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Response of Heat-Stressed Broiler Chicks to Dietary Supplementation with Some Commercial Herbs

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ABSTRACT

An experiment was carried out to investigate the effect of feeding three types of herbs (cinnamon, turmeric and ginger) and ascorbic acid on the performance of broiler chicks kept under Egyptian summer conditions. A basal diet composed mainly of corn, corn gluten and soybean meal was used as a control and tested herbs were singly added at 0.5 g kg^{-1} and ascorbic acid at 200 mg kg^{-1}; thus, five experimental diets were formulated and used from 2-6 weeks of age. All chicks were managed similarly. The criteria of response were growth performance, carcass traits, nutrient digestibility and some blood plasma parameters. Dietary supplementation with the tested herbs and ascorbic acid positively affected growth performance and economic efficiency of chicks while feed intake was unaffected. Feeding the tested materials improved digestibility of crude protein and ether extract but those of other nutrients were unaffected. Dressing-out percentage, carcass yield and liver were significantly improved due to feeding the experimental diets but other carcass traits were unaffected. Blood plasma triglycerides, total cholesterol, low-density lipoprotein-cholesterol, very low-density lipoproteins and creatinine as well as activity of transaminases were significantly decreased while high-density lipoprotein-cholesterol was increased due to feeding the tested materials. Dietary supplementation with the tested materials led to a significant reduction in plasma malondialdehyde but reduced glutathione and activity of superoxide dismutase were increased. Dietary supplementation with cinnamon, turmeric or ginger at a level of 0.5 g kg^{-1} or ascorbic acid (200 mg kg^{-1}) had beneficial effects on growth performance, blood metabolites and oxidative status of heat-stressed broiler chicks.

Key words: Traditional herbs, broiler performance, carcass traits, blood parameters

INTRODUCTION

Recently, broiler became an important aspect of poultry production in Egypt. Feeding cost represents the major part of total cost of poultry production. Minimizing the feed cost could be achieved through the use of cheap untraditional feedstuffs or improving nutrient utilization by addition of some natural growth promoters. Oxidative stress induced by excessive levels of reactive oxygen species that are produced under stressful environments such as heat exposure and some diseases. Such stressors are regarded as one of the major factors that negatively affect the productivity of poultry and may be involved in the pathogenesis of several serious diseases (Lin *et al*., 2006; Dalloul *et al*., 2006; Mujahid *et al*., 2007).

The use of antibiotics in poultry nutrition, as antimicrobial growth promoters, is known to be beneficial for the improvement of zootechnical performance and prevention of diseases of poultry and other animals. However, their use was banned because of bioscurity threats for human and animal health associated with the escalating resistance of pathogens to antibiotics and the accumulation of their residues in animal and poultry products (Falcao-e-Cunha *et al*., 2007). Nowadays, traditional herbs and their oil extracts are commonly used in poultry diets as safe growth promoters (Tollba *et al*., 2010). In this respect, Langhout (2000) observed that aromatic plants have stimulating effects on animal digestive system. In addition, Williams and Losa (2001) reported that herbal growth promoter have a positive effect on the digestion efficiency of dietary nutrients through increasing digestive enzymes and enhanced liver function. Moreover, phytogenics have been reported to improve body weight, weight gain and feed conversion in broiler chickens (Abdel-Malak *et al*., 1995; Ibrahim *et al*., 1998).

