Assessing the impacts and mitigations of heat stress in Japanese quails (*Coturnix coturnix japonica*)

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ABSTRACT

The aim of this study was to assess the impacts and potential mitigations of heat stress (HS) in Japanese quails. In the first experiment, 75 birds were allocated into a control group (CG) and four experimental (HS) groups. The CG was offered a basal diet and kept at 22 °C. The heat stressed birds were offered the basal diet plus either 5% onion (G1), 5% garlic (G2), or 2.5% garlic and 2.5% onion (G3) and the basal diet (G4) and kept at 34°C for 8 h/day for four weeks. In the second experiment, 60 birds were allocated into CG and three HS groups. The CG was kept at 22°C and reared under white light (WL). The HS birds were offered the basal diet and reared under WL (G1), basal diet and subjected to blue light (BL) (G2), basal diet, 5% garlic and BL (G3) and kept at 34°C for 8 h/day for four weeks. There was a significant decrease of tonic immobility and respiratory rate, WBCs and an increase in RBCs, Hb, PCV and MCHC in CG, G1, G2, and G3 in the first experiment and CG, G2 and G3 in the second experiment. Pathological changes that have been noticed in HS birds were alleviated almost completely in birds feed on diet with garlic and partially in birds feed diet with onion. In conclusion, HS in quails could be mitigated by adding garlic and/or onion to the diet, available and cheaper than other feed additives, and rearing under BL.

Keywords: Heat stress, garlic, monochromatic light, onion, quail welfare

INTRODUCTION

In the last few decades global warming becomes one of the major factors affecting production systems and animal welfare (Konca et al., 2008). In poultry, heat stress (HS) is one of the major causes that results in production losses in terms of decreases in weight gain, feed intake and feed efficiency and increased mortality (Sahin et al., 2003, Sahin et al., 2004, Sahin et al., 2007, Sahin et al., 2010). Heat stress in poultry not only affects health status and welfare, but also declines survivability as well as product quality (Mashaly et al., 2004, Bogin et al., 1996, Sandercock et al., 2001). During summer season, heat stress is considered as a major distress in poultry husbandry and welfare especially in the hot regions of the world. Behavioural and physiological changes associated with HS may lead to changes in broilers performance and reactivity (Geraert et al., 1996).
Table 1. Composition of the basic diet

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grains</td>
<td>51.5</td>
</tr>
<tr>
<td>Corn gluten meal (60% crude protein)</td>
<td>7.0</td>
</tr>
<tr>
<td>wheat bran</td>
<td>2.5</td>
</tr>
<tr>
<td>Soybean meal (44% crude protein)</td>
<td>32.0</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>2.0</td>
</tr>
<tr>
<td>Di-calcium phosphate</td>
<td>1.8</td>
</tr>
<tr>
<td>Limestone</td>
<td>2.0</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.18</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>0.33</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td>0.15</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.04</td>
</tr>
<tr>
<td>Premix</td>
<td>0.3</td>
</tr>
<tr>
<td>Other additives</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Calculated chemical analysis

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>90.00</td>
</tr>
<tr>
<td>ME, Kcal/kg diet</td>
<td>2910</td>
</tr>
<tr>
<td>CP</td>
<td>22.84</td>
</tr>
<tr>
<td>EE</td>
<td>2.75</td>
</tr>
<tr>
<td>CF</td>
<td>6.09</td>
</tr>
<tr>
<td>Ash</td>
<td>6.88</td>
</tr>
<tr>
<td>NFC</td>
<td>48.2</td>
</tr>
<tr>
<td>Ca</td>
<td>1.10</td>
</tr>
<tr>
<td>Avp.P</td>
<td>0.51</td>
</tr>
</tbody>
</table>

