ADDING DIFFERENT LEVELS OF TURMERIC POWDER AND CURCUMIN IN THE DIET ON SOME SERUM BIOCHEMICAL OF BROILER REARED UNDER NORMAL AND HEAT STRESS CONDITIONS

M. M. Mustafa(1) F. Karadas(2) I. T. Tayeb(1)
Researcher Prof. Assistant Prof.

1Dep. Of Animal Sci.-Coll. Agric. Engine. Sci. University of Duhok. Iraq
2Yuzuncu Yil University, Faculty of Agriculture, Dep. of Animal Science. Van/ Turkey
E-mail: merkhan@uod.ac

ABSTRACT
This study was carried out to elucidate the effect of supplementing different levels of turmeric powder and curcumin on serum lipid profile, protein, thyroid hormones (T3 and T4), ALT, AST enzymes, uric acid, creatine kinase and glucose. Seven-hundred and fifty chicks Ross 308, received from a local hatchery. Chicks divided into two groups, normal and heat stressed conditions, with 5 treatments and 3 replicates in which 25 chicks for each. The dietary treatments composed of basal diet (control), 50 g curcumin/ton, 75 g curcumin/ton, 1.65 kg turmeric powder/ton and 2.5 kg turmeric powder/ton. Results showed that adding turmeric powder and curcumin had significant effects (P<0.05) on serum lipid profile, protein profile, T3, T4, ALT enzyme, creatine kinase, uric acid and glucose. Concerning the rearing condition, which had a significant effect (P<0.05) on the serum cholesterol, LDL, total protein, albumin, T3 hormone, ALT, AST enzymes, creatine kinase, uric acid and glucose.

Key words: heat stress, turmeric powder, curcumin, broiler, serum profile.

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INTRODUCTION

In the poultry production, high ambient temperature is an important stress factor in tropical countries (19). Under heat stress circumstances, birds tend to maintain homeostasis through several strategies, for instance, biochemical, physiological and behavioral (25). Different experimental situations should be undertaken to indicate the serum biochemical levels in which the variation in this aspect is directly related to the climate factors (6). Economic losses in poultry production are caused through marked deviation in the level of blood biochemical and growth rate. This may be due to the effect of high ambient temperature on the performance and productivity by reducing the feed intake and nutrient utilization (27). Triglyceride, serum cholesterol, packed cell volume, total white blood cells and hemoglobin are the main biochemical parameters that are altered by heat stress (7). Many studies have been carried out on this trend through the manipulation of specific parameters, including biochemical and electrolyte. Researchers stated that these parameters may be useful through realistic evaluation of health conditions, nutritional status, organ function and management practices. Out of these, light has been placed on some specific parameters such as total protein, aspartate aminotransferase (AST), albumin, alkaline phosphatase (ALP), creatine kinase (CK), glucose, sodium, chloride, and potassium (16; 30). Hence, in nutritional factors, particularly turmeric powder had favorable effects on heat stress in poultry through various feeding experiments. Overall, researchers found that feeding turmeric powder at pre- and post-application of heat stress led to high cholesterol HDL fraction, low concentrations of blood total cholesterol and LDL-cholesterol. Additionally, they observed a decrease in the activity of several enzymes during heat stress. An improvement has been obtained by the activity of GPx and SOD by supplementing turmeric powder. These led to a protection in the organism from the increase of malondialdehyde (MDA) concentrations, oxidative damage, which indicate an enhancement of antioxidant and detoxifying status of birds (9; 15; 30). Research on this area had used pure curcumin and its effect on heat stress in quails. In the findings, heat stress alleviation was observed through modification of the heat shock protein 70 and hepatic nuclear transcription factors (27). Therefore, the aim of present study was to elucidate the effect of supplementing different levels of turmeric powder and curcumin on serum lipid profile, protein, thyroid hormones (T3 and T4), ALT, AST enzymes, uric acid, creatine kinase and glucose under normal and heat stress conditions.