Ginger (*Zingiber officinale* L.) roots are commonly used as a culinary spice and have antioxidant properties, since it contains several compounds such as gingerol, gingerdiol and gingerdione that possess strong antioxidant activity (Sekiwa *et al*., 2000; Mohd-Yusof *et al*., 2002; Tapsell *et al*., 2006). However, information on the effect of ginger or its compounds on animal performance, antioxidant status and serum metabolites is lacking (Kikuzaki and Nakatani, 1996). Turmeric (*Curcuma longa* L.) is also reported to have antioxidant, antibacterial, antifungal, antiprotozoal, antiviral, anti-inflammatory, antifertility and hypocholesterolemic activities (Banerjee and Nigamm, 1978; Chattopadhyay *et al*., 2004). In an *in vitro* study, Broadhurst *et al*. (2000) reported that cinnamon leaves have insulin-like activity. In human beings, Hlebowicz *et al*. (2007) found that cinnamon powder decreased the plasma levels of glucose, triglycerides and low-density lipoprotein cholesterol in people with type 2 diabetes. Several researchers observed positive effects of dietary supplementation with ascorbic acid on growth performance of broiler chicks kept under high ambient temperature. According to the scientific literature, the alleviation of the negative effects of heat stress due to feeding the ascorbic acid-supplemented diets on health status of broiler chicks is mainly attributed to reduced body temperature and respiratory rates (Pardue and Thaxton, 1986; Kassim and Norziha, 1995; Lohakare *et al*., 2005). The aim of present study was to investigate the effect of dietary supplementation with ascorbic acid and dried powder of cinnamon, turmeric and ginger in plant protein diets on growth performance, digestibility of nutrients, certain carcass traits and some blood parameters of heat-stressed broiler chicks.

MATERIALS AND METHODS

The current study was carried out at the Poultry Research Unit, Qalabsho Center of Agricultural Researches and Experiments, Faculty of Agriculture, Mansoura University, Egypt.

Experimental diets: Starter and grower basal diets composed mainly of yellow corn, soybean meal and corn gluten meal were formulated to contain adequate contents of all nutrients for broiler chicks, as recommended by the National Research Council (NRC., 1994), for both starting and growing periods. Ingredient composition and calculated analysis of the basal diets are shown in Table 1. Ascorbic acid (200 mg kg^{-1}) and dried powders of cinnamon, turmeric and ginger were added to the grower basal diet at a level 0.5 g kg^{-1}.

Table 1: Ingredient composition and calculated analysis of the basal diets

Ingredient (%)	Starter diet	Grower diet
Yellow corn	62.87	63.00
Soybean meal CP 48%	13.03	8.00
Corn gluten meal CP 60%	18.50	15.00
Wheat bran	....	10.00
Dicalcium phosphate	1.80	1.50
Ground limestone	1.45	1.50
Common salt (NaCl)	0.30	0.30
Vit. And min. premix[§]	0.30	0.30
DL-methionine	0.05	...
L-lysine HCl	0.40	0.40
Total	100.00	100.00
Calculated analysis (NRC., 1994)		
ME (kcal kg^{-1})	3199.00	2991.00
Crude protein (%)	23.00	20.12
Calcium (%)	1.00	0.94
Available phosphorus (%)	0.45	0.39
Lysine (%)	1.10	0.91
Methionine (%)	0.52	0.41
Methionine+Cystine	0.92	0.77
Determined analysis (%) (AOAC., 1990)		
DM	...	89.07
OM		80.03
CP	...	20.25
EE	...	3.53
CF	...	3.57
Ash	...	9.04
NFE	...	63.61

[§]: Supplies the following per kg of formulated diet: Vit. A: 1000 IU, Vit. D_3: 2000 IU, Vit. E: 10 mg, Vit. K: 1 mg, Vit. B_1: 5 mg, Vit. B2: 5 mg, Vit. B_6: 1.5 mg, Vit. B_{12}: 0.01 mg, Folic acid: 0.35 mg. Biotin: 0.05 mg, Pantothenic acid: 10 mg, Niacin: 30 mg, Choline chloride: 250 mg, Fe: 30 mg, Zn: 50 mg, Cu: 4 mg and Se: 0.1 mg

Birds and management: During the Egyptian summer conditions (from July to August), an experiment was conducted using two hundred 14-day-old unsexed Arbor Acres broiler chicks. The duration of study was four weeks (2-6 weeks of age) during which Ambient Temperature (AT) and Relative Humidity (RH) were recorded once a week; four times a day at 10 AM, 2 PM, 6 PM and 10 PM using a special thermometer. Average estimated minimum and maximum means of AT and RH were 28-38°C and 50-90%, respectively.

The chicks were weighed and randomly divided into five equal experimental groups. Chicks of each group were subdivided into four equal replications and housed in battery cages. Day-old chicks received their starter diet containing 23% crude protein and a metabolizable energy of 3100 kcal kg^{-1} up to 14 days of age. Then, they were switched to the experimental grower diets (containing around 20% CP and ME of 2991 kcal kg^{-1}) from 14-42 days of age. Feed and water were offered *ad libitum*. All chicks were kept under the same managerial, hygienic and environmental conditions.

