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Research Article

Growth Performance, Carcass and Viscera Yields, Blood Constituents and Thyroid Hormone Concentrations of Chronic Heat Stressed Broilers Fed Diets Supplemented with Cumin Seeds *(Cuminum cyminum* L.)

Zahra BERRAMA [1] Soraya TEMIM [1] Samir SOUAMES [1] Hacina AINBAZIZ [1]

[1] Laboratoire de Recherches Santé et Productions Animales, Ecole Nationale Supérieure Vétérinaire, Alger, ALGERIE

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Abstract

This study was conducted to determine the effect of dietary supplementation with cumin (*Cuminum cyminum* L.) seeds on growth performances, relative weights of carcass and viscera, haematological and biochemical parameters, and thyroid hormones concentrations of broiler chickens subjected to natural fluctuation of Algerian summer ambient temperatures. A total of 440 28-day old chickens were divided into 2 groups (5 replicates of 44 birds) with similar body weight (971±48 g): a "Control" group fed with a standard diet and a "Cumin" group receiving a basal diet supplemented with 0.2% of cumin. As a result of this study, dietary cumin supplementation did not significantly modify the growth rate and final body weights of heat-exposed chickens but it slightly improved feed conversion ratio (-7%, P=0.1). Carcass traits, viscera (liver, heart, gizzard, spleen, bursa and thymus) intestine morphology and abdominal fat of heat stressed birds did not reveal any changes by cumin inclusion compared to the control ones. Also, thyroid hormones (T3 and T4) concentrations were not significantly influenced by dietary cumin (P>0.05). However, heat-exposed chickens supplemented with cumin exhibited a significant (P<0.01) lower values of plasma glucose, cholesterol, triglycerides and total proteins and higher calcium concentrations than those of control group. Cumin dietary may be a successful means to enhancing diet conversion and reducing glaecimic, lipidaemic and calcaemic disorders in chronically-heat exposed chickens.

Keywords: *Blood parameters, Broilers, Carcass, Chronic heat stress, Climate, Cuminum cyminum, Performance, Thyroid hormones*

Kimyon *(Cuminum cyminum* L.) Çekirdeği İle Beslenen ve Kronik Isı Stresine Maruz Bırakılan Broiler Tavuklarda Büyüme Performansı, Karkas ve Visseral Organ Ağırlıkları, Kan Bileşenleri ve Tiroit Hormon Konsantrasyonları

Özet

Bu çalışma, Cezayir'de yaz çevre ısısının doğal dalgalanmasına maruz kalan broiler tavuklarda yeme kimyon (*Cuminum cyminum* L.) çekirdeği ilavesinin büyüme performansına, karkas ve vissera ağırlığı oranına, kan ve biyokimyasal parametrelere ve tiroit hormon konsantrasyonuna etkilerini belirlemek amacıyla yapıldı. Toplam 440 adet 28 günlük tavuklar vücut ağırlıkları (971±48 g) benzer olmak üzere 2 gruba (44 tavuk, 5 tekrar olarak) ayrıldı. "Kontrol grubu" standart diyet ile beslenirken, "Kimyon grubuna" % 0.2 oranında kimyon ilave edilmiş bazal diyet verildi. Elde edilen sonuçlar ısı stresine maruz kalan broiler tavuklarda diyetsel kimyon ilavesinin büyüme oranına ve nihai vücut ağırlığına önemli bir etki yapmadığını fakat az oranda yem konversiyon oranına (% -7, P=0.1) etki ettiğini gösterdi. karkas özellikleri, visseral organ (karaciğer, kalp, taşlık, dalak, bursa ve timüs), bağırsak morfolojisi ve abdominal yağ miktarı ısı stresine maruz kalan kontrol grubu ile karşılaştırıldığında kimyon ilave edilen grupta bir farklılık göstermedi. Tiroit hormonları (T3 ve T4) konsantrasyonları diyetsel kimyon ile anlamlı derecede farklılık göstermedi (P>0.05). Ancak, kimyon verilen ve ısı stresine maruz bırakılan tavuklarda kontrol grubu ile karşılaştırıldığında anlamlı derecede olmak üzere (P<0.01) düşük plazma glikoz, kolesterol, trigliseritler ve total proteinler seviyeleri ile yüksek kalsiyum konsantrasyonu belirlendi. Diyete kimyon ilavesinin kronik ısı stresine maruz kalan tavuklarda diyet konversiyonunu artırmak ve glasimik, lipidemik ve kalsemik bozuklukları düzeltmek amacıyla kullanılabileceği kanısına varılmıştır.

