها ١% بيتايين وكذلك المجموعة المضاف اليها ٠,٥% بيكربونات صوديوم و ١% بتيائين مقارنة بالكنترول.
- زاد وزن حويصلة فيبريشيوس وغدة الادرينال معنويا عند مستوى ٠,٠١ ، ومستوى ٠,٠٥ للمعاملات الغذائية الثلاثة مقارنة بالكنترول.
- زاد مستوى حجم الاجسام المضادة لمرض النيوكاسل ومستوى T3, T4 معنويا عند مستوى ٠,٠٠١ ومستوى ٠,٠٥ وذلك للمجموعة المضاف اليها ٠,٥% بيكربونات صوديوم و١% بيتايين مقارنة بالمجموعة الكنترول.
- قل معدل H/L معنويا عند مستوى ٠,٠٥ للمجموعة المضاف اليها ١% بيتايين والمجموعة المضاف اليها ٠,٥% بيكربونات صوديوم و١% بيتايين مقارنة بالمعاملة الكنترول.
- قل مستوى كولسترول الدم وكذلك قل مستوى انزيمات الكبد AST, ALT معنويا عند مستوى ٠,٠٠١ للمجموعة المضاف اليها ١% بيتايين والمجموعة المضاف اليها ٠,٥% بيكربونات صوديوم و١% بيتايين مقارنة بالمجموعة الكنترول.
- لم يتأثر معنويا وزن كل من الغدة الدرقية أو الكبد أو الطحال وايضا لم يتأثر معنويا مستوى حمض اليوريك فى الدم.