Criteria of response: All replicate groups were weighed at 14-day old and on a weekly basis thereafter. Records on Live Body Weights (LBW) and Feed Intake (FI) were maintained weekly.

Thus, Body Weight Gain (BWG) and Feed Conversion (FC) were determined weekly. Economic efficiency of feeding was also estimated for the entire experimental period (2-6 weeks of age). When the birds were five weeks of age, digestion trials were run for a three-day collection period during which feed intake and droppings voided for each replicate group were quantitatively estimated. Representative samples of droppings of each treatment were pooled, carefully mixed, oven-dried and stored for later analysis. The proximate analyses of the experimental diets and dried droppings were performed according to the official methods of analysis (AOAC., 1990). Nutrient digestibility and ash retention of the experimental diets were determined.

At the end of the experimental period (6 weeks of age), eight birds from each treatment were randomly selected, around its average body weight, weighed and immediately slaughtered (12 h post-fasting). Just after complete bleeding, their feathers were plucked and reweighed. Then, the hot carcasses were eviscerated, weighed and processed. Records on weights of liver, gizzard, heart and the front and hind parts of carcass were maintained. The percentages of carcass yield and edible organs to live body weight were calculated. At slaughtering, blood samples were collected from the birds in heparinized tubes. Plasma was separated by centrifugation at 4000 rpm for 15 min and stored rapidly at -20°C until the time of analysis. Blood plasma concentrations of creatinine (Henry *et al*., 1974), malondialdehyde (MDA) (Conti *et al*., 1991), superoxide dismutase (SOD) (Sun *et al*., 1988), reduced glutathione (GSH) (Beutler *et al*., 1963), triglycerides (Fossati and Prencipe, 1982), total cholesterol (Allain *et al*., 1974) and High-Density Lipoprotein-Cholesterol (HDL-C) (Sawle *et al*., 2002) were determined. The level of Low-Density Lipoprotein-Cholesterol (LDL-C) in blood plasma was estimated by the equation adopted by Friedewald *et al*. (1972), as follows: LDL-C = Total Cholesterol-(HDL-C+VLDL); where VLDL are very low-density lipoprotein which was calculated as concentration of plasma triglycerides divided by 5. Activity of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were also estimated according to the method of Reitman and Frankel (1957). Data was analyzed by the Statistical Analysis System (SAS., 1990). Duncan's new multiple range test (Duncan, 1955) was used to separate the significant differences) among means of criteria of response at $p \leq 0.05$.

RESULTS AND DISCUSSION

As presented in Table 2, broiler chicks fed the herbal plants (cinnamon, turmeric and ginger)-supplemented diets exhibited significantly heavier final live body weights and higher body weight gains compared with their control counterparts. Feed intake of birds, however, was unaffected as compared to the control ones. Dietary supplementation with vitamin C achieved a

Table 2: Growth performance of broiler chicks as affected by dietary supplementation with cinnamon, turmeric, ginger or vitamin C from 2-6 weeks of age

Dietary treatments	Initial body weight (g)	Final body weight (g)	Total body weight gain (g/bird)	Total feed intake (g/bird)	Feed conversion (g:g)	Economic efficiency (%)
Control	621.00	2456.67^{b}	1769.00^{c}	3768.83	2.13^{a}	74.34^{e}
Cinnamon	620.50	2810.33^{a}	2189.30^{a}	3752.50	1.71^{b}	115.96^{a}
Turmeric	620.30	2758.67^{a}	2138.33^{ab}	3742.60	1.75^{b}	111.73^{b}
Ginger	621.00	2760.00^{a}	2139.00^{a}	3731.57	1.75^{b}	110.98^{c}
Ascorbic acid	620.00	2600.35^{b}	1980.35^{b}	3715.31	1.88^{ab}	92.30^{d}
SEM	2.06	8.26	11.63	30.49	0.094	0.037
Significance	NS	*	*	NS	*	**

