PERFORMANCE, SOME PHYSIOLOGICAL AND IMMUNOLOGICAL RESPONSES TO HEAT STRESS IN BROILER CHICKENS FED ON DIETS CONTAINING BETAINÉ 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) basal diet supplemented with 0.5% sodium bicarbonate, 2) basal diet supplemented with 0.5% sodium bicarbonate and 1% betaine, 3) basal diet supplemented with 1% betaine, and 4) basal diet without any supplements served as control. The birds were subjected to high ambient temperature (40°C±1°C) for 8 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 a 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 (Ain 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 Mcquiston, 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 O₂ and production of CO₂, 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 (Daghiri, 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 countering the pH rise of respiratory alkalosis (Whiting et al., 1991).

Some compounds, such as the sodium bicarbonate, ascorbic acid (Mebta and Shingari, 1999), NH₄Cl, 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 (NaHCO₃) added to the diet or to drinking water (Teeter et al., 1985 ; Branton et al., 1996 ; 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 NaHCO₃/kg or drinking water supplemented with 5.6 g NaHCO₃/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.

Ghazalakh et al. (1998) found that the addition of either 1% NaHCO₃ or 2% of a mixture of NaHCO₃ and NH₄Cl (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 a 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, 1995 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 (NaHCO₃) 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/m²), 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 (NaHCO₃); 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.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starter (1-28 days)</td>
</tr>
<tr>
<td>Physical composition:</td>
<td></td>
</tr>
<tr>
<td>Yellow corn</td>
<td>63</td>
</tr>
<tr>
<td>Soybean meal 44% CP</td>
<td>27</td>
</tr>
<tr>
<td>Broiler protein conc.</td>
<td>10</td>
</tr>
<tr>
<td>Calculated analysis:</td>
<td></td>
</tr>
<tr>
<td>ME (kcal/kg)</td>
<td>2980</td>
</tr>
<tr>
<td>Crude protein %</td>
<td>22.6</td>
</tr>
<tr>
<td>Crude fiber %</td>
<td>3.5</td>
</tr>
<tr>
<td>Ether extract %</td>
<td>3.3</td>
</tr>
<tr>
<td>Calcium %</td>
<td>0.88</td>
</tr>
<tr>
<td>Total phosphorus %</td>
<td>0.66</td>
</tr>
<tr>
<td>Methionine %</td>
<td>0.48</td>
</tr>
<tr>
<td>Lysine %</td>
<td>1.19</td>
</tr>
<tr>
<td>Methionine + cystine %</td>
<td>0.65</td>
</tr>
</tbody>
</table>

*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 haemaggutination inhibition (Hl) test against Newcastle disease (Majzabe 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:

2324
Organ weight

Body weight

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 caullter 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 (NaHCO₃) 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 baseline diet (control group). A similar trend was observed for total feed consumption where the highest value was recorded with 0.5% NaHCO₃ plus 1% betaine group. Concerning the feed conversion, it could be noticed that NaHCO₃ groups gave the best results followed by betaine groups. Birds fed with a combination of NaHCO₃ and betaine gave less results but were better than the control birds. This means that both NaHCO₃ and betaine play a role in food metabolism and increase the food utilization when used alone. Haydon and West (1990) suggested that the improvement resulted from CaCO₃ or NaHCO₃ supplementation to heat stressed animals, was probably due to increased blood buffering capacity. The results obtained for adding NaHCO₃ are in agreement with results outlined by Hooge (2000) who stated that the use of NaHCO₃ 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 CO₂ (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 under 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.**

