EFFECTS OF SUPPLEMENTAL NaHCO₃, KCl, CaCl₂, NH₄Cl AND CaSO₄ ON ACID-BASE BALANCE, WEIGHT GAIN AND FEED INTAKE IN JAPANESE QUAILS EXPOSED TO CONSTANT CHRONIC HEAT STRESS

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ABSTRACT

The effects of dietary supplementation of potassium chloride (KCl) calcium chloride (CaCl₂), ammonium chloride (NH₄Cl), sodium bicarbonate (NaHCO₃) and calcium sulphate (CaSO₄) on acid-base balance, plasma electrolyte, weight gain and feed consumption in chronically thermostressed Japanese quails were investigated. Chronic thermostress lead to significant decrease in pCO₂, HC0₃, tCO₂, weight gain and feed consumption. The supplementation of NH₄Cl, CaCl₂, KCl and CaSO₄ at levels of 1 per cent to the basal diet restricted the increase in pH, while pH significantly increased in the groups received basal diet and dietary NaHCO₃ (P < 0.05). NH₄Cl and KCl significantly increased weight gain and feed consumption (P<0.05) when compared with birds fed the basal diet. The results showed that particularly NH₄Cl and KCl supplementation alleviated the negative effects of chronic heat stress in Japanese quails.

INTRODUCTION


Thermal polypnea associated with heat loss in chickens reduces blood carbondioxide partial pressure (pCO₂) and hydrogen ions (H⁺) concentration and results in acid-base imbalance called respiratory alkalosis (Bottje and Harrison, 1985a). According to Odom (1982), respiratory alkalosis develop within 60 min. after the onset of an acute thermal stress in hens. Blood alkalosis occurred by altering Na:Cl ratios reduces both feed consumption and growth rate of chicks (Hurwitz et al., 1973). Similar to metabolic alkalosis, the negative effects in respiratory alkalosis induced thermal stress were determined in broiler chicks (Bottje and Harrison, 1985b; Teeter et al., 1985; Teeter and Smith, 1986).

Because of the economic effects of reduced growth rate resulting from chronic heat stress and death losses induced acute heat stress, there is an interest in alleviating the effects of high temperature through chemical manipulation of the blood-acid-base balance. It was reported that decline in growth rate induced heat stress resulted directly from reduced feed intake (Bottje et al., 1983; Branton et al., 1986; Smith and Teeter, 1987; Kutlu, 1996). Smith and Teeter (1987) observed that K⁺ excretion increased with heat stress in broilers and their needs increased during period of heat stress. They indicated that dietary levels of 1.5-2 per cent K⁺ in the form of KCl improved weight gain in chicks under chronic heat stress. The use of 1 per cent dietary NH₄Cl as a potential blood acidifier and 0.5 per cent NaHCO₃ as a source of HC0₃ together alleviated the effects of chronic heat exposure in broiler chickens (Teeter et al., 1985).

Bottje and Harrison (1985a) have shown that infusion of carbonated water into crops of cockerels produced a more favorable acid-base balance during acute heat stress than tap water by reducing blood pH change during thermal polypnea and the infusion of high levels of NaHCO₃ (2%) and CaCl₂ (3.5%) lead to abnormal acid-base equilibrium conditions during the heat stress induced respiratory alkalosis. Bottje and Harrison (1985b) obtained better growth rate and feed conversion by using carbonated water rather than tap water as a source for drinking water of broilers exposed to chronic heat stress.

Branton et al. (1986) reported that blood pH of birds was substantially lowered by consumption of water containing either NH₄Cl at 6.25 or 31 g/L while consumption of NaHCO₃ at 6.25 g/L did not significantly affect blood pH.

The study was planned to investigate the effects of supplementing sorted compounds, at the levels offered
by early studies conducted in chickens, on blood acid-base balance, growth rate, weight gain and feed consumption of Japanese quails exposed constantly to chronic heat stress because of the restricted data about the effects of ration supplementation in heat stressed quail chicks.