Means within the same column having different superscripts differ significantly ($p \leq 0.05$), NS: Not significant, *,**Significant different

significant improvement in body weight gain of birds compared with the unsupplemented group. The growth performance of broiler chicks fed the diet-containing cinnamon powder significantly increased ($p \leq 0.05$) when compared to that of the control chicks. The results of this study indicated that the use of cinnamon, turmeric and ginger powders as dietary supplements for the broiler chicks had positive effects on their growth performance and economic efficiency of feeding in comparison with the control group (Table 2). These results could be related to the fact that aromatic herbs have some growth promoting and anti-heat stress properties for growing birds and possibly they may have stimulating effects on the animal digestive system (Langhout, 2000). In accordance with the present results, Sang-Oh *et al.* (2013) observed an increase in body weight and body weight gain and better feed conversion in cinnamon powder-fed broiler chicks that may be related to improved health and immune status of the birds associated with increased serum levels of immunoglobulins. Dietary cinnamon powder has also been reported to have antibacterial activity (Valero and Salmeroj, 2003; Hernandez *et al.*, 2004) and antioxidant properties (Park and Park, 2000).

The positive effect on body weight and weight gain of broiler chicks due to feeding ginger-supplemented diet, reported herein, might be related to the volatile oils present in ginger (Salzer, 1975). Results presented in Table 2 also showed that dietary treatments had no significant effects on total feed intake of broiler chicks from 2-6 weeks of age. This was not surprising since the experimental diets were isocaloric and isonitrogenous and the birds were expected to consume similar amounts of feed (Scott *et al.*, 1982). The increase in body weight and body weight gain and better feed conversion of broiler chicks, observed in the present study, in group of chicks fed the turmeric-supplemented diet may be due to its antioxidant properties that can stimulate protein biosynthesis within the experimental birds (Chattopadhyay *et al.*, 2004). Turmeric has also been reported to have antioxidant, antibacterial, antifungal and antiviral activities (Chattopadhyay *et al.*, 2004). In harmony with the present results, Manwar *et al.* (2007) gave broiler chicks drinking water supplemented with extracts of turmeric and cinnamon leaves and observed a significant increase in live body weight of broilers compared with the control group. In addition, Suvanated (2003) and Zainali *et al.* (2009) reported superior growth performance (body weight and body weight gain) of broilers fed turmeric powder-supplemented diet. Similar findings in this respect were also obtained by other investigators (Osawa *et al.*, 1995; Al-Sultan, 2003; Durrani *et al.*, 2006). Herbal growth promoters are known to improve body weight, weight gain and feed conversion of broilers (Abdel-Malak *et al.*, 1995; Ibrahim *et al.*, 1998). The results of the present study are also in agreement with those of Jaffar and Blaha (1996) who observed a significant increase in body weight of broiler chickens supplemented with vitamin C (at 20 mg/bird/day) in drinking water during acute heat stress (29-43°C and 40-85% relative humidity). Also, Blaha and Kang (1997) observed a high increase in body weight of broiler chickens due to dietary vitamin C supplementation.

The lack of response of feed intake of birds, observed in the present study, in response to feeding the experimental diets agrees with findings of Emadi and Kermanshahi (2006), who found that feeding turmeric-containing diets had no effect on feed intake of broiler chicks. Similar findings were also obtained by Jaffar and Blaha (1996) and Blaha and Kang (1997), who reported that feed intake of broilers was not affected by dietary supplementation with vitamin C. The improved FCR due to feeding the experimental diets supplemented with cinnamon, turmeric, ginger and vitamin C, reported herein, is in agreement with the findings of Sang-Oh *et al.* (2013), who found that feed efficiency was significantly better in response to feeding the cinnamon powder-containing diet compared with the control group. Similarly, Elmakki *et al.* (2013) achieved

Table 3: Nutrient digestibility and ash retention of 5-week-old broiler chicks as affected by dietary supplementation with cinnamon, turmeric, ginger or vitamin C