This may be associated with biochemical and pathological consequences, which can potentially promote the process of oxidative stress (Azad et al. 2010). Oxidative stress is one of the consequences of HS, resulting in increased reactive oxygen species production (ROS) and decrease serum and tissue levels of antioxidant vitamins in poultry which play a role in the antioxidant defence system (Halliwell and Gutteridge, 1989). Oxidative stress occurs from excess ROS production, antioxidant depletion or both (Borisiuk and Zinchuk, 1994). It impairs the cell membrane and mitochondrial integrity (Meng et al., 2008) and causes cell damage through lipid peroxidation (Halliwell and Gutteridge, 1989). Heat stress adversely affects performance and product quality of poultry. Broilers exposed to an environmental temperature of 34°C showed a significant decrease in feed intake (Geraert et al., 1996). These effects could be minimized by dietary supplementation of antioxidant vitamins (Puthponsiriporn et al., 2001; Sahin et al., 2001, Franchini et al., 2002) or natural substances that possess antioxidant potential (Sahin et al., 2008; Tuzcu et al., 2008) with low cost and easy applicability. The medical uses of garlic (Allium sativum) have a long history (Block, 1985) due to its antioxidant, immune-stimulant, antimicrobial, antiprotozoal, antimutagenic, antiplatelet and antihyperlipidemic properties (Harris et al., 2001, Jamroz et al., 2005).

The Egyptian environment becomes hot in summer with a temperature higher than 35°C. Most poultry farms are not well equipped for mitigating HS, therefore performance and production are affected. Moreover, Highly Pathogenic Avian Influenza H5N1 outbreaks have affected poultry industry in Egypt and consequently the prices of poultry products become high (Abdelwhab and Hafez, 2011). Quail production may compensate production losses in poultry to some extent. Garlic and onions have been used as feed additives for mitigating HS in poultry and some other species (Ancsin et al., 2013). The impacts and mitigations of heat stress on quail in Egyptian environment are not well documented. Therefore, the aim of this study was to assess the impacts of heat stress in quail welfare and how to mitigate these impacts.

**MATERIALS AND METHODS**

**Birds, diets, experimental design and performance**

One hundred and thirty five, six weeks old unsexed Japanese quails (Coturnix coturnix japonica) of similar body weight were used and divided into nine groups, three replicates each. All birds were reared on deep litter floor with wheat straw as a bedding material. In this study, two experiments were conducted. In the first experiment (75 bird), birds were randomly assigned into one control group and four experimental groups 15 bird each. The control group was kept in a temperature-controlled room at 22°C for 24 h/day. The experimental groups were kept at 34°C for 8 h/day (9 am–5 pm) followed by 16 h/d under normal environmental temperature (heat stressed group). The control group was offered a balanced basal diet (NRC, 1994) as illustrated in Table 1. For assessing the impacts of different feed additives as anti-stress, the heat stressed...
birds were offered the basal diet plus 5% onion (G1), 5% garlic (G2), a mixture of 2.5% garlic and 2.5% onion (G3) and the basal diet (G4). For assessing the impact of different lighting colours as anti-stress (the second experiment, 60 bird), the control group (15 bird) was kept at 22°C for 24 h/day and reared under monochromatic white light (WL) (400 to 700 nm). The heat stressed birds were divided into 3 sub-groups 15 birds each; birds were received the basal diet and reared under WL (G1), basal diet and subjected to monochromatic blue light (BL) of 480 nm wave length (G2), basal diet, 5% garlic and BL (G3). The amount of garlic and onion were calculated based on the expected average daily feed intake, and were finely chopped and offered to the birds as free choice on a daily basis. The light schedule was constant at 16L: 8D under 15 lx light intensity during the whole entire experiment. The temperature was recorded three times per day for each experiment.