**MATERIALS AND METHODS**

Seventy, male 3 weeks old Japanese quail chicks were used in the study. The birds were randomly assigned into 7 groups including ten chicks in each. All groups were housed in separate wire cages within temperature controlled chamber under continuous lighting. One of these groups was used as thermoneutral group (20-22°C). Remaining groups were exposed to chronic heat stress. The heat exposure was performed by stepwise increase of chamber temperature from 20-22 to 33-34°C and lasted ten days at this temperature. The thermostressed groups (from II to VII) received basal diet (group II) and basal diet containing KCl (group III), CaCl₂ (group IV), NaHCO₃ (group V), NH₄Cl (group VI) and CaSO₄ (group VII) at level of 1 per cent during the chronic heat stress period, respectively, whereas thermoneutral group (group I) received basal diet (Table 1).

Table 1: Composition of the basal ration used in the experiment

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground corn grain</td>
<td>55.0</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>36.0</td>
</tr>
<tr>
<td>Meat and bone meal</td>
<td>6.2</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1.0</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.9</td>
</tr>
<tr>
<td>Vitamin mix</td>
<td>0.5</td>
</tr>
<tr>
<td>Salt (Sodium chloride)</td>
<td>0.3</td>
</tr>
<tr>
<td>Trace mineral</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Prior to experiment, one week was utilized to adopt all birds to basal diet and environment. For each trial, feed and water were continuously available.

At the end of the 10th day, all chicks were weighed, then venous blood samples were drawn into heparinized (lithium heparin) syringe for determination of pH, HCO₃⁻, pCO₂, BE, Na⁺, K⁺, Ca²⁺ and PCV by blood gases analyser (Ciba-Corning, 288 blood gas system). Also weight gain, feed consumption were calculated in all groups. The pH, HCO₃⁻, pCO₂, BE, Na⁺, K⁺, Ca²⁺ and PCV were determined.

Data were analysed statistically by student’s t test to obtain significance of differences between group means and correlation coefficient between pH weight gain and feed consumption (Steel and Torrie, 1982).

**RESULTS AND DISCUSSION**

At the end of the chronic heat stress period, blood pH in groups fed the basal diet and the diet with NaHCO₃ significantly increased (P < 0.05) compared to thermoneutral group and the other groups. Supplementing the basal diet with KCl, CaSO₄, CaCl₂, and NH₄Cl restricted the increase in pH. It was determined that pH in groups fed the diets with KCl, CaCl₂ and NH₄Cl did not differ from that in thermoneutral group (Table 2).

Parker and Boone (1971) observed that pH in the male turkey decreased when exposed to thermal stress, whereas Kohen and Jones (1975) observed that chronic heat stress leads to decrease in egg production, egg shell thickness and egg weight in turkeys, but had no effect on blood acid-base balance.

A study conducted in quails (Altan and Oguz, 1996) demonstrated that although chronic heat stress (2 hours at 35-36°C/day for one week) caused a significant decrease in blood pCO₂ and shell thickness and a significant increase in blood pO₂, there was no significant difference in blood pH, egg production and egg weight. On the other hand, acute heat stress resulted in significant increase in blood pH and significant decrease in pCO₂ and HCO₃⁻ levels of quails (Durgun et al., 1996).

The chronic heat stress significantly decreased pCO₂, HCO₃⁻ and tCO₂ levels (P < 0.05) in all thermostressed groups (Table 2) similar to results reported for hens (Bottje and Harrison, 1985a; Teeter et al., 1985) and quails (Altan and Oguz, 1996; Durgun and Keskin, 1996) unlikely turkey (Kohne and Jones, 1975; Parker and Boone, 1971). The levels of pCO₂ in the groups fed the diets with CaCl₂ and NH₄Cl and HCO₃⁻ in the groups fed the diets with CaCl₂, NH₄Cl and CaSO₄ were significantly lower than those in the group received NaHCO₃ (P < 0.05). On the other hand tCO₂ level in the group received NaHCO₃ was significantly higher than in other thermostressed groups. These are similar to results of previous studies (Bottje and Harrison, 1985a; Teeter et al., 1985). Despite of the decrease in pCO₂, HCO₃⁻ and tCO₂ levels of the groups received acidogenic supplements, limitation of the increase in pH of these groups reflects a compensation of alkalosis occurred by hyperventilation (Bottje and Harrison, 1985a; Boulahezn et al., 1989; Lopez and Aoustic, 1993).