MATERIALS AND METHODS

Subjects and experimental design

Seven-hundred- and fifty-day old chicks (Ross 308) were provided by a local hatchery. After arrival, chicks were weighed. They were equally and randomly placed in two halls, which were stressed and normal condition. Under each condition, five groups were made with three replicates (25 chicks each) for each group. Floor cages (1.6 m x 2 m) were used to keep the birds. The halls were equipped with essential equipment including heating facilities and adjustable setting of temperature. In stresses hall, the temperature was set in 37 °C for the first day before gradual decrease to reach 33 ±1 °C at the 3rd week of age and this was left constant until the end of the experiment. However, the temperature of 34 °C was used on the first day then it was decreased gradually to 24 °C – 25 °C until the end of the experiment. In both halls, continuous incandescent white light was used.

Ethical consideration

Rearing of the birds was undertaken according to the Animal Ethical Guidelines of Department of Animal Production, College of Agricultural Engineering Sciences, University of Duhok as a part of the PhD thesis. Therefore, the study was ethically approved.

Feed and treatments

To meet the nutrient requirements of the broilers, the chickens were fed a basal diet, which was prepared according to National Research Council (1994) (Table 1). Dry and fresh roots of turmeric were purchased from local markets and were powdered by a mechanical instrument. Additionally, a prepared commercial curcumin (Force 6® Poultry) was obtained from Phode Company, France. For better homogenization, at first, an
appropriate amount of turmeric powder or curcumin was mixed with a small amount of the basal diet; then, a small amount of it was mixed with larger amounts of the basal diet. The starter diet was provided to birds from 1-17 days of age. Later, from 18-35 days, the birds were fed on the finisher diet. Food and water were provided to the birds ad libitum.

The experimental groups were: T1: basal diet, T2: 50g of curcumin powder/ton of feed, T3: 75g of curcumin powder/ton of feed, T4: 1.65 kg of turmeric powder/ton of feed and T5: 2.5kg of turmeric powder/ton of feed.

**Data collection: serum biochemical parameters and hormone level measurements**

The serum biochemical parameters were measured according to (3). For this purpose, at 35 days of the experiment, two blood samples were taken from each cage. Immediately, the samples were saved on ice and transferred to the laboratory. Later, they were centrifuged for 10 minutes at 1500g to separate the serum and stored at -20 C until they are analysed. The measured parameters were triglyceride, glucose, globulin, albumin, total protein, cholesterol, HDL, LDL, VLDL, AST, ALT, uric acid, creatine kinase T3 and T4. The Auto analyzer (Cobas 6000, Roche Diagnostics, Germany) was used for measuring data.

### Table 1. the composition of the basal diets

| Ingredients (kg)                  | Starter (kg/ton) | Grower (kg/ton) |
|-----------------------------------|------------------|-----------------|
| Corn                              | 472              | 495             |
| Wheat flour                       | 50               | 50              |
| Wheat bran                        | 40               | 50              |
| Soybean meal 46%                  | 370              | 340             |
| Vegetable oil                     | 23               | 24              |
| limestone                         | 10               | 8               |
| Dicalcium phosphate               | 0.200            | 0.200           |
| DL methionine                     | 1                | 0.5             |
| L-lysine                          | 1                | 1               |
| Anti-toxin                        | 1                | 1               |
| Salt                              | 1                | 1               |
| Premix                            | 25               | 25              |
| Anti coccidial                    | 0.250            | 0.250           |
| Enzyme                            | 0.5              | 0.5             |

**Analyzed chemical composition**

| Moisture (%)                      | 11.57            | 11.78           |
| Crude protein (%)                 | 22.49            | 20.65           |
| Energy Kcal/kg                    | 2966             | 3055            |
| Fat (%)                           | 2.97             | 3.36            |
| Fiber (%)                         | 2.18             | 2.64            |
| Ash (%)                           | 4.83             | 3.34            |
| Starch (%)                        | 44.22            | 46.29           |
| Sugars (%)                        | 4.02             | 3.87            |
| Calcium (%)                       | 1.12             | 0.97            |

Statistical analysis

The data were placed in Microsoft Excel spreadsheet so as to be prepared for analysis. Then, they were projected to SAS statistical software program. In the SAS statistical package (PROC GLM) was used to determine the significance of the main effects (SAS, 2013). Duncan’s multiple range test was used to detect the differences between individual treatment means.