<table>
<thead>
<tr>
<th>Traits</th>
<th>Sodium bicarbonate</th>
<th>Sodium bicarbonate + betaine</th>
<th>Betaine</th>
<th>Control</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial body weight (g) at 7 d of age</td>
<td>102.80±1.01</td>
<td>165.30±1.68</td>
<td>105.67±1.12</td>
<td>101.80±1.43</td>
<td>NS</td>
</tr>
<tr>
<td>Final body weight (g) at 49 d of age</td>
<td>1602.49±13.39</td>
<td>1624.16±25.72</td>
<td>1560.11±19.19</td>
<td>1534.18±20.34</td>
<td>**</td>
</tr>
<tr>
<td>Body weight gain (g)</td>
<td>1499.68±12.79</td>
<td>1518.89±24.18</td>
<td>1454.44±18.29</td>
<td>1432.32±19.34</td>
<td>**</td>
</tr>
<tr>
<td>Total feed consumed (g)</td>
<td>3579.62±20.66</td>
<td>3590.80±27.27</td>
<td>3587.84±11.73</td>
<td>3590.87±25.05</td>
<td>***</td>
</tr>
<tr>
<td>Average feed conversion</td>
<td>2.39±0.021</td>
<td>2.62±0.046</td>
<td>2.51±0.033</td>
<td>2.74±0.049</td>
<td>**</td>
</tr>
<tr>
<td>Water consumption ml/bird/hr</td>
<td>261.90±6.58</td>
<td>259.09±2.98</td>
<td>232.37±5.98</td>
<td>259.52±8.71</td>
<td></td>
</tr>
</tbody>
</table>

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 NaHCO₃ 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.**

<table>
<thead>
<tr>
<th>Traits</th>
<th>Sodium bicarbonate</th>
<th>Sodium bicarbonate + betaine</th>
<th>Betaine</th>
<th>Control</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectal temperature (°C)</td>
<td>41.63±0.29b</td>
<td>41.43±0.14b</td>
<td>42.07±0.07b</td>
<td>42.70±0.07b</td>
<td>**</td>
</tr>
<tr>
<td>Blood pH</td>
<td>7.36±0.025a</td>
<td>7.27±0.027b</td>
<td>7.25±0.029b</td>
<td>7.38±0.005b</td>
<td>**</td>
</tr>
</tbody>
</table>

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 NaHCO₃ decreased blood pH (P<0.01) of heat-stressed chicks. Adding NaHCO₃ alone had no effect on blood pH. This result seems to agree with those obtained by Rudolph et al. (1986) ; Petronini 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 NaHCO₃ 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 NaHCO₃ 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 index¹ of broiler chickens subjected to high ambient temperature in the different experimental diet groups at 49 day of age.**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>NaHCO₃</th>
<th>NaHCO₃ + betaine</th>
<th>Betaine</th>
<th>Control</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bursa of fabricius</td>
<td>15.2±0.70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.43±0.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.60±1.55&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.20±0.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>***</td>
</tr>
<tr>
<td>Spleen</td>
<td>14.12±2.68</td>
<td>15.93±1.30</td>
<td>16.69±0.94</td>
<td>16.38±1.66</td>
<td>NS</td>
</tr>
<tr>
<td>Liver</td>
<td>263.16±38.64</td>
<td>287.69±37.77</td>
<td>265.17±3.07</td>
<td>282.68±5.45</td>
<td>NS</td>
</tr>
<tr>
<td>Thyroid gland</td>
<td>2.22±0.34</td>
<td>1.38±0.06</td>
<td>2.49±1.39</td>
<td>2.27±0.43</td>
<td>NS</td>
</tr>
<tr>
<td>Adrenal gland</td>
<td>4.77±0.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.69±0.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.60±0.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.76±0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NS</td>
</tr>
</tbody>
</table>

