Effect of Feed Restriction and Ascorbic Acid Supplementation on Performance of Broiler Chicks Reared under Heat Stress

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Abstract: The experimental was conducted to study the effect of ascorbic acid (A.A) on broiler chicken and fasting broiler under heat stress. A total number of 120 day old (Ross) unsexed experimental birds were divided into eight groups, the first four groups were offered normal feeding system with vitamin C while the rest of the groups were subjected to daily restricted feeding period of 12 hr. period from 8 a.m to 8 p.m. The parameters taken in experiments were initial weight, final live weight, gained weight, total feed intake, feed intake / bird, feed conversion ratio, mortality, temperature and relative humidity. The group which was supplemented by 250 mg/kg A.A whether on restricted feed or not, gave the best result in final live weight and weight gains, when compared with other groups. While the final weight and weight gain decreased in the groups which were supplemented with high level of A.A (500-750 mg/kg). The effect of feed restriction was not significant, because all groups were affected by temperature elevation, which is associated with decrease in feed consumption.

INTRODUCTION

The environment can be defined as the combination of external conditions (biological and physiological), which affect or have an impact on animals and humans. Heat stresses are known to be one of the major problems facing broiler rearing in tropical and subtropical areas. Absence of poultry industry in the desert area of the Sudan is mainly due to the pathological and economical effects of heat stress. It is well known that under normal conditions, the body temperature of the bird is above that of the environment and that heat is constantly lost to environment by a combination of processes of evaporation, radiation, convection and conduction. Birds have the highest productivity at environmental temperature within the thermo neutral rang because of their minimum energy requirements for thermoregulation as reported by Obaldiston and Sainsbury. However, maximum body weight in chicks was reported at temperatures ranging from 18 °C to 24 °C (64.4 – 75.2 °F) as demonstrated by Charleis and Spencer. 47% decrease in feed consumption and weight gain by broiler kept at 32 °C (89.6 °F) as compared with those reared at 24 °C (75.2 °F) reported by Cerniglia. In broiler, the feed consumption and growth rate decrease as the ambient temperature rises Dale and Fuller. Air temperature above 32 °C decreases gain in body weight of broilers as a result of reduced feed intake as showed by Meltzer. Feed efficiency of broiler exposed to high temperatures at early age (5 days), was significantly improved, without adverse effects on body weight gain as reported by Arjona, et al. Cumulative feed intake and weight gain were depressed in old broilers by about 16 - 53 gm per bird per every 1 °C, rise in temperature, respectively as obtainec by Charles. As the body temperature reaches the lethal limit (47 °C the adult), many birds are likely to die as reported by Bell and Freeman. Broilers reared for the last weeks at a temperature of 26.7 °C (80.06 °F) showed significant decrease in weight gains compared with those kept at a temperature below than 26.7 °C (80.06 °F) as demonstrated by Deaton, et al.

Generally, in hot environment, emphasis should be placed on diets to increase intake or to alter levels of protein, amino acids or other nutrients to improve the conversion of feed units into production units Fuquay. Broilers subject to high environmental temperature exhibit many behavioral changes which allow them to re-establish heat balance with their surroundings as demonstated by Gray, et al. It was...
noted that heat stressed birds fed by supplemental ascorbic acid exhibited relatively, less panting than the unsupplemented ones Kutlu and Forbes[39]. Adrenal ascorbic acid depletion is considered a classical indicator of heat stress response in chickens Siegle[34]. During heat stress, however, it was noted that the adrenal gland weight and ascorbic acid concentration were reduced; this was attributed to exhaustion of cholesterol Siegle[34]. The addition of ascorbic acid in the diet for 21 days caused liver and kidney injury, even though this vitamin could reduce heat stress, respiratory rate and lung damage in broilers under chronic heat stress as recorded by Aengwanich[11]. Relative humidity of 60-70% is ideal for broiler as reported by Hoffman and Gwin[14]. Ascorbic acid or (Vitamin C) is a simple compound, which was initially detected in the mammalian adrenal gland as reported by Szent and Gyorgi[30]. It was given the name; hexuronic acid; later, vitamin C was also known as cevitaminic acid scorbutamin and ant scorbutic vitamin Kutsky[30]. Vitamin C is actually a white crystalline compound known as L- ascorbic acid as reported by Fletcher and Cason[11]. The biosynthesis of ascorbic acid in mammals and birds takes place in the liver, kidney or in both. In chicken, the synthesis occurs primarily in the kidneys as reported by Roy and Guha[12]. Usually, sugars such as glucose, fructose and mannose serve as precursors for vitamin C. In later reports done by Freeman[12], many organs (Spleen, liver and intestine) were shown to contain a concentration of ascorbic acid several times greater than that of the plasma. In view of this, and knowing that these organs have high metabolic activity, vitamin C is then suggested to have role in reaction involved in the electron transfer in the cell as reported by Mc.Laren[14]. It was also noted that steroiodogenic tissues in general and the adrenal specifically, exhibit the highest concentration of vitamin C, where levels of adrenal vitamin C in chickens ranged from 61 to 350 mg/kg tissues as demonstrated by Pardue and Thaxton[24].