**RESULTS AND DISCUSSION**

**Serum lipid profile:** The interaction of the experimental factors according to Duncan significantly increased the cholesterol content of blood serum in T1S (141.16 ±1.55). Whereas, the lowest cholesterol content was detected in T2N (120.83 ±3.87) followed by T3N and T5N (123.16 ± 2.78) (Table 2). There was a significant (P<0.01) interaction between the experimental factors indicating the lower HDL in control birds under both rearing conditions. Furthermore, the interaction of the experimental factors revealed the highest (P<0.05, Duncan test) LDL in T1S. However, the lower LDL content was found in T5N followed by T2N and T1N. A significant interaction was between the experimental factors indicating the higher (P<0.05, Duncan test).
test) VLDL and triglycerides in control birds in both rearing conditions. Whereas, the lowest VLDL and triglycerides were in T5N. Considering as a main factor, the level of the additives had significant effects on serum biochemistry parameters that investigated in this experiment. The concentration of serum cholesterol, LDL, VLDL and triglyceride were significantly decreased (P<0.01); while, that of HDL was significant increased (P<0.01) in all treatments compared to the control. These results were in line with the findings of (15) who found that adding different levels of turmeric powder significantly decreased cholesterol, LDL and increased HDL in broiler at 42 days of age. Moreover, (11) recorded that adding turmeric powder in broiler diet had significant effect on total cholesterol, HDL and LDL in comparison with the control diet. Furthermore, (29) estimated that adding different levels of curcumin in broiler diet had a significant effect on the broiler serum total cholesterol, HDL, LDL VLDL and triglyceride evaluated on the basis of normal diet. However, results of this study were in contrast of (28), who found that turmeric powder had no significant effect on the serum cholesterol level compared to the control diet. Furthermore, (1) stated adding different levels of turmeric had no significant effect on the broiler serum total cholesterol, HDL and LDL compared to the normal diet. Significantly the higher cholesterol and LDL contents were recorded in stressed birds than those that were reared under normal conditions (Table 2). Our results were in line with the findings of (5), who reported that rearing chicken under heat stressed conditions significantly increased serum content of total cholesterol and LDL; while, it had no significant effect on the serum HDL, VLDL and triglyceride compared to normal condition. Moreover, (17) mentioned that heat stress conditions significantly increased serum total cholesterol in dealing with stress compare to normal condition. Results of serum cholesterol were contrary to the findings of (16) who found that exposure of chicken to the heat stress had no significant effect on the serum cholesterol level.

Serum protein profile: The interaction of the experimental factors according to Duncan test significantly increased the albumin, globulin and total protein content of blood serum in T2S which were 1.281 ± 0.012, 2.488 ± 0.201 and 3.770 ± 0.211, respectively. On the other hand, the lower albumin, globulin and total protein contents were recorded in T1N being 1.106 ± 0.026, 1.860 ± 0.070 and 2.966 ± 0.080, respectively (Table 3). Regarding the effect of main factor, the level of the additives had significantly (P<0.01) increased albumen, globulin, total protein and albumin to globulin ratio referring to control. Results were in line with findings of (26), who found that adding different levels of turmeric powder had no significant effect on total protein and globulin of broiler serum at 35 days of age compared to the control diet. Furthermore, (10) claimed that there was no significant effect on total protein concentrations in broiler chickens treated with different levels of turmeric powder in comparison to control. Additionally, (1) found that adding different levels of turmeric powder in broiler diet had no significant effect on serum albumin to globulin ratio compared to control. On the other hand, results were in contrast with the findings of (2) who found a significant increase in serum total protein concentration in broiler chickens that received a diet containing different levels of turmeric powder reared under normal conditions. Moreover, (21) reported that using turmeric powder in broiler diet had significantly (P<0.02) effect on the serum total protein and globulin of broiler birds compared to control diet. Chicken with stressed conditions had significantly (P<0.01) higher albumin, total protein and increased albumin to globulin ratio (P<0.05) compared to control (Table 3). These results were consistent with the findings of (5; 16), who reported that heat stressed conditions has significant effect on the serum globulin and albumin to globulin ratio compared to the normal condition. Whereas, our results were not in line with the findings of (5;16), who reported that heat stressed conditions had no significant effect on broiler serum total protein and albumin content compared to the normal thermal condition.
Table 2. Effect of adding different levels of turmeric powder and curcumin in broiler diet on serum lipid profile of chicken reared under normal and heat stress condition