**Stress and fear indices**

The duration of tonic immobility (TI) was measured for each quail. The birds were taken to a separate room (no visual contact with other birds) and subjected to TI measurements. It was defined as the length of time during which the bird remained immobile after it had been held on its back for 10 s to induce the freezing reaction (Hoekstra et al., 1998). Unnecessary noise or movement was avoided. Direct eye contact between the observer and the bird was avoided as it may prolong TI duration (Jones, 1986). For practical reasons, the measure of TI was terminated if the bird had remained immobile for 5 min (TI=300) or if it failed to remain at all immobile after five attempts at inducing TI (TI=0). The number of inductions required to perform TI was recorded.

Respiratory rate (RR) was recorded for 9 quails (3 birds per replicate) by counting the number of thoracic movement per minute visually (Kassim and Norziha, 1995) for each treatment then the average RR per bird was estimated. It was recorded inside the quail’s house. Carful precautions to avoid unnecessary stress and noise were applied.

**Laboratory analysis**

At the end of the experiment (four weeks), six birds (2 birds per replicate) were carefully euthanized via exsanguination from a neck cut that severed the carotid artery and jugular vein. This method is considered humane when performed by a trained person (Gracey 1986). Blood samples (3 ml) for haematological examination were taken from the vena basilica of the left wing, and were collected in vacuum tubes with EDTA. The samples were collected within 1 min of capture to ensure that the levels of the monitored parameters were not affected by any stress induced by pre-sample handling. After necropsy, liver, kidney, brain, lung, heart and spleen samples were collected and preserved in formalin. Blood and organ samples were directly transferred from the animal experimental house to the laboratory for analysis.

**Haematology**

Red and white blood cell (RBC, WBC) counts were performed using a modified Neubauer hemocytometer and Natt and Herrick solution (Natt and Herrick, 1952) as a special diluent for chicken’s blood according to Harrison and Harrison (1986). The haemoglobin concentration is measured spectrophotometrically by using cyanometemoglobin method after centrifugation removal of free red cell nuclei and membrane debris. Haematocrit (PCV) was determined using a micro-haematocrit centrifugation (10,500 ×g for 5 min) and a micro-capillary reader (Seiverd, 1983). The values found were used to calculate the mean corpuscular haemoglobin concentration (MCHC), the mean corpuscular haemoglobin (MCH), and the mean corpuscular volume (MCV).

**Histopathological investigation**

Organs were dehydrated and embedded in paraffin wax by routine methods (Bancroft, et al., 1991). They were then sectioned at 3 µm, stained with haematoxylin and eosin (HE), and examined by light microscopy.

**Statistical analysis**

Data were tested for distribution normality and homogeneity of variance. Data were reported as means and the pooled standard deviation (SD). Data were analysed by one-way ANOVA using statistical package Minitab® software version 16. The significance of difference among the different groups was evaluated by Tukey test. The significance level was set at $P<0.05$.

**Ethical approval**

All experimental studies and handling of birds were in accordance with animal welfare regulations at the Faculty of Veterinary Medicine, Kafrelsheikh University, Egypt.
Table 2. Effect of garlic and/or onion supplementation on tonic immobility (TI) reactions and respiratory rate (RR) in heat stressed quail.

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Heat treated birds</th>
<th>SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>G1</td>
<td>G2</td>
<td>G3</td>
</tr>
<tr>
<td>TI induction</td>
<td>1.67</td>
<td>2.33</td>
<td>1.44</td>
<td>2.44</td>
</tr>
<tr>
<td>TI duration/S</td>
<td>67.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>68.56&lt;sup&gt;b&lt;/sup&gt;</td>
<td>71.56&lt;sup&gt;b&lt;/sup&gt;</td>
<td>69.11&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Respiratory rate/Min</td>
<td>44.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>55.33&lt;sup&gt;c&lt;/sup&gt;</td>
<td>60.22&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>64.11&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

G1 Basal diet with 5% onion, G2 Basal diet with 5% garlic, G3 Basal diet with 2.5% garlic and 2.5% onion and G4 Basal diet, different superscriptions in the same raw indicate statistical significance (P<0.05)

RESULT

The first experiment

Stress and fear indices

There was a significant (p <0.05) decrease in TI duration and RR (table 2) in groups of the quails subjected to HS and fed rations supplemented with 5% onion (G1), 5% garlic (G2), a mixture of 2.5% garlic and 2.5% onion (G3) as a feed additives and control group compared to quails that reared under HS and received basal diet (G4). Regarding to TI inductions, there was no significant difference (p <0.05) between all experimental groups.