Anahtar sözcükler: *Kan parametreleri, Broiler, Karkas, Kronik Isı Stresi, İklim, Cuminum cyminum, Performans, Tiroit hormonları*

İletişim (Correspondence)
+213 699 041873
zahra_berrama@yahoo.fr

INTRODUCTION

In summer season, chronic heat stress continues to be a great problematic for poultry production. The prolonged periods of high ambient temperatures compromise productivity and cause large economic losses [1]. Heat exposure decreases broilers growth rate, which is generally due to the reduced feed intake and generate many physiological, hormonal and molecular changes [2]. Also, it has been established that chronic heat stress affect development of several internal organs such as digestive (proventriculus, gizzard, intestine) and lymphoid organs (thymus, spleen, and bursa of fabricius), which could compromise the efficacy of nutrient digestibility and absorbability as well as the immune responses of birds [2,3].

To alleviate the negative effects of high environment temperature on poultry production, scientific investigations have considerably increased in the last decades [4]. Several nutritional approaches using safe and natural feed additives have been suggested. In this respect, many studies have shown that antioxidant nutrients supplementation in their synthetic (vitamins, minerals) or natural (herbs, spices) form can be used to improve productivity [5], enhance nutrient availability and prevent against detrimental effect of heat stress [6,7].

Cuminum cyminum is a small annual and herbaceous plant belonging to Apiaceae (Umbelliferae) family, which is cultivated in Arabia, India, China and in the countries bordering the Mediterranean Sea [8]. *Cuminum cyminum* seeds have shown excellent antioxidant, anti-inflammatory and antimicrobial activities which are generally attributed to their major components such as cuminaldehyde, terpinenes, polyphenols and flavoids [9]. Little is known about the effect of cumin *(Cuminum cyminum L.*) on zootechnical performances and physiological responses of broilers reared under high environmental temperatures. The few existing studies have focused on the effects of dietary *Cuminum cyminum L.* inclusion on growth performance of broilers under standard thermoneutral conditions [10,11]. Al-Kassy [11], found that dietary supplementation with 0.5 or 1% of cumin seed improved body weight gain and feed conversion ratio of broilers reared under thermoneutral conditions, with decreasing hematological values such as haemoglobin, red blood cells and packed cell volume. Under heat stress conditions, cumin dietary feed supplementation at level of 2 g/kg has been shown to ameliorate weight gain, enhance carcass, liver, pancreas and proventriculus percentage and increase haematocrit values and blood haemoglobin concentration of slow-growing chicks [12]. To our knowledge, this study is the only published trial on the effect of *Cuminum cyminum* dietary inclusion on broiler chickens subjected to heat stress. The influence of cumin on growth, performance, metabolism and thyroid hormones of commercial broilers under hot climate remains to be explored. In this context, the aim of this study is to assess the efficacy of dietary supplementation with cumin seeds (2 g/kg) to improve growth performances, carcass characteristics, lymphoid organs weights, and some haematological, biochemical and hormonal parameters of commercial broiler chickens reared in hot conditions (natural fluctuation of Algerian summer ambient temperatures).

MATERIAL and METHODS

Birds and Experimental Design

This research was approved by the scientific council of the Superior National Veterinary School of Algiers, Algeria. A total of 500 one-day-old of unsexed ISA HUBBARD broilers chicks obtained from a local hatchery were used in this experiment. From 1 to 28 days of age, chicks were given a standard starter diet (2.800 kcal ME/kg, 20% crude protein) from 1 to 10 d of age and a grower diet (2.900 kcal ME/kg, 19% crude protein) from 11 to 28 d of old. All animals were reared under standard breeding conditions. At 28 days old (experimental period), 440 chicks were selected on the basis of their body weight and equally divided into 2 groups, with similar average body weight (971±48 g) with 5 replicate pens of 44 birds each. Control chickens were fed a basal diet (grower diet from 28 to 42 d old and a finisher diet from 43 to 49 d old) as shown in *Table 1*. In cumin group, chickens received the same basal diet supplemented with 0.2% of cumin *(Cuminum cyminum L.*) in form of fine powder. During all the experimental period, all chicks were given free access to diet and water and were kept under similar rearing conditions and were exposed to the natural fluctuations of the summer ambient temperature *(Fig. 1)*.