Dietary NaHCO₃ significantly increased (P < 0.05) Na⁺ level in this group compared with the other groups.
whereas $K^+$ level was found to be significantly (P<0.05) higher in the group received KCl than the Dietary NaHCO$_3$ significantly increased (P<0.05) Na$^+$ level in this group compared with the other groups whereas K$^+$ level was found to be significantly (P<0.05) higher in the group received KCl than the finding has been explained by either a K$^+$ shift between muscle and extracellular fluid (acute hyperventilation), an increase K$^+$ excretion (chronic heat stress) or by an increase in K$^+$ uptake of erythrocytes and/or skin (acute heat stress) (Smith and Teeter, 1987; Boulaishen et al., 1989). Also Laiken and Fanestil (1985) reported that respiratory alkalosis in mammals reduced competition between H$^+$ and K$^+$ for urinary excretion and thereby increased urinary K$^+$ loss.

PCV in thermostressed groups was generally lower than those in the thermoneutral group, decreased hematocrit in response to heat stress alone has been determined in the birds treated with NaHCO$_3$ (P<0.05) compared with the thermoneutral group (Table 3). The reason of the significantly decline in PCV for the group received NaHCO$_3$ may be due to increased water consumption adding to peripheral vasodilation which reflects an influx of extracellular fluid into the vascular space (Darre and Harrison, 1986; Boulaishen et al., 1989). It was demonstrated that dietary NaHCO$_3$ increased water consumption relative to the other dietary supplements such as CaCl$_2$, NH$_4$Cl, KCl (Morgan and Schultz, 1986; Branton et al., 1986; Davison and Wideman, 1992). Hence, voluntary intake of water inclines with the increase in ambient temperature (Ogunji et al., 1983).

The feed intake and body weight gain were restricted in all thermostressed group (Table 3) compared with thermoneutral group (P<0.05) as demonstrated by earlier studies (Hurwitz et al., 1973; Bottje and Harrison, 1985b; Teeter et al., 1985; Kutlu, 1986). The highest weight gain and feed consumption were obtained in the group supplemented with NH$_4$Cl (Table 3). Dietary NH$_4$Cl significantly increased weight gain relative to the basal diet and the diet with NaHCO$_3$, while dietary KCl increased the weight gain alone relative to the basal diet. On the other hand, either dietary NH$_4$Cl and KCl significantly (P<0.05) increased the feed intake compared with the basal diet and the diet with NaHCO$_3$. It is also noteworthy that the other supplements except NH$_4$Cl and KCl caused at least partially growth improvement compared with the basal diet unless difference in the study. These data agree with results of the other investigations conducted in hens (Bottje and Harrison, 1985b; Teeter et al., 1985; Branton et al., 1986; Smith and Teeter, 1987; Lopez and Austic, 1993).

The beneficial effects of dietary NH$_4$Cl supplementation may be due to both H$^+$ and Cl$^-$ dissociation and also reducing Na:Cl ratio (Teeter et
The positive effects of CaCl₂ and KCl on weight gain and feed consumption relative to unsupplemented diet in the study may be attributed to the reduction of Na:Cl ratio in which any decrease lowers the blood pH (Hurwitz et al., 1973). Hence, Teeter et al. (1985) reported that the reason of the improving effects of KCl on weight gain and feed consumption was to meet the K⁺ requirement occurred by respiratory alkalosis in related to heat stress. Despite CaSO₄ supplementation slightly increased weight gain and feed intake when compared with the basal diet, this finding indicated that SO₄ (sulfate) was less acidogenic than chloride. The lower acidogenicity of sulfate as compared with chloride in the study is consistent with results of other studies (Lopez and Austic, 1993; Durgun et al., 1996).

Any beneficial effects of NaHCO₃ on weight gain in the study would likely be due to the HCO₃ anion, independent of pH, as pH was not favorably affected in agreement with the reports of Teeter et al. (1985) who suggest that reduced blood HCO₃ level precipitated by chronic thermostress create a dietary as well as physiological requirement for this anion.

In the study, negative correlation between feed consumption and blood pH was determined in the groups treated basal diet, dietary NaHCO₃ and NH₄Cl (r = -0.759, -0.930, -0.781, respectively) while blood pH was inversely related with weight gain in the groups treated with basal diet dietary CaCl₂, NaHCO₃ and NH₄Cl (r = -0.806, -0.755, -0.714, -0.810, respectively).

Consequently, by resisting these data, lowered feed intake and thereby growth rate resulting from respiratory alkalosis in thermostressed quail chicks can be improved dietarily by supplements such as NH₄Cl, KCl that affect favorably the acid-base status during the heat stress.

REFERENCES