|                | Cholesterol mg/dl | HDL mg/dl | LDL mg/dl | VLDL mg/dl | Triglyceride mg/dl |
|----------------|-------------------|-----------|-----------|-------------|-------------------|
| **Mean**       | 129.05 ± 1.25     | 88.80 ± 0.94 | 29.61 ± 0.68 | 6.58 ± 0.13 | 32.93 ± 0.66      |
| T1 N           | 135.16 ± 1.83 ab  | 79.66 ± 1.54 c | 30.66 ± 0.80 abc | 8.24 ± 0.15 a | 41.20 ± 0.79 a    |
| T2 N           | 120.83 ± 3.87 d   | 93.16 ± 1.60 a | 26.00 ± 1.46 cd | 6.10 ± 0.27 bc | 30.50 ± 1.36 bc   |
| T3 N           | 122.16 ± 2.38 ed  | 90.16 ± 1.10 a | 27.00 ± 1.80 ed | 6.36 ± 0.35 bc | 31.83 ± 1.77 bc   |
| T4 N           | 129.83 ± 6.77 bcd | 89.83 ± 2.60 a | 29.00 ± 3.56 bcd | 6.06 ± 0.17 bc | 30.33 ± 0.88 bc   |
| T5 N           | 123.16 ± 2.78 cd  | 87.50 ± 3.33 ab | 24.50 ± 2.09 d | 5.66 ± 0.33 c | 28.33 ± 1.66 c    |
| T1 S           | 141.16 ± 1.55 a   | 81.00 ± 1.57 bc | 35.33 ± 1.38 a | 8.16 ± 0.38 a | 40.83 ± 1.90 a    |
| T2 S           | 126.50 ± 2.37 bcd | 94.83 ± 3.91 a | 28.33 ± 1.05 bcd | 6.26 ± 0.12 bc | 31.33 ± 0.61 bc   |
| T3 S           | 128.16 ± 2.79 bcd | 93.50 ± 2.53 a | 32.83 ± 0.87 ab | 5.96 ± 0.20 bc | 29.83 ± 1.01 bc   |
| T4 S           | 132.66 ± 2.27 abc | 88.33 ± 2.47 a | 33.83 ± 1.53 ab | 6.66 ± 0.18 b | 33.33 ± 0.91 b    |
| T5 S           | 130.83 ± 4.02 abcd| 90.00 ± 2.28 a | 28.66 ± 1.89 bcd | 6.36 ± 0.22 bc | 31.83 ± 1.1 bc    |
| **Normal**     | 126.23 ± 1.92 b   | 88.06 ± 1.24 | 27.43 ± 0.98 b | 6.48 ± 0.20 | 32.44 ± 1.01      |
| **Stress**     | 131.86 ± 1.47 a   | 89.53 ± 1.42 | 31.80 ± 0.77 a | 6.68 ± 0.17 | 33.43 ± 0.87      |
| T1             | 138.16 ± 1.46 a   | 80.33 ± 1.06 b | 33.00 ± 1.03 a | 8.20 ± 0.19 a | 41.01 ± 0.98 a    |
| T2             | 123.66 ± 2.33 c   | 94.00 ± 2.03 a | 27.16 ± 0.92 b | 6.18 ± 0.14 b | 30.91 ± 0.72 b    |
| T3             | 125.16 ± 1.97 bc  | 91.83 ± 1.41 a | 29.91 ± 1.29 ab | 6.16 ± 0.20 b | 30.83 ± 1.02 b    |
| T4             | 131.25 ± 3.43 b   | 89.08 ± 1.72a | 31.41 ± 1.99 a | 6.36 ± 0.15 b | 31.83 ± 0.75 b    |
| T5             | 127.00 ± 2.60 bc  | 88.75 ± 1.96 a | 26.58 ± 1.48 b | 6.01 ± 0.21 b | 30.08 ± 1.09 b    |
| **P values**   |                  |           |           |             |                   |
| Interaction    | 0.969             | 0.888     | 0.907     | 0.185       | 0.185             |
| Environment    | 0.011             | 0.34      | 0.0004    | 0.22        | 0.22              |
| Treatments     | 0.0006            | 0.0001    | 0.003     | 0.0001      | 0.0001            |