Growth Performance

Body weights, feed intake and feed conversion ratios (g of feed/g of gain) for each group were recorded at 42 days and 49 days of old.

Carcass Traits

At the age of 49 d, ten birds per group were weighed, slaughtered, and then their feathers were removed. After eviscerating, carcasses, abdominal fat and the removed internal organs (liver, heart, gizzard, spleen, thymus, bursa, and intestine) were weighed and then expressed as percentage of live body weight. Also, the total length of intestine was measured and the intestine density was calculated.

Laboratory Analysis

At the end of experimental period (49 d), ten birds having a similar body weight to the average of their group were selected from each group and used for determination of the blood parameters. The birds were fasted for approximately 12 h before blood collection.

***Table 1.** Composition of the basal diet of the experiment*

Ingredient (g/100 g)	Starter (d1-10)	Grower (d11-42)	Finisher (d43-49)
Maize	60.90	64.80	68.60
Wheat bran	5.90	5.00	6.00
Soybean meal (46%CP)	29.20	26.40	21.80
Limestone	0.57	1.20	1.30
Dicalcium phosphate	2.40	1.60	1.30
Methionine	0.03	-	-
Vitamin-mineral premix S-G[a]	1.00	1.00	-
Vitamin-mineral premixF[b]	-	-	1.00

[a] Each kilogram of starter and grower diet provided: 850.000 IU of vitamin A; 170.000 IU of vitamin D_3; 1.350 IU of vitamin E; 199 mg of vitamin K_3, 100 mg of vitamin B_1; 450 mg of vitamine B_2; 150 mg of vitamine B_6; 1 mg of vitamine B_{12}; 1.5 mg of biotin; 600 mg of pantothenic acid; 1.000 mg of niacin; 40 mg of folic acid; 34.800 of choline chloride: 100.000 mg ; 738.8 mg of crude ash; 142.7 mg of calcium; 5.1 mg of magnesium; 130.5 mg of sodium; 1.2 mg of sulfur; 15.5 mg of insoluble ash; 3.600 mg of iron (Fe carbonate); 7.488 mg of zinc; 2250 mg of copper (sulfate); 75.052 mg of manganese (oxyd); 121 mg of iodine (iodate); 40 mg of cobalt (carbonate); 25 mg of selenium (selenite); 120.000 mg of methionin; 10.000 mg of BHA-ethoxyquine; 85 mg of molybdenum; 6.000 mg of narasin; [b] Each kilogram of finicher provided: 1.000.000 IU of vitamin A; 240.000 IU of vitamin D_3; 2.500 IU of vitamin E; 200 mg of vitamin K_3, 180 mg of vitamin B_1; 600 mg of vitamine B_2; 290 mg of vitamine B_6; 1 mg of vitamine B_{12}; 1.5 mg of biotin; 900 mg of pantothenic acid; 2.900 mg of niacin; 26 mg of folic acid; 49.998 mg of choline chloride: 100.000 mg; 766 mg of crude ash; 204.3 mg of calcium; 5.1 mg of magnesium; 130.5 mg of sodium; 1.2 mg of sulfur; 15.5 mg of insoluble ash; 3.600 mg of iron (Fe carbonate); 7.488 mg of zinc; 2.250 mg of copper (sulfate); 75.052 mg of manganese (oxyd); 121 mg of iodine (iodate); 40 mg of cobalt (carbonate); 25 mg of selenium(selenite); 120.000 mg of methionin; 10.000 mg of BHA-ethoxyquine; 85 mg of molybdenum