The results also reflected that, there was a significant positive correlation (figure 1) between TI duration and RR among experimental groups.

Haematology

Effect of garlic and/or onion on some hematological parameters in heat stressed Japanese quail: RBCs, Hb, PCV, MCV, MCH, MCHC, and WBCs were measured in all groups (table 3). Firstly, the values of RBCs, Hb, PCV, MCH, and MCHC of the Japanese quails exposed to heat stress and supplemented with basal diet only were significantly decreased when compared with those of the control group (p<0.05). However, the values of MCV were significantly increased in Japanese quail exposed to heat stress and supplemented with basal diet only in comparison with those of the control group (p<0.05). In contrast, heat stress had no significant adverse effect on all these values in all groups of Japanese quails exposed to heat stress and supplemented with basal diet plus garlic and/or onion (p>0.05). Furthermore, values of TLC were significantly higher in Japanese quail exposed to heat stress and supplemented with basal diet only in comparison with those of the control group (p<0.05). While, there was no significant difference between these values in all groups of Japanese quails exposed to heat stress and supplemented with basal diet plus garlic and/or onion and control group (p>0.05).
Table 3. Effect of garlic and/or onion supplementation on some haematological parameters of heat stressed quails.

<table>
<thead>
<tr>
<th>Blood parameter</th>
<th>Control group</th>
<th>Heat treated birds</th>
<th>SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1</td>
<td>G2</td>
<td>G3</td>
<td>G4</td>
</tr>
<tr>
<td>RBCs (×10^6)</td>
<td>3.03</td>
<td>2.76</td>
<td>2.88</td>
<td>2.75</td>
</tr>
<tr>
<td>Hb (g/l)</td>
<td>119</td>
<td>121</td>
<td>123</td>
<td>117</td>
</tr>
<tr>
<td>PCV (l/l)</td>
<td>0.524</td>
<td>0.518</td>
<td>0.538</td>
<td>0.510</td>
</tr>
<tr>
<td>MCV (fl)</td>
<td>173</td>
<td>189</td>
<td>188</td>
<td>186</td>
</tr>
<tr>
<td>MCH (pg)</td>
<td>39.24</td>
<td>43.92</td>
<td>42.76</td>
<td>42.74</td>
</tr>
<tr>
<td>MCHC (%)</td>
<td>22.70</td>
<td>23.26</td>
<td>22.78</td>
<td>22.94</td>
</tr>
<tr>
<td>WBCs (×10^3)</td>
<td>24.45</td>
<td>26.55</td>
<td>21.95</td>
<td>29.10</td>
</tr>
</tbody>
</table>

G1 Basal diet with 5% onion, G2 Basal diet with 5% garlic, G3 Basal diet with 2.5% garlic and 2.5% onion and G4 Basal diet, different superscriptions in the same raw indicate statistical significance (P<0.05)

Histopathological findings

There were no observed pathological changes in the examined organs including liver, kidney, brain, lung, heart and spleen from the control group. Histopathological findings of the experimental groups are summarised in the following sub-sections.

