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Effects of Heat Conditioning and Dietary Ginger Oil at Early Age on Productivity, Oxidative Stress Status, and Immune Response in Broilers

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Abstract

HEAT STRESS is among significant environmental elements that negatively affected broiler performance. The experiment designed to evaluate impacts of two heat conditioning at an early age (EHC; 32°C and 40°C) and 3 levels of ginger oil (Gin; 200, 400 and 600 mg/kg diet) supplementation productivity, oxidative stress status, and chicken broiler immune response. 300 chicks were split into 6 treatments using a completely randomized factorial design, with 10 birds per cage (replicate) and 5 replicates for each treatment. During the five-weeks experimental period, data on production measurements were collected. Blood metabolites such as: total cholesterol, glucose, glutathione (GLU), HSP70, T4, immunological indices (IL1β, IFN-γ, IL10, and C3), and antioxidant markers (TAC, CAT, SOD, and MDA) were observed. Temperature humidity index (THI) was assessed and indicated severe heat stress during the experimental period. No interaction effects as well as the two EHC and Gin inclusion in diets enhanced the feed conversion rates and plasma levels of T3, total protein and HDL-cholesterol, lysozyme, GLU, and CAT. Moreover, EHC improved body weight, hepatic HSP70, immunological indices, and antioxidant markers except for MDA level which was lowered as well as plasma triglycerides. However, growth hormone, T4, total cholesterol in plasma were not affected. Diets supplemented with 400 Gin mg/kg diet has almost the same effect as 600 Gin mg/kg diet. In general, results suggest that both EHC (40°C) and adding ginger oil (up to 400 mg/kg diet) may increase broiler chicken production efficiency and oxidative status when exposed to heat stress.

Keywords: Heat stress, Broilers, Ginger oil, Productivity, Oxidative stress, Immune response.

Introduction

In the sector of poultry farming, heat stress is a major hazard that mostly affects broiler chicken, which is essential for the world's meat supply [1]. The long-term survival of the poultry industry is at risk because these pressures have a detrimental effect on avian development, well-being, and general health despite improvements in breeding and management. Broiler chicks are basically raised for meat in the poultry farming industry. As the world's population continues to grow, there is an increasing need for animal protein, which makes efficient poultry production even more crucial [2]. The birds go through a stunning transformation over the brief five to eight-week production cycle. As day-old chicks, they weigh between 40 and 55 g, but they swiftly gain weight, reaching 2.5 kg at market age. The broiler chickens grow quickly, which makes them susceptible to issues like heat stress (HS). Environmental stresses have a negative impact on broiler chicken performance, health, and welfare because these innovations have modified relationships with the environment [3,4]. Environmental elements such as high humidity, air flow, and temperature all have a significant impact on broiler chicken health. The most important of these stressors is thermal stress, which is brought on by high temperatures and is made worse by the continuous changes in the global climate [5,6].

Early heat conditioning (EHC) is a potential strategy for dealing with the harmful effects of heat stress on poultry [7]. This strategy is not expensive, giving positive results at the productive level and physiological status of the birds, and providing

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immediate application in poultry farms. In the same trend, [8,9] reported that a single brief exposure to heat stress in broilers prior day 7 of age has a significant impact on their preparation for projected future heat stress circumstances, which stimulate the hypothalamus's immature development in chicks that assist thermotolerance at a later stage of growth.

Natural feed additives have been established as a safe alternative to synthetic medications used as growth promoters. Feed accounts for 65-70% of the entire value of chicken productivity costs. Ginger was administered as a protective agent in broiler diets because no acute toxic side effects seen during the experiment. It can be utilized as a phytobiotic feed supplement to replace chemical growth promoters and increase broiler farming revenues by improving broilers' health profiles fed an experimental diet [8,9,10]. Ginger oil (Gin) originated from *Zingiber officinale* roots, which its components influenced according to the geographical area, root condition and extraction protocols (fresh or dry) [7,8]. Gin contained a high concentration of hydrocarbons, notably sesquiphellandrene (27.16%), followed by caryophyllene (15.29%), zingiberene (13.97%), foreseen (10.52%), and curcumin (6.62%).