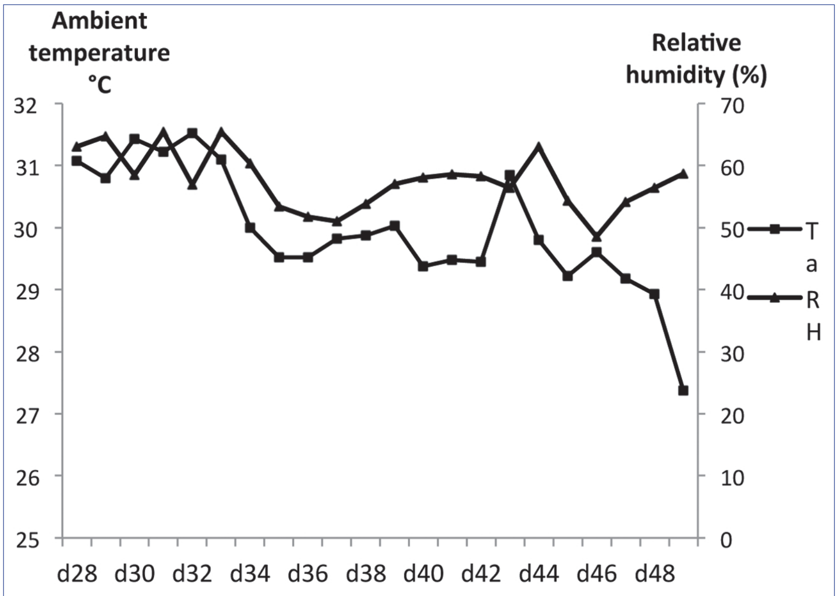

Fig 1. Evolution of daily mean ambient temperature and relative humidity during the experimental period (28-49d ays). Ta, ambient temperature; RH, relative humidity

Haematology Analysis

At slaughtering, blood samples were collected into EDTA tubes. The measurement of haematocrit percentage, haemoglobin concentration and total red blood cells (RBC) were performed on the same day using automated hematology analyzers as described by Post et al.[13].

Biochemical Analysis

Blood samples were collected from the slaughtered birds in heparinized tubes and then centrifuged at 3.000 rpm for 10 min. The blood plasma obtained were collected and stored at -20°C until analysis. Plasma glucose, total protein, total cholesterol, triglycerides and calcium were determined by using a spectrophotometer (LKB Novastec) and available commercial kits (SPINREACT, SA, Espagne) at various wavelengths as follows: Glucose concentration was determined as mg/dL by using GOD POD method [14] at 505 nm; total protein concentration was analyzed by the Biuret Method (colorimetric test) [15] at 540 nm; plasma cholesterol concentration was determined as mg/dL by using the CHOD PAP [16] method at 505 nm; plasma triglyceride concentration was determined as mg/dL by using the GPO-PAP enzymatic method [17] at 505 nm; plasma calcium concentration was determined as mg/dL by using the o-Cresophtalein v/v complex method [18] at 570 nm.

Thyroid Hormone Analysis

Blood samples were collected in heparinized tubes, centrifuged at 3.000 rpm for 10 min. The plasma samples were collected and kept at -20°C until analysis. The total plasma triiodothyronine (T3) and thyroxin (T4) concentrations were measured by radioimmunoassay (RIA)[19].

Statistic Analysis

Data are expressed as means ± standard error and subjected to one factor variance analysis (ANOVA1) performed with the STATVIEW software [20]. Differences were considered statistically significant at P<0.05.

RESULTS

Growth Performance

The effects of dietary supplementation of cumin seed at 0.2% on body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) of chronically heat stressed broilers are presented in *Table 2*. In the present study, body weights of cumin supplemented chickens were similar to those of control animals both at the age of 42 d (1886±68 g *vs.* 1799±59 g; P>0.05) and 49 d (2302±62 g *vs.* 2264±69 g; P>0.05) (data not presented in *Table 2*). When considering overall weight gain of heat-stressed broilers, we found that cumin inclusion in diet did not affect this parameter despite a lower weight gain during finishing period (-11%, P=0.03). In heat-exposed chickens, feed intake recorded from 28 to 42 d of age was significantly (P<0.05) decreased by the dietary inclusion of cumin (-20% comparing to control) while it was similar in the two groups from 43 to 49 d of age. In the growing period (28 to 42 d of old), dietary cumin supplementation resulted in a significant improvement of feed conversion ratio (FCR) while in the finishing period (42 to 49 d of age), this parameter was significantly increased comparing to control animals. Throughout the experiment (28 to 49 d of age), the inclusion of 0.2% of cumin to diet seemed slightly enhanced FCR (-7%, P=0.1).