¹: Internal organs weight index = organ weight/ body weight x 10000

<sup>a</sup> and <sup>b</sup>: means in the row with different superscripts vary significantly compared to control.
<sup>* P<0.05</sup>  <sup>*** P<0.001</sup>  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 NaHCO₃ and/or betaine to heat-stressed chicks' diets increased the level of antibody titer (P<0.001) at 35<sup>th</sup> day of age; the best results were obtained when a combination of NaHCO₃ 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.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Treatment</th>
<th>NaHCO₃</th>
<th>NaHCO₃ + betaine</th>
<th>Betaine</th>
<th>Control</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI at 21 day of age</td>
<td>5.75±0.25</td>
<td>5.50±0.05</td>
<td>6.00±1.00</td>
<td>5.25±0.25</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>HI at 35 day of age</td>
<td>6.00±0.41</td>
<td>7.25±0.25</td>
<td>5.75±0.25</td>
<td>4.33±0.33</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>H/L ratio</td>
<td>1.02±0.02</td>
<td>0.93±0.02</td>
<td>0.92±0.03</td>
<td>1.13±0.11</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>HCT %</td>
<td>26.61±0.83</td>
<td>28.84±0.69</td>
<td>26.33±0.64</td>
<td>27.11±0.68</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

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 a 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 NaHCO₃ 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.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>T4 (µg/dL)</th>
<th>T3 (ng/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaHCO₃</td>
<td>6.60±0.17</td>
<td>135.59±16.15</td>
</tr>
<tr>
<td>NaHCO₃ + betaine</td>
<td>9.50±1.06</td>
<td>176.90±6.19</td>
</tr>
<tr>
<td>Betaine</td>
<td>8.00±0.49</td>
<td>135.63±14.46</td>
</tr>
<tr>
<td>Control</td>
<td>6.53±0.36</td>
<td>114.27±6.52</td>
</tr>
</tbody>
</table>

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 NaHCO₃ 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.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Treatments</th>
<th>NaHCO₃</th>
<th>NaHCO₃+ betaine</th>
<th>Betaine</th>
<th>Control</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total protein (g/dL)</td>
<td>2.74±0.03⁷</td>
<td>3.95±0.12⁷</td>
<td>3.42±0.14⁷</td>
<td>2.54±0.13⁷</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>1.19±0.04⁷</td>
<td>1.88±0.05⁷</td>
<td>1.59±0.07⁷</td>
<td>1.21±0.06⁷</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Globulin (g/dL)</td>
<td>1.54±0.02⁷</td>
<td>2.08±0.08⁷</td>
<td>1.83±0.08⁷</td>
<td>1.34±0.08⁷</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>A/G ratio</td>
<td>0.77±0.03⁷</td>
<td>0.91±0.02⁷</td>
<td>0.87±0.03⁷</td>
<td>0.91±0.04⁷</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholesterol (mg/dL)</td>
<td>152.50±0.65⁷</td>
<td>144.75±1.70⁷</td>
<td>111.67±1.87⁷</td>
<td>174.75±9.87⁷</td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

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 NaHCO₃ and those fed on diet with NaHCO₃ 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, Schute et al. (1997) reported that betaine may interact with the lipid metabolism by stimulating the oxidative catalysis of fatty acid via its role in carnitine 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 8. 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, nonpathological 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.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Treatments</th>
<th>NaHCO₃</th>
<th>NaHCO₃+ betaine</th>
<th>Betaine</th>
<th>Control</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum AST (UL) (GOT)</td>
<td>37.75±0.48⁷</td>
<td>26.50±1.71⁷</td>
<td>30.00±0.58⁷</td>
<td>37.50±0.65⁷</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Serum ALT (UL) (GPT)</td>
<td>2.26±0.14⁷</td>
<td>1.38±0.24⁷</td>
<td>1.75±0.14⁷</td>
<td>3.50±0.29⁷</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Serum uric acid (mg/dL)</td>
<td>5.50±0.05</td>
<td>5.47±0.06</td>
<td>5.53±0.06</td>
<td>5.45±0.02</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

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

*** P<0.001        NS Not significant

2329
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.

REFERENCES


الآداء الإنتاجي وبعض الاستجابات الفسيولوجية والمناعية للاجهاد الحراري في
دجاج التسمين المغذى على علاج محتوى بيليبيتيتين وبيكربونات الصوديوم
كلاً على حدة أو معاً. 