Preclinical trials have distinguished ginger's antifungal, antibacterial, anti-inflammatory, analgesic, and immunomodulatory impacts. [11] pointed to supplementing diets with ginger oils (100 and 200 mg/kg diet) increased antibody production in chicken. It was also established that ginger supplementation increases broiler performance [10] and immunity, most likely due to ginger's high antioxidant activity [12]. In addition, [13] reported that 0.5 ml Gin might improve quail blood biochemical constituents and oxidative stress parameters. It has also been demonstrated that ginger rhizomes are less expensive locally and easier to use than manufactured antibiotics, with no adverse effects in poultry diets. Economical broiler production heavily depends on optimal feed use, increased body weight, disease control, and a lower mortality rate. The use of chemical feed additives as growth boosters has been criticized due to their negative effects on consumers, and there is a growing demand for organic meat and eggs. Gin is a major oil with potential for use in poultry production and processing [10,13]. These essential oils can be used as feed additives or in drinking water in chicken rations. Essential oils' therapeutic effects are mostly attributed to their antibacterial, antifungal, antiviral, antioxidant, and immunostimulant qualities [12]. Furthermore, their role in gut health has recently been studied, and it has been related to their digestive conditioning, antibacterial, and microbiota modulation capabilities [13]. Considering the foregoing, an experiment was conducted to evaluate the effects of heat conditioning at an early age and dietary Gin on productivity, blood constituents, oxidative stress, and immune response in broiler chickens.

Materials and Methods

Experimental birds were treated in guidelines and recommendations of Agricultural Research Center, Egypt. The Animal Ethics Committee of Poultry Breeding, Animal Production Research Institute (APRI), Ministry of Agriculture approved the experimental design, treatments for the birds, and sample collection and analysis., (approval No.: 429/3/ 5l l).

The care of birds and the layout of the experiment:

Cobb-500 unsexed broiler chicks (one-day-old, n:300) were obtained from a commercial hatchery to study the productive and physiological impacts of EHC at the 5th day of age for 24 hours and Gin supplementation during the first week of age under heat stress conditions up to the market age (5 weeks of age). Chicks were distributed randomly using a factorial design of 2 x 3 with 2 levels of rearing temperatures during the 5th day of age (32 vs. 40°C) and 3 levels of Gin supplementation (200, 400, 600 mg/kg diet) and their interaction. Each treatment was replicated 5 times (5 chicks per cage as a replicate) and the experimental unit is the replicate [14].
Managerial conditions and Vaccination program were applied as recommended for Cobb-500 broilers in line with guidelines of the chick producing company. The basal diets were formulated to meet or exceed the recommendations for broilers **[15]** (Table l). The birds were fed the starter diet until 2l days of age, followed by the grower-finisher diet from day 22 to 35 days of age. Feed and water were added for birds at *ad libitum*. A continuous light program was provided for the birds during the first 3 days and after that 23 L: l D light program with a light intensity of 20 Lux was applied. Birds were raised in battery cages (l x 0.65 m^2) and housed in an open house during summer season. The minimum and maximum house temperature (°C) and relative humidity (RH) were assessed daily and then humidity temperature index (THI) was calculated in accordance with World Meteorological Organization (WMO) described by [14] (Table 2).

Productive characteristics:

The birds were weighed individually upon arrival to determine the average initial body weight (BW). The BW was then measured at 7, 27, and 35 days. The feed conversion ratio (FCR) was calculated in line with [16], and feed intake (FI) was calculated as the difference between the weight of the given feed and residues remaining after each repetition. Every day, mortality figures were recorded.

Blood sample collections

Towards the end of the experiment (35 days of age), l0 birds of each treatment (l per replicate) were

selected for blood biochemical and hepatic analyses. For hematological assessment, heparinized tubes were used to collect blood samples of every bird through wing vein, and then, centrifuged on l3 min at 3000x g. The supernatants (plasma samples) were then placed into Eppendorf tubes and kept at 20°C until biochemical analyses. Then, the l0 birds of every treatment were slaughtered in accordance with the institutional committee's recommendation, and a portion of the liver tissue was collected, vacuum-packed, and stored on 80°C to heat shock protein (HSP70) estimation.

Plasma constituents, hepatic HSP70 and lipid profile:

Plasma total protein (TP) and plasma albumin (ALB) were measured using commercially available kits (Spinreact Co., Santa Coloma, Spain). An automatic biochemical analyzer analyzed the plasma level of glucose (Robotnik Prietest ECO Ambernath (W), India as described by [16]. Tri-iodothyronine (T3) and thyroxine (T4) were measured using chicken ELISA kits (Cat. #: MBS269454 and MBS265796) from My Biosource Co., San Diego, CA, USA, the determination, following instructions of covered flyers of every kit. Specific ELISA kits (cat#: MBS703924; My BioSource, San Diego, California, USA) were applied to assess the HSP70 in liver tissues. Diagnostic enzymatic colorimetric kits (Cat#: ab 65390 and ab 65336; Abcam, Waltham, MA, USA) were used to measure plasma cholesterol components (total-, high density lipoprotein (HDL), low density lipoprotein (LDL)) and triglycerides. Very low-density lipoprotein (VLDL) cholesterol was calculating by subtracting HDL and LDL from the total-cholesterol.