Carcass and Internal Organs Traits

The effects of cumin seeds inclusion on carcass and viscera weights and their relative weights are shown in *Table 3*. Supplementing diet with 0.2% of cumin did not significantly (P>0.05) affect weights and relative weights of carcass, gizzard, liver, heart, abdominal fat per 100 g of body weight of broiler reared under chronic heat stress. Intestine weight, length and density of cumin supplemented birds did not differ significantly from those of control. Also, results showed that none of lymphoid organ (thymus, bursa, and spleen) weights and their relative weights were significantly influenced by dietary cumin supplementation.

Table 2. *Effect of dietary cumin supplementation on body weight gain, feed intake and feed to gain ratio of broiler chickens reared under high temperature summer from 28 to 49d of age*

Variables	Control Group	Cumin Group	P-value
Feed intake (g)			
28-42 days	1012±53	810±48	0.03
43-49 days	1082±68	1146±26	0.41
28-49 days	2094±120	1956±65	0.35
Body weight gain (g)			
28-42 days	845±35	898±19	0.23
43-49 days	465±12	416±13	0.03
28-49 days	1310±43	1314±19	0.93
Feed to gain ratio			
28-42 days	1.20±0.03	0.90±0.05	<0.01
43-49 days	2.32±0.10	2.76±0.11	0.02
28-49 days	1.60±0.04	1.49±0.04	0.11

Table 3. *Effect of dietary cumin supplementation on carcass and internal organs weights and as a percentage of body weight (BW) of broiler chickens reared under high temperature summer*

Variables	Control Group	Cumin Group	P-value
Carcass (g) Carcass (%BW)	1600.13±48.33 69.40±9.00	1616.53±47.27 70.02±7.00	0.81 0.46
Liver (g) Liver (%BW)	45.23±2.54 2.00±1.00	44.29±2.29 1.90±1.00	0.76 0.85
Heart (g) Heart (%BW)	10.15±0.62 2.00±22x10^{-4}	9.36±0.44 2.00±17x10^{-4}	0.31 0.26
Gizzard (g) Gizzard (%BW)	31.94±1.27 1.40±0.01	32.85±0.83 1.40±0.00	0.55 0.46
Abdominal fat (g) Abdominal fat (%BW)	29.00±1.42 1.30±0.01	28.66±2.48 1.20±0.01	0.68 0.72
Intestine weight(g) Intestine weight/%BW	101.53±4.68 4.37±0.12	95.89±3.74 4.07±0.13	0.35 0.10
Intestine length (cm) Intestine density (g/cm)	239.70±4.21 0.42±0.02	241.30±4.18 0.40±0.01	0.79 0.25
Spleen weight (g) Spleen (%BW)	2.96±0.22 0.13±0.10	3.07±0,16 0.13±0.09	0,68 0.82
Bursa (g) Bursa (%BW)	1.53±0.31 0.07±0.01	1.20±0.15 0.05±0.01	0.35 0.28
Thymus (g) Thymus (%BW)	7.26±0.46 0.36±0.04	8.57±0.07 0.39±0.03	0.27 0.38

Table 4. *Effect of dietary cumin supplementation on haematological and biochemical parameters and plasma thyroid hormones concentration of broiler chickens reared under high temperature summer*

Variables	Control Group	Cumin Group	P-value
Glucose (mg/dL)	236.38±9.08	212.13±3.63	0.019
Total proteins (g/dL)	3.27±0.10	2.75±0.07	0.0002
Triglycerides (mg/dL)	94.19±11.91	43.95±2.93	0.0003
Cholesterol (mg/dL)	107.33±4.71	70.29±4.27	<0.0001
Calcium (mg/dL)	4.71±0.38	10.51±0.48	<0.0001
Haematocrit (%)	26.40±0.57	25.19±0.44	0.103
RBC (x10^6/µL)	2.54±0.06	2.44±0.05	0.190
Haemoglobin (g/dL)	8.66±0.23	8.13±0.29	0.166
T3 (pmol)	2.38±0.23	2.70±0.35	0.457
T4 (pmol)	6.13±3.88	6.73±2.91	0.701
T3/T4	0.86±0.29	0.48±0.09	0.222

Biochemistry, Haematology and Thyroid Hormones Concentrations

The effects of dietary cumin supplementation on blood biochemistry, haematological parameters and thyroid hormones (T3; T4) concentrations of chronically heat stressed broiler chickens are presented in *Table 4*. A significant decrease of plasma glucose (-10 %, P<0.05), triglyceride (-53%, P<0.001), cholesterol (-34%, P<0.0001) and total proteins (-16%, P<0.001) concentrations were recorded in the cumin supplemented groups compared to the control ones, while, a significant (P<0.0001) increase in plasma calcium concentration by this diet additive was observed.