Dietary treatments	DM	OM	CP	CF	EE	NFE	Ash retention
	(%)						
Control	77.82	76.88	76.09^{b}	24.56	75.78^{b}	76.86	79.86
Cinnamon	78.64	77.85	79.82^{a}	24.81	80.93^{a}	77.70	81.30
Turmeric	78.01	77.66	79.88^{a}	24.14	79.30^{a}	77.33	80.91
Ginger	78.29	77.76	79.95^{a}	24.75	79.07^{a}	77.53	80.85
Ascorbic acid	77.99	77.86	79.89^{a}	24.55	79.78^{a}	77.42	80.69
SEM	0.231	0.245	0.283	0.661	0.543	0.213	0.241
Significance	NS	NS	*	NS	*	NS	NS

Means within the same column having different superscripts differ significantly ($p \leq 0.05$), NS: Not significant, *: Significant

better feed conversion ratio of broiler chicks due to feeding diets containing ground ginger root. In addition, McKee and Harrison (1995) and Blaha and Kang (1997) observed an improvement in FCR of broilers as a result of vitamin C supplementation during heat stress.

In contrast to the present results, Hernandez *et al.* (2004), reported that the incorporation of cinnamon essential oils (200 ppm) in broilers diets had no effect on their growth performance at 21 and 42 days of age. Lee *et al.* (2003) also showed that body weight gain, feed intake and feed conversion ratio were not affected by dietary addition of cinnamaldehyde (100 ppm). In addition, Toghyani *et al.* (2011) observed no significant differences in FCR of broilers due to feeding cinnamon powder (2-4 g kg^{-1})-supplemented diets as compared to the control birds. Similar observation was also obtained by Al-Sultan (2003), who showed that turmeric, as a feed additive, had no effect on feed conversion efficiency of broiler chicks.

However, Sadeghi *et al.* (2012) reported that adding 5 g L^{-1} of drinking water of cinnamon, thyme and turmeric in equal ratios caused a significant decrease in live body weight of broiler chicks. In addition, birds fed the turmeric powder had lower feed intake compared with that of the unsupplemented birds (Wuthi-Udomler *et al.*, 2000; Samarasinghe *et al.*, 2003; Durrani *et al.*, 2006). Similar observations were also recorded by Tuleun and Njoku (2000), who reported decreased feed consumption following to feeding vitamin C-supplemented diets.

Nutrient digestibility: Significant increases in crude protein and ether extract digestibility were achieved by birds fed the diets supplemented with cinnamon, turmeric, ginger or ascorbic acid compared with those of the control group (Table 3). But digestibilities of DM, OM, CF and NFE and rate of ash retention (%) were not affected by feeding the experimental diets (Table 3).

The increased digestibility of crude protein and ether extract, observed in the present study, coincided with the improved growth performance of broiler chicks due to feeding the experimental diets are in accordance with the results of Nadia *et al.* (2008) and Al-Kassie *et al.* (2011). The latter investigators reported that feeding the essential oils extracted from herbs can stimulate the secretion of digestive enzymes and so improving the nutrient digestibility of diets and thus enhancing the performance of broilers. Such improvement induced by dietary herbs could be attributed to their essential oils active components that possess antibacterial, antioxidant and antifungal activities and accordingly may improve the utilization of dietary nutrients by the bird. This observation is in harmony with the findings obtained by Hernandez *et al.* (2004), who showed that cinnamon essential oil extract (200 ppm) improved nutrient digestibility in broilers. Similarly, Cross *et al.* (2007) studied the effects of five herbs or their essential oils on broiler growth and

Table 4: Carcass traits of broiler chicks (percentages of LBW at slaughter) as affected by dietary supplementation with cinnamon, turmeric, ginger or vitamin C

Dietary treatments	LBW (g)	Dressing-out	Carcass yield	Liver	Gizzard	Heart	Front parts	Hind parts
		(%)						
Control	2456.67^{b}	75.321	70.70^{b}	2.06^{c}	2.01	0.551	41.55	29.15
Cinnamon	2810.33^{a}	76.756^{a}	71.69^{a}	2.64^{a}	1.88	0.547	41.30	29.29
Curcuma	2758.67^{a}	76.467^{a}	71.69^{a}	2.41^{ab}	1.84	0.527	41.54	29.16
Ginger	2760.00^{a}	76.535^{a}	71.70^{a}	2.40^{ab}	1.89	0.545	41.55	29.15
Ascorbic acid	2600.35^{b}	76.420^{a}	71.70^{a}	2.20^{b}	1.97	0.550	41.54	29.16
SEM	8.01	0.017	0.005	0.067	0.890	0.023	0.086	0.086
Significance	*	*	*	*	NS	NS	NS	NS