500 mg/kg of ascorbic acid supplementation resulted in an improved weight gain (P<0.01) and weight gain (P<0.05) until the fifth week, and body weight at slaughter, carcass weights and carcass yield were not affected by ascorbic acid supplementation as reported by Mehmet, et al[23]. Under climatic stress, ascorbic acid demands become greater than that provided by tissue synthesis and therefore dietary supplementation may be beneficial as found by Mc.Donald, et al[22]. Pardue, et al[29] showed that vitamin C demand, in chickens, when exposed to heat stress, may increase beyond its synthesis ability. Several studies have been conducted to determine whether supplemented ascorbic acid can improve performance of broiler chicks exposed to heat or management stressors. There are different methods to supplement ascorbic acid such as injection, dietary supplementation or water supplementation as found by Pardue and Thaxton[24]. Quarles and Adrian[30] indicated that when vitamin C was supplemented at a level of 976 ppm/128 gal in the drinking water for 24 hrs prior to pickup for slaughter carcass yield was significantly increased. Under stress conditions a differential leucocytes count indicated that the percentage of lymphocytes decreased and the percentage of heterophils increased Woldford and Ringer[38]. Others results shown by Gross, et al[15] reported that exposure of birds to high environmental temperature causes an increase in the plasma corticosterone that subsequently depressed the activity of the lymphoid organs and total leucocytes count. The role of ascorbic acid as mentioned earlier by Schemirb and Nockles[33] was found to reduce the amount of corticosterone in the plasma with subsequent maintenance of the normal leucocytes count.

Objectives of this study are:

- Estimate effect of feed restriction on broiler chicken at temperature more than 40 °C.
- Estimate effect of vitamin C on broiler chicken at temperature more than 40 °C.

MATERIALS AND METHODS

The experiment was carried in El-Rawakeeb dry land which is area southwest Omdurman Governorate. According to Walsh and Tigan[17] El- Rawakeeb area lies in the tropical (semi - aired) region whose climate is characterized by short rainy season (July-October) and high evaporation potential. The relative humidity values are low and thus indicate the general Aridity of the area. Experimental rations were formulated as three experimental diets with the addition of vitamin C at three levels 250 mg, 500 mg and 750 mg /kg. Total number of one hundred and twenty (Ross) unsexed broiler chicks were reared during the experiment in one production cycle a day old to the end point set for slaughter. All experiment of birds weren’t vaccinated because the area can be classified as a disease free area, and the farm was empty since 1986.

Experimental birds were divided into eight groups (15 birds / group), named as $V_{aR_o}$, $V_{bR_o}$, $V_{cR_o}$, $V_{dR_o}$, $V_{eR_o}$, $V_{fR_o}$, $V_{gR_o}$ and $V_{hR_o}$. The first four groups were put under normal feeding system while the rest of the groups were subjected to daily off feeding period from 8 a.m. to 8 p.m. Group 1 was fed a ration without vitamin C as control while group 2, 3 and 4 were given three levels of vitamin C (250, 500 and 750 mg/kg of feed respectively). Group 5 fed a ration without vitamin C as control while group 6,7 and 8 were given (250,500 and 750 mg/kg of feed respectively).
For the non-feed restricted chickens, there is no restricted and non-feed restricted chickens can be seen. Therefore, chickens were reared under heat higher than the upper limit for therm – neutral zone for 58.8% . The range of houseshadte temperature was during the period of the experiment ranged from 25.8 58.8%. The range of houseshadte temperature was higher than the upper limit for therm – neutral zone for chickens. Therefore, chicken a were reared under heat stress.