Haematological parameters in term of haematocrit percentage, red blood cell count and haemoglobin concentration were not affected by supplementing diet with 0.2% of cumin. However, a slight tendency to a decrease of these blood contents by cumin diet was observed.

There were no significant (P>0.05) effects of cumin seeds supplementation on plasma T3 and T4 concentrations and on T3:T4 ratio. However, numerical results revealed slight increases for T3 (+13%; P>0.05) and T4 (+10%; P>0.05).

DISCUSSION

In the present study, the overall body weight gain of heat stressed chickens did not differ significantly by cumin inclusion. These results disagree with those obtained in fast-grower chicks reared under thermoneutral conditions [11], and those reported in slow-growing chicks subjected to heat stress [12]. The improvement of weight gain induced by cumin supplementation of local Egyptian strains [12] could be explained by the rusticity and thus a lower sensitivity of these breeds to heat stress. It can also be justified by the length and magnitude of the applied heat challenge which was 4 h per day during 3 successive days per weeks while in our conditions, birds were daily exposed to the high temperature of the summer period. In this study, the lower feed consumption occurred at the beginning of the dietary cumin supplementation could be related to a period of adaptation of chickens to the smell and the taste of the diet. However, the overall feed intake (d 28-49) of cumin supplemented birds was similar to those of control group. In slow-growing chickens subjected to heat stress, dietary cumin supplementation at the level of 0.2% did not induce a significant variation of feed consumption [12]. Similarly, in commercial broiler chickens maintained at thermoneutral conditions, adding cumin to diet (increasing doses of 0.5 to 1.5%) did not significantly alter feed intake [11]. Throughout the experiment (28 to 49 d of age), the inclusion of 0.2% of cumin to diet numerically enhanced FCR (-7%) *(Table 2)* as it has slightly reduced feed intake without affecting the growth rate. The positive effect of cumin on FCR is in agreement with previous results [11,12] and could reveal a better feed efficiency probably related to the beneficial properties of this spice to enhance digestive enzymatic activities, and thus, nutrients digestibility and absorbability [21]. At high ambient temperatures, birds reduce their feed intake and consequently less nutrients were provided to the internal organs, which compromise their developments [2]. In the present study, diet supplemented with 0.2% of cumin seeds did not ameliorate carcass and the selected internal organs weights measured at 49 d of age. In literature, inconsistent results have been reported on the effects of natural [22] and synthetic [6] diet additives used in avian diet on broiler carcass traits and organs yields. In contrast to our results, Ali et al.[12] stated that the negative effect of heat stress on carcass yield was reduced by adding 0.2% of *Cuminum cyminum* during 12 weeks (21-84 d). Also, they recorded a significant improvement for liver, pancreas and proventriculus percentage. However, similar to our results, these researchers have reported no significant effect of cumin feeding on relative weights of heart, gizzard and abdominal fat. It is very likely that the responses of broilers to this feed additive may be influenced by heat stress challenge and also by duration and period of cumin inclusion. In addition, the lack of positive impact on the carcass yield in the present study is probably associated with the absence of differences in body life weight at slaughtering age between the two groups of birds. Indeed, some researchers have reported a strong relationship between live body weight and carcass yield of broiler chickens [23]. Several studies have shown that heat stress can affect intestinal maturation [24]. Marchini et al.[3] have stated a decrease in intestinal length and a reduction in the intestinal absorption capacity of broiler chickens reared under hot climate. In the current study, cumin supplementation did not affect intestine morphometry of birds reared under high ambient temperatures *(Table 4)*. To our knowledge; there were no available data on the effect of cumin on intestine morphometric characteristics when broilers were heat challenged. The most reports on digestive effects of cumin seeds on broiler chickens were carried out under thermoneutral conditions. It has been reported that *Cuminum cyminum* seed improve the absorption of nutrients and reduce time of transit in intestine [21]. Recently, Sharifi et al.[25] failed to detect any improvement in gastrointestinal tract by adding 1.5% of *Cuminum cyminum* in diet of broilers reared under standard conditions. In our study, the lack of enhancement of the intestinal morphology was may be due to the inclusion period of cumin in diet (28 to 49 d) which coincides with the slow development period of intestine. Thus, some researchers have reported that the rapid rate growth of small intestine related to the body weight of broilers occurs earlier at the beginning of the starter phase (1 to 6-10 d of age), and after 10 d post-hatch, this rate begins to slow, determining the end of the rapid development phase [26]. Also, Teixeira et al.[27] have reported that the total length of intestine was influenced by weight gain of broiler but, in the current study, this last parameter remains unchanged by the cumin supplementation. It was well documented that heat stress can perturb the immune system and thus, affect the defense mechanisms of poultry [2,28] Reduced relative weights of both primary and secondary lymphoid organs, such as thymus, bursa of Fabricius and spleen have been found under heat stress [28]. Also, it has been reported that changes in dietary ingredients, greatly influences the development of this above-mentioned organs [29]. Our results showed that none of lymphoid organ weights and their relative weights (thymus, bursa, and spleen) were significantly influenced by dietary cumin supplementation *(Table 3)*. In this respect, no effect of cumin supplementation on the relative thymus weight was observed in slow-growing chickens subjected to heat stress [12], whereas, this feed additive increased significantly the relative bursal weight of these chickens strain [12]. Also, in thermoneutral conditions, Alimohamadi et al.[30] failed to obtain any enhancement of immune responses expressed by measuring lymphoid organ weights when birds were fed a diet supplemented with cumin at the level of 0.4%. At higher level of inclusion (0.8%), these authors have recorded higher relative weight of bursa of Fabricius and thymus. In another study, cumin seed was shown to have the potential to stimulate the cellular immunity and increase spleen and thymus weights of normal and immune-suppressed swiss albino mice [31]. These authors demonstrated that the immunomodulatory activity recorded by this spice can be attributed to its flavonoid glycoside compound.