T1 control, T2 50g curcumin per ton, T3 75g curcumin per ton, T4 1.65 kg turmeric powder per ton, T5 2.5 kg turmeric powder per ton. N = normal condition. S= heat stress condition
Table 3. Effect of adding different levels of turmeric powder and curcumin in broiler diet on albumen, globulin, total protein and albumin to globulin ratio of chicken serum reared under normal and heat stress condition

| Treatments | Albumen mg/dl | Globulin mg/dl | Total protein mg/dl | Albumen to globulin ratio |
|------------|---------------|----------------|---------------------|--------------------------|
| Mean       | 1.188 ± 0.010 | 2.104 ± 0.038 | 3.293 ± 0.044       | 0.57 ± 0.007             |
| T1 N       | 1.106 ± 0.026 | 1.860 ± 0.070 | 2.966 ± 0.080 e     | 0.59 ± 0.024             |
| T2 N       | 1.203 ± 0.017 | 2.346 ± 0.138 ab | 3.550 ± 0.153 ab | 0.52 ± 0.024             |
| T3 N       | 1.151 ± 0.022 | 2.123 ± 0.118 bc | 3.275 ± 0.127 bcde | 0.55 ± 0.030             |
| T4 N       | 1.116 ± 0.037 de | 1.933 ± 0.061 c | 3.050 ± 0.090 ed | 0.57 ± 0.016             |
| T5 N       | 1.193 ± 0.016 | 1.965 ± 0.039 c | 3.158 ± 0.050 cde | 0.60 ± 0.009             |
| T1 S       | 1.146 ± 0.010 | 1.958 ± 0.031 c | 3.105 ± 0.028 cde | 0.58 ± 0.012             |
| T2 S       | 1.281 ± 0.012 | 2.488 ± 0.201 a | 3.770 ± 0.211 a | 0.52 ± 0.033             |
| T3 S       | 1.261 ± 0.053 ab | 2.175 ± 0.077 bc | 3.436 ± 0.096 abc | 0.58 ± 0.031             |
| T4 S       | 1.230 ± 0.011 | 2.165 ± 0.083 bc | 3.395 ± 0.075 bcd | 0.57 ± 0.027             |
| T5 S       | 1.195 ± 0.031 bc | 2.033 ± 0.080 bc | 3.228 ± 0.099 bde | 0.59 ± 0.022             |

Normal       | 1.154 ± 0.012 b | 2.045 ± 0.050 | 3.200 ± 0.058 b | 0.57 ± 0.010             |
Stress       | 1.223 ± 0.015 a | 2.168 ± 0.056 | 3.387 ± 0.064 a | 0.57 ± 0.011             |
| T1          | 1.126 ± 0.014 c | 1.909 ± 0.039 c | 3.035 ± 0.045 c | 0.59 ± 0.013 a             |
| T2          | 1.242 ± 0.015 a | 2.417 ± 0.11 a | 3.660 ± 0.12 a | 0.52 ± 0.019 b             |
| T3          | 1.206 ± 0.032 ab | 2.149 ± 0.067 b | 3.355 ± 0.097 b | 0.56 ± 0.021 ab             |
| T4          | 1.173 ± 0.025 bc | 2.049 ± 0.060 bc | 3.222 ± 0.076 bc | 0.57 ± 0.015 a             |
| T5          | 1.194 ± 0.016 ab | 1.999 ± 0.043 bc | 3.193 ± 0.054 bc | 0.59 ± 0.011 a             |