Means within the same column having different superscripts differ significantly ($p \leq 0.05$), NS: Not significant, *: Significant

digestibility of nutrients and found that herbs had positive effects on nutrient digestibility of broiler chicks. In agreement with the present results, Sahin and Kucuk (2001) reported higher means of digestibility of crude protein and ether extract when Japanese quail chicks were fed dietary vitamin C (200 mg kg^{-1} diet) under chronic heat stress.

Carcass traits: It was observed that carcass traits (including percentages of front parts and hind parts as well as relative weights of heart and gizzard) were not affected by dietary treatments (Table 4). But the dressing-out percentage and relative weights of carcass (carcass yield) and liver were significantly increased in response to feeding the diets containing cinnamon, curcuma, ginger or ascorbic acid as compared to those of the control birds. Cinnamon-fed broilers showed the highest relative weight of liver compared with the other supplemented groups.

The beneficial effect of feeding the diets supplemented with cinnamon, curcuma, ginger and ascorbic acid on the dressing-out percentage and carcass yield might be due to the stimulating effect of their bioactive compounds on protein and fat metabolism, as reported by Osawa *et al.* (1995) and Zhang *et al.* (2009). The increased relative weight of liver due to feeding the experimental diets, evaluated herein, could be related to less hepatic lipid mobilization since liver is the major site of lipogenesis in poultry (Leveille *et al.*, 1975). Another possibility for this observation might be related to the shifting in lipids uptake from the circulation to hepatic tissue since plasma concentrations of triglycerides and total cholesterol, LDL-cholesterol and VLDL-cholesterol of broiler chicks were significantly decreased due to feeding the diets supplemented with cinnamon, curcuma, ginger and ascorbic acid (Table 5). The increased relative weight of liver, reported herein, agrees with the findings obtained by Elmakki *et al.* (2013), who found a significant increase in absolute and relative weights of liver of broiler chicks following to feeding the ground ginger roots. In accordance also with the present results, Hernandez *et al.* (2004) and Durrani *et al.* (2006) showed that the relative weight of gizzard of broiler chicks was not affected by dietary turmeric herb or cinnamon essential oil. In agreement with the present results, Sang-Oh *et al.* (2013) reported that broiler chickens fed cinnamon powder-containing diets (3.0, 5.0 and 7.0%) exhibited significantly higher dressing percentage while gizzard relative weight was not affected. Similar results were obtained by Lohakare *et al.* (2005), who found that the dressing percentage was significantly higher in broiler chickens fed ascorbic acid-supplemented diets. Also, Zhang *et al.* (2009) reported that birds fed the ginger-supplemented diet had a higher carcass yield compared with that of their control group.

In contrast to the present results, Mehala and Moorthy (2008) observed no significant differences in carcass yield of broiler chicks when they were fed turmeric powder as feed additive

Table 5: Blood parameters of broiler chicks as affected by experimental treatments