Several metabolic disturbances such as carbohydrates, fat, protein and calcic metabolism were observed when broiler chickens were exposed to heat stress [28]. Also, researchers have reported a decrease in haematological values of heat challenged birds [32]. Our results demonstrated that feed cumin addition greatly influence the plasma nutrients concentration of broiler reared under summer high ambient temperatures *(Table 4)*. The observed anti-hyperglycaemic, antihypercholesterolaemic and antihypertriglyceridaemic properties of cumin were expected, the fact that, some investigations on humans, rabbits and rats have revealed such beneficial effects [33,34]. Also, the contribution of the antioxidants in the form of herbs, spice or synthetic substances to improve the negative effects of heat stress on term of blood metabolites has been shown [28,35]. In termoneutral conditions, Golian et al.[10] and Alimohamadi et al.[30] have not observed any changes of plasma glucose when broilers were respectively fed diet supplemented with 0.2, 0.4, 0.6, 0.8 and 1% of cumin seed and with 0.4 and 0.8% of cumin essential oil. However, other researchers [33] have shown that glycaemia in diabetic or normal rats and normal rabbits may be lowered by cumin inclusion. This hypoglycaemic response was attributed to the enhancement of insulin sensitivity by protecting pancreatic beta cells integrity, improvement of serum insulin content [33] and/or to the regulation of glucose homeostasis by increasing peripheral utilization of glucose, increasing hepatic glycogen synthesis or decreasing the glycogenolysis. Furthermore, similarly to our results, the hypolipidaemic and hypocholesteroleamic properties of *Cuminum cyminum* in form of seeds, essential oil and/or extracts components have also been reported previously in human, rabbits, turkeys and rats [36,37]. In broiler, Al Kassi [11] have reported the effectiveness of adding 1 and 1.5% of cumin seeds to commercial strain chickens diet and maintained at thermoneutral conditions in reducing plasma cholesterol and triglycerides. In another study, the inclusion of 0.8 g of cumin essential oil per 1 kg of broiler diet have not change triglycerides level, whereas, cholesterol concentration was significantly reduced [38]. In contrast to our results, slow-growing chicks subjected to heat stress, have showed no significant effects of dietary cumin seeds supplementation on plasma cholesterol concentration [12]. Also, an insignificant difference in blood triglycerides and cholesterol levels has been reported in broilers fed diets supplemented with cumin seeds at 0.4 and 0.8% compared with no supplemented birds reared under standards conditions [30]. Several mechanisms by which cumin can lower blood cholesterol and triglycerides concentrations were suggested. Some published researches have reported that the active compound (flavones) of *Cuminum cyminum* can activate the antioxidant enzymes (superoxide dismutase and catalase) [39] which can reduce the rate-limiting enzyme for cholesterol synthesis (3-hydroxy-3-methylglutaryl-CoA reductase: HMG-CoA reductase) [40]. Also, presence of sterol in *Cuminum cyminum* seeds can increase bile acids production and lipase activity [41]. The triglycerides lowering effect induced by cumin was associated with the unsaturated fatty acids of this spice [42]. Birds'plasma protein profile can be modulated by heat stress [32]. In the present study, total plasma proteins concentration decreased significantly in the blood of cumin supplemented birds reared under hot summer temperatures *(Table 4)*. This result was inconsistent with those reported by Ali et al.