P values
Interaction 0.21 | 0.90 | 0.793 | 0.852
Environment 0.0002 | 0.073 | 0.011 | 0.92
Treatments 0.0021 | 0.0001 | 0.0001 | 0.02

Thyroid hormones and alt, ast enzymes
The interaction of the experimental factors significantly increased (P<0.05) T3, and T4 (according to Duncan test) contents of blood serum in T2N being 2.76 ± 0.14 and 24.16 ± 1.07, respectively (Table 4). Whereas, the lowest contents of T3 and T4 were 1.53 ± 0.10 and 14.63 ± 0.99, respectively. Interaction among experimental factors according to Duncan test had significantly decreased the level of ALT in blood serum compared to control under both rearing conditions. The higher level of ALT was for T1S (7.15 ± 0.19); while, the lower content of ALT was for T2N (3.53 ± 0.17). Regarding the main factor of experiment, adding different levels of turmeric powder and curcumin significantly (P<0.01) increased T3 and T4 content of serum although, significantly (P<0.01) decreased the content of ALT enzyme in blood serum in opposition to control. Results were in agreement with the finding of (32), who stated that adding turmeric powder in broiler diet reared under heat stressed conditions significantly increased T4 in serum compared to normal diets. Furthermore, (20) claimed that adding turmeric powder under heat stress significantly decreased ALT enzyme levels and had no significant effect on AST level in broiler serum compared to control diets. In addition, (10; 15) announced that supplementing different levels of turmeric powder significantly decreased the concentration of ALT enzyme in serum compared to control ration. Moreover, (18) reported that using various levels of curcumin had no significant effect on the AST enzyme in serum compared to control. (1) Declared that using different levels of turmeric powder had no significant effect on serum AST enzyme levels in comparison to control. On the other hand, results obtained were against
the findings of (18) who found that chicken fed diets containing different levels of curcumin had no significant effect on ALT enzyme concentration in serum. Additionally, (1) stated that chicken fed different doses of turmeric powder had no significant effect on serum ALT enzyme concentration compared to chicken fed normal diet. Similarly, (32) mentioned that adding turmeric powder in broiler diet reared under heat stressed conditions had significantly decreased T3 hormone concentration in serum compared to control. Heat stressed conditions significantly (P<0.01) decreased the content of T3 in blood serum compared to normal condition being 2.04 ± 0.07 and 2.49 ± 0.07, respectively. On the other hand, chicken reared under heat stress conditions had significantly higher ALT being 5.81 ± 0.17 and4.00 ± 0.12 and AST content of blood serum being 384.76 ± 8.20 and 343.86 ± 13.36), respectively (Table 4).

Results recorded in the present study are in line with the results of (13 and 4). They found that heat stress conditions significantly reduced the concentration of T3. Furthermore, (22) reported that chicken reared under heat stressed conditions at the age of 28 days, had significantly lower concentration of T3 hormone compared to normal condition. Moreover, (16) reported that heat stress conditions had significant effect in increasing the levels of AST and ALT enzymes in broiler serum with reference to normal condition. (5) claimed that AST level was significantly higher for broiler reared under heat stress condition. On the other hand, the results of this study are contrary to the findings of (23), who found that heat stress conditions significantly increased T3 and decreaseT4 concentrations in serum compared to natural conditions. Furthermore, (5) indicated that heat stress conditions had no significant effect on the ALT level of broilers compared to normal condition. Ultimately, (8) reported that adding turmeric powder in broiler diet reared under heat stress significantly decreased AST enzyme in serum measured against the control diet.