Heat stressed group with 5% onion supplementation (G1)

Liver showed vacuolar and hydropic degeneration of hepatocytes (plate 1, Figure 1) in addition to mild congestion and very mild perivascular mononuclear cells infiltrations. The kidney revealed mild degree of congestion together with very mild fatty change of renal tubular epithelial cells (plate 2, Figure 1) in addition to very mild hyaline casts; however, in some birds the kidney was normal without any pathological changes. The spleen showed normal lymphocytic cell population (plate 3, Figure 1) like that of the control birds. The brain showed mild congestion of the cerebral blood vessels, and mild neuronal degeneration and necrosis. Lung showed congestion varied from mild to moderate degree. The heart revealed mild fatty change.
Heat stressed group with 5% garlic supplementation (G2)

The liver showed alternative areas of perivascular vacuolar and hydropic degeneration and fatty change in very few birds however, some of the birds showed very mild fatty change (plate 1, Figure 2), mild degree of congestion in addition to very few foci of hepatic cell necrosis infiltrated with mononuclear cells infiltrations and in most of the other birds the liver was completely similar to control bird. The kidney was normal except in few birds showed mild congestion, hyaline casts (plate 2, Figure 2), vacuolar and hydropic cell degeneration of renal tubular epithelial cells together with mild focal mononuclear cells infiltrations. The spleen showed normal lymphocytic population (plate 3, Figure 2). The lung and heart were normal like control birds. The brain showed mild neuronal degeneration and necrosis in degree somewhat less than G1.

Heat stressed group with mixed 2.5% garlic and 2.5% onion supplementation (G3)

The liver showed fatty change varied from moderate to severe degree (plate 1, Figure 3) in some birds like that observed in heat stressed birds. However, in other birds alternative areas of fatty changes and perivascular vacuolar and hydropic degeneration were observed. In some sections vacuolar degeneration was observed. The kidney in few birds showed multiple interstitial mononuclear cells infiltrations (plate 2, Figure 3) but in some birds the kidney was normal like control except mild mononuclear cells aggregations and mild renal tubular cells fatty change. The spleen showed mild to moderate lymphoid depletion (plate 3, Figure 3). The heart and lung were normal. The brain showed more congestion, neuronal degeneration and necrosis than those observed in G1 and G2.

Heat stressed group with a basic diet (G4)

The liver showed severe congestion and advanced fatty change (plate 1, Figure 4 below). Multiple foci of hepatic cells necrosis (plate 1, Figure 5 below) infiltrated with mononuclear cells were also observed. The kidney revealed moderate fatty change and hydropic degeneration of renal tubular cells, severe congestion, mild to moderate necrosis of renal tubular cells (plate 2, Figure 4 below) in addition to several foci of mononuclear cells infiltrations together with mild hyaline droplet degeneration. The spleen showed moderate to marked lymphoid depletion as well as degeneration and depletion of lymphoid follicles (plate 3, Figure 4 below). Marked congestion was observed in the lung. Marked congestion (plate 4, Figure 1 below), neuronal degeneration and necrosis (plate 4, Figure 2 below) were observed in the brain together with areas of softening and neuronal...
Plate 1, Figure 3. G3, liver showing marked fatty change. H&E. X 200.

Plate 2, Figure 3. G3, kidney showing interstitial mononuclear cells infiltration, congestion and degeneration of renal tubules. H&E. X 200.

Plate 3, Figure 3. G3, spleen showing marked lymphoid depletion. H&E. X 200.

Plate 1, Figure 4. G4, liver showing marked fatty necrosis and change. H&E. X 200.

Plate 1, Figure 5. G4, liver showing congestion, fatty change of hepatocytes. H&E. X 200.

Plate 2, Figure 4. G4, kidney showing congestion, fatty change and necrosis of renal tubular cells. H&E. X 200.

Plate 3, Figure 4. G4, spleen showing marked lymphoid depletion and degeneration and depletion of lymphoid follicles (arrow). H&E. X 200.
Plate 4, Figure 1. G4, brain showing congestion of cerebral blood vessels. H&E. X 200. Figure 2. G4, the brain showing neuronal degeneration and necrosis. H&E. X 200. Figure 3. G4, the brain showing neuronal degeneration and vacuolation (arrow). H&E. X 400.