[12] who showed no significant variation of plasma total protein of slow-growing chickens subjected to heat stress. Also, under thermoneutral conditions, plasma total proteins concentration was not affected by dietary cumin inclusion [30,38]. It is well established that during heat stress, immune responses require specific nutrients needs and the reduction in nutrients availability due to reduce feed intake result in redistribution of body resources to detriment of growth requirements. However, the plasma total protein results lead us to suppose that cumin supplemented broilers expressed less stress, since as we have previously mentioned and discussed, cumin feeding have reduced feed intake without affecting growth, which may mean that proteins were rather used for growth than for immune responses. In this respect, Ali et al.[43] have shown that the addition of cumin seed at 0.2% to a low energy diet of broilers has significantly decreased plasma total protein and reduce numerically globulin values, but did not influence growth performances. Thus, these authors have concluded that this spice reduces immune cost for a more efficient use of proteins in growth and supposed that cumin can protect proteins from free radical injuries. In the present study, calcium concentration showed a significant increase by diet cumin supplementation *(Table 4)*. This result agrees that reported for broiler chickens [44] and for Turkey poults [45] reared under standard environmental conditions. In the best of our Knowledge there is no study available concerning the effect of *Cuminum cyminum* seed on calcium profile of broilers under heat stress. In this study, the plasmatic concentration increase of calcium, lead us to suggest an enhancement in absorption and digestibility of this mineral element by cumin feeding. Also, Pradeep et al.[46] have reported that cumin seeds are good source of minerals. In same trend of our results, no significant variation was observed on blood haematology by dietary cumin of broiler chickens reared under hot [12] and thermoneutral [30] conditions. However, the deleterious effect of cumin on haematopoiesis by decreasing haemoglobin concentration, red blood cells number and percentage of haematocrit was reported when high level of *Cuminum cyminum* 1.5% [11] was included in broiler diet.

A rise in ambient temperature was generally accompanied with decreased in the level of triiodothyronine (T3) and tetraiodothyronine (T4) hormones in response to a reduction on thyroid activity in order to reduce internal heat production of broilers [47]. In our study, there were no significant effects of *Cuminum cyminum* seeds supplementation on plasma T3 and T4 concentrations and on T3:T4 ratio *(Table 4)*. Up to now no studies have reported the effects of *Cuminum cyminum* seeds on broiler blood thyroid hormones whether in thermoneutral or heat stress conditions. Also, limited numbers of animal studies on the effects of some feeding spice products and medicinal herbs acting as an antioxidant on thyroid hormones were reported and discrepant results were obtained [48,49].

The supplementation of broiler chicken's diet with *Cuminum cyminum* seeds at a level of 0.2% enhanced broiler feed efficacy during the summer and concomitantly, alleviated the negative effects of chronic heat stress on glycaemia, lipidaemia and calcaemia of broilers. However, this feed additive did not affect blood haematology, carcass and viscera yields, and thyroid hormones concentrations. The mechanisms of action of this medicinal spice need more clarification.

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