From Table (3) the effect of vitamin C on feed restricted and non-feed restricted chickens can be seen. For the non-feed restricted chickens, there is no significant difference (p ≥ 0.05) between the first four groups (V₃R₀, V₁R₀, V₃R₀ and V₃R₀) for initial weight, final live weight and body weight gain, but group V₃R₀ gave the highest value for final live weight and body weight gain. Group V₁R₀ gave the lowest value for final live weight and body weight gain. Group V₃R₀ showed the highest value for total feed intake and feed intake / chicken, but group V₁R₀ gave the least amount of total feed intake. Group V₃R₀ gave the higher value for feed conversion ratio and metabolically energy, but group V₁R₀ gave the least value of feed conversion ratio.

While the effect of vitamin C on feed restricted chicken groups, revealed significant difference (p ≤ 0.05) between the treatment groups. Group V₁R₁ showed the superior value for final live weight and body weight gain and the same group gave the highest value for total feed intake and metabolic energy intake, but V₃R₀ gave the lower value for metabolic energy intake and group V₁R₁ gave the lower value for total feed intake and feed conversion ratio.

Table (3) shows the mortality percentage for both feed and non feed restricted chicken groups. It is observed that group V₃R₁ showed the highest mortality percentage followed by V₃R₀, V₁R₀, V₃R₀ and V₁R₁. While group V₁R₀ and V₃R₁ showed no mortality.

Figure (1) indicates the effect of the three doses of vitamin C on serum albumin of broiler chicken reared under heat stress. Comparing the three doses of vitamin C with the control group, it is clear that the dose of 750 mg/Kg gave the highest value of serum albumin followed by 500, 250 mg/Kg, respectively.

Figure (2) indicates the effect of the three doses of vitamin C on white blood cell count of broiler chicken reared under heat stress. Comparing the three doses of vitamin C with the control group, it is clear that the dose of 750 mg/Kg gave the lowest value of white blood cell count followed by 500, 250 mg/Kg, respectively.

Figure (3) represents the effect of the three doses of vitamin C on lymphocytes % of broiler chicken reared under heat stress. Comparing the three doses of vitamin C with the control group, it is clear that the dose of 250 mg/Kg gave the highest value of lymphocytes percentage followed by 500, 750 mg/Kg, respectively.

Figure (4) reveals the effect of the three doses of vitamin C on haemoglobin concentration of broiler chicken reared under heat stress. Comparing the three doses of vitamin C with the control group, it is clear that the dose of 500 mg/Kg gave the highest value of haemoglobin concentration followed by 250, 750 mg/Kg, respectively.

Figure (5) shows the effect of the three doses of vitamin C on red blood cell count of broiler chicken

### Table 1: Percentage inclusion rate (by weight) of ingredients used in the rations.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Starter (Kg)</th>
<th>Finisher (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dura</td>
<td>640.5</td>
<td>630.8</td>
</tr>
<tr>
<td>Groundnut cake</td>
<td>289</td>
<td>239.01</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Sesame oil</td>
<td>-</td>
<td>32.7</td>
</tr>
<tr>
<td>NaCL</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Calcium</td>
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<td>10</td>
</tr>
<tr>
<td>Super concentrate</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Lysine</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Premix</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 2: Calculated chemical composition (dry basis) of diet used in experiment.