**Serum creatin kinase, uric acid and glucose:**
Experimental factor interacted to affect significantly (P<0.01) on the level of serum creatin kinase, uric acid and glucose (according to Duncan test). The higher levels of creatin kinase, uric acid and glucose were recorded for T1S, which were 6881.67 ± 84.34, 7.38 ± 0.09 and 236.66 ± 4.14, respectively. The lower serum contents of creatin kinase, uric acid and glucose were for T2N being 4516.67 ± 216.66 and 4.76 ± 0.13. Turmeric powder and curcumin significantly (P<0.01) deceased the serum creatin kinase, uric acid and glucose compared to control. The results of this study are similar to the findings of (20), who declared that adding turmeric powder in broiler diets reared under heat stressed conditions had significantly reduced the uric acid in serum compared to control diet. Furthermore, (24) stated that adding different levels of turmeric had significantly decreased serum glucose, uric acid and creatin kinase of chicken reared under heat stressed conditions measured against normal diet. In contrary, our results were in a disagreement with the finding of (15; 26), who investigated that adding different levels of turmeric powder had no significant effect on serum creatin kinase of broilers reared under heat stressed conditions as compared to control. In addition, some researchers reported that using turmeric powder in broiler diet had no significant effect on the serum uric acid compared to control (12). Moreover, it was found that serum glucose levels were not significantly affected by adding different levels of turmeric in broiler diet compared to control (28 ; 26).

Concerning the rearing conditions, heat stress conditions had significantly (P<0.01) increased serum creatin kinase, uric acid and glucose compared to normal condition. These results are in agreement with the finding of (16) who reported that serum creatin kinase level of broiler reared under heat stressed conditions significantly was higher than those reared under normal conditions. Whereas, the results of present study are in contrast to the findings of (5) who claimed that heat stress conditions had no significant effect on the serum glucose and uric acid levels.
Table 4. Effect of adding different levels of turmeric powder and curcumin in broiler diet on thyroid hormone and liver enzymes of chicken reared under normal and heat stress condition

|                  | T3 nmol/ml | T4 nmol/ml | ALT U/L | AST U/L |
|------------------|------------|------------|---------|---------|
| Mean             | 2.26 ± 0.05| 20.82 ± 0.46| 4.90 ± 0.15| 364.31 ± 8.22|
| T1 N             | 2.01 ± 0.14 cd| 17.26 ± 1.54 d| 5.13 ± 0.07 c| 379.16 ± 49.42|
| T2 N             | 2.76 ± 0.14 a| 24.16 ± 1.07 a| 3.53 ± 0.17 d| 316.50 ± 24.31|
| T3 N             | 2.50 ± 0.08 ab| 21.90 ± 1.00 ab| 3.75 ± 0.07 d| 323.33 ± 12.99|
| T4 N             | 2.60 ± 0.14 ab| 20.75 ± 0.77 bc| 4.00 ± 0.18 d| 354.16 ± 36.76|
| T5 N             | 2.56 ± 0.15 ab| 22.81 ± 1.19 ab| 3.61 ± 0.19 d| 346.16 ± 11.09|
| T1 S             | 1.53 ± 0.10 e| 14.63 ± 0.99 e| 7.15 ± 0.19 a| 422.83 ± 31.27|
| T2 S             | 2.27 ± 0.06 bc| 23.63 ± 0.22 ab| 4.91 ± 0.20 c| 371.33 ± 1.78|
| T3 S             | 2.31 ± 0.05 bc| 22.65 ± 0.29 ab| 5.21 ± 0.26 c| 373.66 ± 7.28|
| T4 S             | 1.72 ± 0.05 de| 18.40 ± 0.51 cd| 6.33 ± 0.12 b| 379.00 ± 23.37|
| T5 S             | 2.37 ± 0.09 b| 22.05 ± 0.37 ab| 5.43 ± 0.29 c| 377.00 ± 1.91|
| Normal           | 2.49 ± 0.07 a| 21.38 ± 0.64 a| 4.00 ± 0.12 b| 343.86 ± 13.36 b|
| Stress           | 2.04 ± 0.07 b| 20.27 ± 0.65 a| 5.81 ± 0.17 a| 384.76 ± 8.20 a|
| T1               | 1.77 ± 0.11 c| 15.95 ± 0.96 c| 6.14 ± 0.31 a| 401.00 ± 28.65|
| T2               | 2.52 ± 0.1 a| 23.9 ± 0.53 a| 4.22 ± 0.24 c| 343.91 ± 14.26|
| T3               | 2.40 ± 0.05 a| 22.27 ± 0.51 a| 4.48 ± 0.25 c| 348.50 ± 10.39|
| T4               | 2.16 ± 0.15 b| 19.57 ± 0.56 b| 5.16 ± 0.36 b| 366.58 ± 21.10|
| T5               | 2.47 ± 0.09 a| 22.43 ± 0.60 a| 4.52 ± 0.32 c| 361.58 ± 7.09|