Table 2. Tonic immobility (TI) reactions and respiratory rate in heat stressed quail reared under different monochromatic light and supplemented with basal diet with or without garlic

<table>
<thead>
<tr>
<th>Control group</th>
<th>Heat treated birds</th>
<th>SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1</td>
<td>G2</td>
<td>G3</td>
</tr>
<tr>
<td>TI induction</td>
<td>2.22</td>
<td>1.33</td>
<td>2.11</td>
</tr>
<tr>
<td>TI duration/S</td>
<td>43.89&lt;sup&gt;c&lt;/sup&gt;</td>
<td>107.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>57.33&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Respiratory rate /Min</td>
<td>42.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>84.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.89&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

G1 Basal diet and white light (WL), G2 Basal diet and blue light, G3 Basal diet with 5% garlic and blue light (BL), different superscriptions in the same raw indicate statistical significance (P<0.05)

Line chart 2: Correlation between respiratory rate (RR) and tonic immobility (TI) in heat stressed quail reared under different monochromatic light and supplemented with basal diet with or without garlic (P-value = 0.027)

Normal (CG), quails reared under WL, normal room temperature and supplemented with basal diet. HS (G1), quails reared under WL, heat stress and supplemented with basal diet. BL (G2), quails reared under BL, heat stress and supplemented with basal diet. BL and garlic (G3), quails reared under BL, heat stress and supplemented with basal diet and 5% garlic.

vacuolation (plate 4, Figure 3 below).

The second experiment

Stress and fear indices

Results in table 4 were observed in quails that received basic diet and reared under BL (G2) and with those reared under BL with 5% garlic as a feed additive (G3). In which there was a significant decrease in TI duration and RR (p<0.05) compared to quails that received basic diet and reared under WL (G1). There were no significant differences (p<0.05) in the TI inductions between all experimental groups. The results also reflected that, there was a significant positive correlation (figure 2)
between TI duration and RR among experimental treatments.

DISCUSSION

High ambient temperature is of great concerns in all types of poultry production. Severe HS adversely affect feed intake, growth rate, hatchability, mortality, and other important traits governing the success of the poultry industry (Bartlett and Smith, 2003). A positive correlation was recently established between dietary supplementation with phytochemicals and the reduction of detrimental effects of HS (Sahin et al., 2012). The aim of this study was to assess the impacts of HS in quail and how to mitigate these impacts. The results showed that, HS resulted in significant detrimental effects in Japanese quail and that dietary garlic and onion supplementation offered a feasible way to improve welfare through the reduction of clinicopathological changes. The alleviation of clinicopathological changes was attributed to the antioxidant properties of garlic and onions in several studies. It was reported that long-term oral administration of raw garlic homogenate caused a significant increase in super oxide dismutase (SOD) and catalase activities of rat heart. This was associated with a concomitant decrease in lipid peroxidation (Banerjee et al., 2002).

In the present study, rearing quails under HS, using 5% garlic, 5% onion and a mixture of 2.5% garlic and 2.5% onion as feed additives for mitigation of HS was investigated. Also rearing of quails under HS with WL, BL and BL with 5% garlic as feed additives was investigated as methods for reducing the effect of HS and improving welfare in quails. There was an increase in TI duration and RR in quail exposed to the high ambient temperature (Teeter et al. 1985, Aşkı et al. 2006). In this study, using of 5% garlic, 5% onion and a mixture of 2.5% garlic and 2.5% onion, BL and BL with garlic as feed additives significantly decreased TI duration and RR, indicating that these supplements and BL alone or with 5% garlic had the ability to alleviate the negative effects of the heat stress. These results could be attributed to the effect of garlic in reducing cortisol in blood (Ao et al. 2011) and the calming effect of BL and the birds become less active and less nervous (Prayitno et al. 1997, Mohamed et al. 2014). The behaviour during TI induction period was very different between quails subjected to HS and those treated by using garlic, onion, a mixture of garlic and onion, BL and BL with garlic. Most of the HS quails remained calm as soon as the induction began and lay motionless until the end of the induction period. However in the treated groups, quails struggled during induction, some trying to escape even it were withheld by the operator. The behaviour of quails during TI induction under stressful conditions reported in the present study is in agreement with previous study conducted by Eddy et al. (1991). The behaviour of the quails during measuring of RR in the group reared under HS, most of the birds showed panting in both rest and locomotion. During which the bird raised its heat upward, open its mouth, and tried to gasp the air. At the same time, fewer birds showed wing flapping. On the other hand, these signs were not present in the other experimental groups. The behaviour of quails during RR measuring under stressful conditions reported in the present study is in agreement with previous study conducted by Smith and Teeter (1993).