<table>
<thead>
<tr>
<th>Experiment diets</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Starter</td>
<td>Finisher</td>
</tr>
<tr>
<td>Dry matter</td>
<td>94.309</td>
<td>94.802</td>
</tr>
<tr>
<td>Crude protein</td>
<td>26.075</td>
<td>25.725</td>
</tr>
<tr>
<td>Ether extract</td>
<td>3.193</td>
<td>4.060</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>4.9</td>
<td>4.5</td>
</tr>
<tr>
<td>Nitrogen – free extract</td>
<td>60.011</td>
<td>60.802</td>
</tr>
<tr>
<td>Ash</td>
<td>5.179</td>
<td>4.913</td>
</tr>
<tr>
<td>ME (kcal/kg)</td>
<td>3468</td>
<td>3532</td>
</tr>
</tbody>
</table>

Calculate according to Lodhi, et al.

### Statistical Analysis: The one-way analysis of variance (ANOVA) with the significant level of 0.05 was carried out according to SPSS

### RESULTS AND DISCUSSION

#### Results: The maximum temperatures during the 3rd and 4th weeks were 42 °C while the minimum temperature during the 5th week was 40.4 °C. Relative humidity during the period of the experiment ranged from 25.8 58.8%. The range of houseshadte temperature was higher than the upper limit for therm – neutral zone for chickens. Therefore, chicken a were reared under heat stress.

From Table (3) the effect of vitamin C on feed restricted and non-feed restricted chickens can be seen. For the non-feed restricted chickens, there is no significant difference (p ≥ 0.05) between the first four groups (V₃R₀, V₁R₀, V₃R₀ and V₁R₀) for initial weight, final live weight and body weight gain, but group V₃R₀ gave the highest value for final live weight and body weight gain. Group V₁R₀ gave the lowest value for final live weight and body weight gain. Group V₃R₀ showed the highest value for total feed intake and feed intake / chicken, but group V₁R₀ gave the least amount of total feed intake. Group V₃R₀ gave the higher value for feed conversion ratio and metabolically energy, but group V₁R₀ gave the least value of feed conversion ratio.

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Figure (5) shows the effect of the three doses of vitamin C on red blood cell count of broiler chicken
Fig. 1: Effect of three levels of vitamin C on albumin concentration (g/d)

Fig. 2: Effect of three levels of vitamin C on white blood cells

reared under heat stress. Comparing the three doses of vitamin C with the control group, it is observed that the dose of 500 mg/Kg gave the highest value of red blood cell count followed by 250, 750 mg/Kg, respectively.

Discussion: All experimental birds showed physiological responses to increased ambient temperature which reached up to 42°C, such as panting, reduced activity and spreading the wings away from the body. These findings were reported by Gray, et al. [14] who stated that such behaviors were exhibited by birds to allow them to re-establish heat balance with their surroundings.

Although the highest environmental temperature recorded was 42°C, the experimental birds were
able to reduce the detrimental effect of heat stress (low mortality, acceptable weight gain) because the average ambient humidity was very low (45%), these results were in line with Card and Nesheim[15] who found that birds were able to survive at 35°C when the relative humidity below 60%. Also Hoffman and Gwin[16] concluded that the relative humidity of 60-70% is ideal for broiler.

For both restricted and non-restricted groups, the level of 250 mg vitamin C mg/kg (V R , and V R) gave superior performance in final live weight and weight gain better than the control. But addition of Vitamin C at higher doses (500 mg and 750 mg/kg) gave lower performance even when compared with the control (zero Vitamin C level). These findings agreed with Kafri and Cherry[17], and Mcbee, et al[18] who reported that under heat stress conditions dietary supplemented ascorbic acid alleviates the effect of heat stress on the performance of broiler chicks. Excessive supplementation of the diet with Vitamin C can reduce the performance of broiler chicks, especially in the absence of stress as demonstrated by Kutlu and Forbes[19].