P values: Interaction 0.97, Environment 0.0001, Treatments 0.02

T1 control, T2 50g curcumin per ton, T3 75g curcumin per ton, T4 1.65 kg turmeric powder per ton, T5 2.5 kg turmeric powder per ton. N = normal condition. S= heat stress condition

Table 5. Effect of adding different levels of turmeric powder and curcumin in broiler diet on serum creatine kinase, uric acid and glucose of chicken reared under normal and heat stress conditions

|                  | Creatin kinase U/L | Uric acid mg/dl | Glucose mg/dl |
|------------------|---------------------|-----------------|--------------|
| Mean             | 5045.59 ± 124.01    | 5.50 ± 0.11     | 207.40 ± 2.39|
| T1 N             | 4623.33 ± 189.09b   | 6.10 ± 0.10 b   | 214.33 ± 4.73 bc|
| T2 N             | 4516.67 ± 216.66 b  | 4.76 ± 0.13 d   | 185.33 ± 5.59 e|
| T3 N             | 4625.00 ± 240.05 b  | 4.86 ± 0.20 cd  | 193.16 ± 60.7ed|
| T4 N             | 4600.00 ± 317.28 b  | 5.91 ± 0.21 b   | 208.16 ± 1.85bcd|
| T5 N             | 4655.00 ± 227.89 b  | 4.91 ± 0.11 ed  | 191.66 ± 4.24 e|
| T1 S             | 6881.67 ± 84.34a    | 7.38 ± 0.09 a   | 236.66 ± 4.14 a|
| T2 S             | 4623.33 ± 336.18 b  | 4.85 ± 0.13 cd  | 199.50 ± 4.66dec|
| T3 S             | 4952.60 ± 74.79b    | 4.95 ± 0.10 cd  | 208.50 ± 9.41bcd|
| T4 S             | 6266.67 ± 272.41 a  | 5.98 ± 0.18 b   | 220.16 ± 1.70 b|
| T5 S             | 4696.17± 17916b     | 5.31 ± 0.21 c   | 216.50 ± 2.45 b|
| Stress           | 4604.00 ± 100.88 b  | 5.31 ± 0.12 b   | 198.53 ± 2.81 b|
| T1               | 5502.41 ± 198.12 a  | 5.69 ± 0.18 a   | 216.26 ± 3.16 a|
| T2               | 5752.50 ± 354.48 a  | 6.74 ± 0.20 a   | 225.50 ± 4.50 a|
| T3               | 4570.00 ± 191.34 b  | 4.80 ± 0.09 c   | 192.41 ± 4.07 d|
| T4               | 4773.91 ± 139.26 b  | 4.90 ± 0.11 c   | 200.83 ± 5.81 cd|
| T5               | 5433.33 ± 320.74 a  | 5.95 ± 0.13 b   | 214.16 ± 2.17 b|
| P values         | 0.0001              | 0.0004          | 0.0001        |

P values: Interaction 0.0001, Environment 0.0001, Treatments 0.0001

T1 control, T2 50g curcumin per ton, T3 75g curcumin per ton, T4 1.65 kg turmeric powder per ton, T5 2.5 kg turmeric powder per ton. N = normal condition. S= heat stress condition
CONCLUSION
From the present study, according to the results found, it can be concluded that adding different levels of turmeric powder and curcumin could improve serum biochemical parameters of broiler chicken reared under normal and heat stress condition for 35 days of age.

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