صبري بدر وأبو السعود,
قسم أنتاج الدواجن- كلية الزراعة بكفر الشيخ- جامعة طنطا

أجريت هذه الدراسة على عدد 180 كرتون تسمى هردي عمر يوم، ربيت هذه الكتكاوات على
البرد، وتم توزيعها على أربعة مجموعات تجريبياً، كل مجموعة (مكلاة) من ثلاث ككرات بكسل
 الكبرى 52 كرتون، وبذلك ستغذى كرية كارثية (أداء الكتكاوات والاستجابات الفسيولوجية والمناعية) لنتم
نظرة بشأن الآداء الحراري عندما يضيف إلى الملاك البيليبيتيتين وبيكربونات الصوديوم وكذلك الممثلة
كلاً:

1. المجموعة الأولى: العضلات الإسائية: 0,5% بيكربونات الصوديوم

2. المجموعة الثانية: العضلات الإسائية: 0,5% بيكربونات الصوديوم + 1% بيتايتين

3. المجموعة الثالثة: العضلات الإسائية: 1% بيتايتين

4. المجموعة الرابعة: الملاك الإسائية فقط. 

وبعد تغذية الظروف إلى درجة حرارة 40 درجة مئوية لمدة 6 ساعات يومياً سنن الفاكهة المثلثية
بمثابة وحشية اللائحة بعد الظهر، وزيادة سهولة النزورة وذلك عند عمر 35 يوم حتى نهاية التجربة
عند عمر 49 يوم.

وتتم دراسة معدل النمو والكفاءة الغذائية معدل استهلاك الماء ودرجة حرارة الجسم و pH
وزن بعض الإحصائيات والغذاء الداخلي، ومستوى الإمداد المغذي لمريض اليوپيوم، بقيمة الطراف ونسبة
الганه، ونسبة اليميتوكيت- تركيز اليوپيوم الكلي- اليوپيوم واليوپيوم في الدم وتركيزات الهيدروهيدروكسي،
والكولسترول، وتركيز الفوسفور، والفرزنج والإيثيلين في الدم وتركيز ولتنوعات الكبد
AST، ALT وتركيز حمض الوريب في الدم.

وبينتج النتائج كالتالي:

- زيادة في معدل النمو عند عمر 49 يوم وذلك معدل النمو معيونياً عند مستوى 0,110 للكلية المضابط
  البالغة 0,5 بيتايتين بالمقارنة مع مجموعة العضلات الصوديوم (الكلضات).
- زيادة في نسبة الكفاءة الغذائية معيونياً عند مستوى 0,101، وتم الضراع من مجموعات البالغة 0,5 بيكربونات
  الصوديوم، بالمقارنة مع مجموعة الكلضات.
- قيم الهايا عند نهاية التجربة كملياً مميزة، وتم الضراع من مجموعات البالغة 0,5 بيكربونات
  الصوديوم ونسبة 0,5 بيتايتين بالمقارنة مع مجموعة الكلضات.
- زيادة في معدل النمو، عند عمر 49 يوم ونسبة اليوپيوم معيونياً عند مستوى 0,110 والكلية المضابط البالغة 0,5
  بيكربونات الصوديوم ونسبة 0,5 بيتايتين، بالمقارنة مع مجموعة الكلضات.
- زيادة في معدل النمو عند مستوى 0,110 ونسبة اليوپيوم معيونياً عند مستوى 0,101، والكلية المضابط البالغة 0,5
  بيكربونات الصوديوم ونسبة 0,5 بيتايتين، بالمقارنة مع مجموعة الكلضات.
- اليوپيوم الكلي، ونسبة اليوپيوم في الدم وتركيزات الهيدروهيدروكسي، والكولسترول، والكولسترول
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- اليوپيوم الكلي، ونسبة اليوپيوم في الدم وتركيزات الهيدروهيدروكسي، والكولسترول، والكولسترول
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2334