Feed intake showed slight reduction when feed was restricted for 12 hours i.e. restricted and non restricted groups differed slightly in feed intake which might be due to high environmental temperature during the experiment. This fact was in harmony with Cerniglia, et al[20] and Dale and Fuller[21] who found that feed consumption and weight gain decreases as ambient temperature increases. The most important response of poultry to ambient temperature in environment is
Table 3: Performance values of experimental chicks

| Item                               | Mean ± Standard Deviation | F-Value | V R | V R | V R | V R | V R | V R | V R | V R | V R |
|------------------------------------|---------------------------|---------|----|----|----|----|----|----|----|----|----|----|
| No. of chicks housed               |                           |         | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Mortality %                        |                           |         | 0.6 % | 0.6 % | 0.6% | 0% | 0% | 0% | 0.6 % | 20 % | 13.3 % | 0.000* |
| Initial Wt/chick at 2 wk           |                           |         | 154.33 ± 7.57 | 146.33 ± 4.51 | 148.33 ± 6.66 | 152.67 ± 5.51 | 152.33 ± 6.56 | 152.00 ± 12.77 | 159.33 ± 6.03 | 153.67 ± 6.97 | 0.674** |
| Final live wt/chick at 6 wk        |                           |         | 174.1 ± 9.02 | 177.4 ± 9.71 | 172.7 ± 6.11 | 172.4 ± 8.62 | 164.5 ± 7.94 | 176.6 ± 10.6 | 165.5 ± 11.02 | 1619 ± 9.02 | 0.001* |
| Body weight gain g/bird            |                           |         | 1573 ± 11.02 | 1626 ± 7.00 | 1584 ± 12.50 | 1567 ± 14.00 | 1483 ± 7.77 | 1568 ± 5.29 | 1492 ± 9.61 | 1469 ± 7.21 | 0.000* |
| Total Feed intake kg/group         |                           |         | 45.01 | 46.8 | 40.99 | 40.88 | 40.17 | 43.66 | 41.42 | 38.75 |         |
| Feed intake g/bird                 |                           |         | 3000 ± 37 | 3113 ± 24 | 2732 ± 43 | 2729 ± 22 | 2665 ± 20 | 2881 ± 44 | 2761 ± 37 | 2583 ± 12 | 0.000* |
| Feed conversion ratio              |                           |         | 1.91 ± 0.61 | 1.91 ± 0.52 | 1.72 ± 0.53 | 1.74 ± 0.63 | 1.80 ± 0.52 | 1.84 ± 0.65 | 1.85 ± 0.51 | 1.76 ± 0.73 | 0.000* |
| Metabolizable energy intake (Kcal) |                           |         | 10501 ± 132 | 10895 ± 87 | 9564 ± 152 | 9533 ± 79 | 9327 ± 72 | 10084 ± 155 | 9663 ± 130 | 9041 ± 44 | 0.000* |

- * Denotes F-value significant (P<0.05).
- NS Denotes F-value not significantly (P>0.05).
- MS in a row followed by the same letter or no letter do not differ significantly (P>0.05).

![Fig. 5: Effect of three levels of vitamin C on red blood cells (g/d)](image)

**Fig. 5** Effect of three levels of vitamin C on red blood cells (g/d)

categorized by respiratory alkalosis and increase in blood pH as a result of panting and decreased weight gain as a result of depressed feed intake. Vitamin C decreases the corticosterone in blood circulation which increases during exposure to ambient temperature as demonstrated by Richard[33]. This led to decrease in the lymphocytes percentage and according by the total white blood cell increased.

In this study, chickens fed on 250, 500 and 750 mg of vitamin C /Kg added feed showed decrease in white blood cell as vitamin C increased with gradual decrease in lymphocytes percentage. This effect of vitamin C might be due to the pathological effect on the internal organs such as liver and kidney that led to decrease in lymphocytes / heterophils ratio and serum albumin when Vitamin C was added at the level of 250 mg /Kg to the feed and they increased when vitamin C was added at the level of 500, 750 mg/Kg to the feed.

Haemoglobin concentration differed slightly with the groups fed the 250, 500, 750 mg/Kg vitamin C supplemented feed. This result agrees with those obtained by Mehmet[25] who observed that the blood parameters included pH, Na, K, PCV, HCO3 Hb were not effected by vitamin C supplementation under hot lymphocytes percentage condition. Whereas, red blood cells differed slightly among the supplemented groups.

**Conclusion:** The groups which were fed with feed supplemented with 250 mg / Kg or the non gave best results compared to those with 500, 750 mg /Kg vitamin C feed.

The effect of restriction was not significant because all groups were affected by temperature elevation, associated with decrease in feed consumption.

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