	Dietary treatments						
Blood parameters	Control	Cinnamon	Turmeric	Ginger	Ascorbic acid	SEM	Significant
AST (IU L^{-1})	20.33^{a}	8.00^{e}	18.67^{b}	16.00^{b}	9.00^{c}	0.624	*
ALT (IU L^{-1})	212.33^{a}	154.33^{e}	156.67^{c}	182.33^{b}	178.89^{b}	1.36	*
Creatinine (mg dL^{-1})	0.567^{a}	0.267^{c}	0.367^{b}	0.400^{b}	0.387^{b}	0.029	*
MDA (µmol mL^{-1})	7.10^{a}	2.77^{e}	3.00^{e}	4.13^{b}	3.87^{b}	0.172	*
SOD (U mL^{-1})	13.33^{d}	22.83^{a}	19.03^{b}	15.03^{c}	18.33^{b}	0.306	*
GSH (µmol mL^{-1})	20.23^{d}	27.77^{a}	24.63^{b}	22.40^{c}	22.40^{c}	0.285	*
Triglycerides (mg dL^{-1})	98.33^{a}	72.00^{e}	77.67^{d}	84.33^{b}	83.86^{b}	1.12	*
Cholesterol (mg dL^{-1})	113.00^{a}	90.33^{e}	93.00^{e}	100.33^{b}	100.41^{b}	1.28	*
HDL (mg dL^{-1})	31.00^{d}	44.33^{a}	41.00^{b}	38.33^{c}	39.01^{c}	0.799	*
LDL (mg dL^{-1})	62.33^{a}	31.60^{d}	36.47^{c}	43.67^{b}	44.23^{b}	1.98	*
VLDL (mg dL^{-1})	19.67^{a}	14.40^{d}	15.53^{c}	16.87^{b}	17.03^{b}	0.542	*

Means within the same column having different superscripts differ significantly ($p \leq 0.05$), *: Significant

(0.1 and 0.2%). Similarly, Sang-Oh *et al.* (2013) reported that broiler chickens fed cinnamon powder-containing diets (3.0, 5.0 and 7.0%) had no significant effects on relative weight of liver. Also, Elmakki *et al.* (2013) reported that dietary ginger incorporation had no significant effects on dressings-out percentage in broiler chicks. Similar results were reported by Zomrawi *et al.* (2013), who found that dressing-out percentage of broiler chicks was not affected by dietary ginger root powder.

Blood parameters: In the present study, plasma levels of triglycerides, total cholesterol, LDL and VLDL and creatinine as well as activity of AST and ALT in blood plasma were significantly decreased ($p \leq 0.05$) in response to feeding dietary supplementation with cinnamon, curcuma (turmeric), ginger or ascorbic acid compared with the control group.

On the other hand, plasma level of HDL was significantly increased ($p \leq 0.05$) as compared to that of the control birds. Cinnamon, curcuma, ginger and ascorbic acid have been reported to be excellent biological chain-breaking antioxidants that protect cells and tissues from lipid peroxidative damage induced by free radicals (Osawa *et al.*, 1995; Lee *et al.*, 2004).

The alleviating of heat stress due to supplemented with cinnamon, curcuma, ginger or ascorbic acid was exhibited in improved growth performance of chicks (Table 2) and positive changes achieved in blood biochemical variables (Table 5).

In agreement with the present results, Hosseini-Vashan *et al.* (2012) reported that heat-stressed broiler chickens feed turmeric powder-containing diets exhibited significantly decreased levels of blood serum cholesterol and LDL-cholesterol and reduced activity of AST and ALT while plasma level of HDL-cholesterol was significantly increased compared with the control birds. In harmony with the present results, Ademola *et al.* (2009) found that broiler chicks fed ginger-supplemented diets exhibited lower levels of serum cholesterol and triacylglycerols compared with the control group.

In the present study dietary supplementation with cinnamon, curcuma, ginger or vitamin C led to a significant reduction in plasma level of MDA but activity of SOD and level of reduced glutathione in blood plasma were significantly increased compared with those of the control group. The decreased level of plasma MDA following to feeding the experimental diets is an indication of

reduced lipid peroxidation. This observation is in harmony with the finding obtained by Jena *et al.* (2013), who found that supplemented dietary vitamin C caused significant decrease in plasma level of MDA. Similarly, Satoshi *et al.* (1989) observed reduced serum level of MDA of broilers due to feeding ginger-supplemented diets. In accordance with the present study, Zhang *et al.* (2009) reported that dietary supplementation with dried ginger roots increased the activity of serum SOD but reduced serum concentration of MDA of broiler chicks. The present findings are also in agreement with the results reported by Hosseini-Vashan *et al.* (2012), who found that broiler chickens fed turmeric rhizome powder-supplemented diets exhibited significantly higher level of SOD as compared to the control counterparts.

CONCLUSION

It can be concluded that dietary supplementation with cinnamon, curcuma (turmeric), ginger or ascorbic acid had beneficial effects on growth performance, blood metabolites and oxidative status of heat-stressed broiler chicks.

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