Regarding the effect of heat stress on haematological parameters of Japanese quails fed basal diet supplemented with garlic and/or onion; firstly heat stress significantly decrease RBCs, Hb, PCV, MCH, and MCHC values in quails reared under HS and fed basal diet only when compared with those of control group. While, MCV values were increased in quails reared under HS and fed basal diet only when compared with those of control group. These findings were similar to Furlan et al. (1999), Yahav et al. (1997), Borges et al. (1999), Aengwanich (2002), Aengwanich and Chinrasri (2002) and Aengwanich and Simaraks (2003). Aengwanich (2002) found that when broilers were maintained at high environmental temperatures, their MCV increased. He suggested that after broilers had been exposed to high heat, they were under vascular hemolysis. Therefore, the MCV of birds at high environmental temperatures increased more than the MCV of birds at thermoneutral.

The TLC values in the present study were higher than the normal range in heat stressed Japanese quails fed basal diet only when compared with those of control group and supplemented groups. In general, when the TLC increases than the normal range is consider suggestive of leucocytosis. Stress is considered one of the main causes of leucocytosis. Many studies revealed that birds exposed to acute heat stress had significant effect on lymphoid organs and pathophysiology of WBCs, increased percentage of heterophils and monocytes as a result of high plasma corticosteroids.

Histopathological changes in liver were advanced fatty changes and multiple areas of hepatic cell necrosis. In the brain, there were marked congestion, neuronal degeneration, necrosis and vacuolation. In the spleen and kidney, there were lymphoid depletion, fatty change and necrosis of renal tubules. These changes were alleviated almost completely with garlic and partially with onion which may be due to antioxidant properties that significantly correlated to total phenolics content as reported by Benkeblia, 2005. It was found that, garlic extract has the highest capability for scavenging radicals.
(RAS) and inhibiting lipid peroxidation, while green onion has the lowest one which significantly correlated to total phenolics content (Benkeblia,2005). One of the most important findings of this study is the alleviation of hepatic steatosis induced by HS by garlic and onion supplementation. Recent studies showed that, garlic by-product, inhibits high fat diet-induced hepatic steatosis and oxidative injury through LKB1-dependent AMPK activation (Han et al., 2011). In rats, garlic reduced lipid synthesis and influenced glycogen metabolism in the liver (Chang and Johnson,1980). Dietary supplementation with garlic extract might have promoted the catabolism of glucose and/or fatty acid in rats (Saimei Mari, 2003) similar to what observed in the present study. Dietary garlic inhibited the synthesis of lipids in the liver and increased the level of serum insulin, thereby lowering serum glucose and increasing glycogen in liver. It was suggested that the possible mechanism in hypoglycemia was the enhancement of insulin level in blood (Saimei Mari, 2003). Wang et al. (2007) demonstrated that heat exposure could significantly increase the concentration of serum cortisol which is involved mainly in carbohydrate, lipid, and protein metabolism. On the other hand, garlic can reduce cortisol in blood (Ao et al. 2011).

In conclusion, garlic and/or onion supplementation ameliorated the clinical and histopathological changes induced in Japanese quail kept under HS. Rearing Japanese quail under monochromatic BL with or without garlic supplementation reduced the stressful effects of HS under Egyptian environmental conditions.

REFERENCES