Antioxidant indicators and immune indices:

The enzyme-linked immune-sorbent assay (ELISA) kits (Ca#: MBSZOZ44}6, MBS700243, MBS 70l683; My BioSource co., Life Span Biosciences, Inc., Seattle, WA, USA) were used to quantified interleukin 1β (IL1β), interferon gamma (IFN-γ), interleukin 10 (lL10), and complement 3 (C3), respectively. The plasma lysozyme activity was determined using the turbidimetric method according to [17]. Glutathione (GLU) was determined using ELISA kits (My Biosource Co. San Diego, CA, USA) with Cat. #: MBS266317), in accordance with the guidelines in the kit's attached pamphlets. Blood plasma total antioxidant capacity (TAC), catalase (CAT) activity and superoxide dismutase (SOD) were measured with a colorimetric testing kit (ab 65329, ab 83464 and ab 65354, respectively; Abcam, Waltham, MA, USA). Specific ELISA kits (cat#: M 8S9718963; My BioSource, San Diego, California, USA) was applied for assessing the lipid peroxidation product [malondialdehyde (MDA)] in the plasma.

Statistical Analysis

Data were subjected to the 2-ways analysis of variance (ANOVA) with interaction by implementing the General Linear Model Procedures (GLM.) of the Statistical Analysis System (SAS) [18]. The results were expressed as means ± standard error of the mean (SEM). The level of statistical significance was set at $P<0.05$. The differences between treatments were detected by using Duncan's multiple range test [19].

Results

According to obtained results of THI in Table (2) and the categories proposed by [**13,20**], birds were exposed to moderate and severe heat stress during the experimental periods (2-5 weeks of age).

Productive performance:

The results of BW and FCR in response EHC, Gin, and their interaction from 1 to 35 days of age for cobb-500 broiler chicks are presented in Table (3). No interaction effect was detected for any of the studied productive traits. The mortality rate was negligible and not related to the treatments. Both EHC and Gin treatments improve FCR. Moreover, it is clear from the obtained results that EHC treatment (40°C at the 5th day of age) improves BW and FCR at 21 and 35 days of age by 1.45 and 2.92% for BW and by 2.05 and 11.73% for FCR, respectively. In addition, FCR was improved by 0.81 and 1.46% during 21-35 days of age and by 0.72 and 0.88% during 1-35 days of age for Gin treatments (400 and 600 mg/kg diet), respectively.

Physiological traits: Blood biochemical constituents (proteinogram and metabolites) and hepatic HSP70

Results in (Table 4) show the levels of plasma growth hormone, T3, T4, glucose, TP, ALB as well as the hepatic HSP70 of broiler chickens at 35 days of age in response to EHC and Gin treatments. No interaction effects were detected. However, both effects increased plasma T3 and TP. Moreover, EHC (40°C at the 5th day of age) improved plasma ALB and hepatic HSP70 levels and Gin (600 mg/kg diet) increased glucose level by 1.13%. On the other hand, growth hormone and T4 were not affected by any of the treatments.

Lipid profile

No interaction effects between EHC and Gin for all lipid profile traits were observed (Table 5). Both EHC and Gin, had positive impacts on plasma HDL- and LDL-cholesterol levels in cobb-500 broiler chicks at 35 days of age. Also, triglycerides level was decreased by 3% in response to ECH (40°C at the 5th day of age) treatment. However, no differences were detected for total- or VLDL-cholesterol by the 2 treatments.

Immune indices, antioxidant markers

Plasma immune indices and antioxidant markers parameters for the 2 treatments and their interaction are presented in Tables (6 and 7). No interaction effects were detected for all traits. The ECH (40°C at the 5th day of age) treatment increased all traits except for MDA which was decreased. The lysozyme, GLU, and CAT levels in plasma were decreased by Gin treatments and both levels (400 and 600 mg/kg diet) had almost the same effects.

Discussion

Productive and physiological status and hepatic HSP70:

No interaction effect was observed for all traits. The obtained results of the mortality rate confirm that the managerial conditions including feed, water, and ventilation are well controlled. As a result, the current study postulated that exposing chickens to heat conditioning (40°C) at an early age (the 5th day of age) would aid in the development of thermo-tolerance, allowing chicks to survive high environmental temperatures later in their development. According to [20] in broilers and [21] in quails, early heat conditioning is an effective approach for increasing broiler output and physiological status. Furthermore, these findings are consistent with broiler studies that found heat-conditioned chickens reacted similarly to chronically stressed birds, emphasizing the role of EHC in adapting to stress waves at marketing age [22]. These findings are supported by the findings of [20,23], who reported that EHC may reduce the negative impact of heat exposure on physiological changes such as biochemical constituents, hormone concentrations, and immunological parameters, resulting in improved BW and FCR in broiler chicks at marketing. [21] found that early heat conditioning enhances productivity (BW and FCR) and physiological status (plasma TP and T3 hormone) in quail hens. As demonstrated by the significant rise in plasm T3 hormone in chicks subjected to heat conditioning at almost the age of life, it is well known that thyroid hormones are essential for the thermal regulation of birds. Higher feed intake and body weight in comparison with control, which indicate that this happened of internal heat resistance adaptation at marketing age. The obtained results are comparable with those of [23,24]. Heat conditioning at an early age enhanced nutrition consumption and made birds more heat tolerant. It is well established that ginger oil supplementation plays an important positive role under heat stress conditions [25]. Heat stress boosts curcumin release also, the mobilization from tissues while lowering curcumin retention, which can lead to curcumin insufficiency and suggests that curcumin needs may increase [26].

The current study's findings reveal that both ginger supplementation levels (400 or 600 mg/kg diet) have the same positive effects on productive attributes as BW and FCR when compared with those that are supplemented by 200 mg/kg diet. As a result, it is economical to employ a lower level of Gin (400 mg/kg diet). The findings on broiler production in response to ginger oil supplementation are comparable with those of [27], who found linear and quadratic effects of ginger supplementation on productive attributes in broilers. Furthermore, [25] discovered that supplementary curcumin improved BW, BWG, and FI in chicks. [28] noticed that ginger oil supplementation improved the BW and FI of broilers subjected to high temperatures. Furthermore, [29] found that 0.5% curcumin supplementation increased chicken performance. [30] found that 0.5% curcumin administration enhanced carcass, breast muscle, also, thigh muscle absolute weights. Thermal stress abnormalities in the digestive tract could explain the potential benefits of curcumin supplementation on productive qualities [23]. Furthermore, the rise in villi height reported by [31] may indicate that birds fed ginger-supplemented diets had improved nutrient absorption and utilization, as increased villi height results in a larger surface area for nutrient absorption. In fact, higher villi height improves nutrition utilization and, as a result, improves performance. On the other hand, the current investigation contrasts those of [32], who noticed no positive benefits of curcumin supplementation on broiler performance in this age. The absence of positive benefits of curcumin on performance in these studies could be attributable to the dose used. According to [33] incorporating more than 0.5% (1% or more) curcumin into the diet can be harmful and cause weight loss. It could possibly be related to the high temperatures seen throughout the experimental period of these trials, or it could be due to similarities in performance observed across treatments [34]. The heat shock protein (HSP) functions as a reverser or inhibitor of denaturation or unfolding of cellular proteins in birds under heat stress [20]. Most protein synthesis slows down in living things under heat stress, however the synthesis of a class of highly conserved proteins called HSPs speeds up dramatically [35]. The HSP is known as a molecular chaperone due to its physiological and defensive functions at the cellular level. Stressful events cause HSP70 levels to rise, which is a sign of heat stress. By inhibiting the aggregation of other proteins, HSP70 prevents the breakdown of protein function, hence protecting cells. However, the physiological cost of HSP production is that it affects growth by lowering the composition of other proteins [36].

At 35 days of age, broilers treated with both EHC and Gin showed a significant change in blood HDL, LDL, and triglycerides. In the same context, [37] stated that ginger oil increased the level of unsaturated fatty acids in broiler meat. The EHC (40°C at the 5th day of age) affected positively most immune indices and antioxidant markers and additionally, there was no change in plasma glucose levels, indicating that both EHC and Gin produced tolerance. These results imply that birds are protected against heat stress until they reach market age because of the early warning system provided by EHC.

These positive effects were observed also by Gin supplementation for lysosome GLU and CAT levels in plasma. It could be, partially, explained by regulating the production of cytokines to a normal level by protecting lymphoid organs from oxidative damage by suppressing lipid peroxidation because these organs have increased antioxidant enzyme activities when under heat stress in broiler and quail chickens according to [38, 39]. Because they lack sweat glands, birds release heat through breathing, which is different from other animals and has an adverse effect on their physiological and productive state [40]. Heat stress significantly reduced antioxidant capacity and caused a rise in plasma TP in broilers, according to [25]. Conversely, dietary curcumin supplementation preserved internal environment homeostasis while increasing GLU activity in comparison to the heat treatment control [41]. In addition, prolonged exposure to high temperatures increases body temperature, metabolic rates, and metabolic enzyme activities, which in turn causes changes in antioxidant enzyme levels and a weakened broiler's ability to endure oxidative stress. Under comparable circumstances, heat stress decreases the activity of antioxidant enzymes and increases the production of free radicals. the capacity to scavenge free radicals, leading to oxidative stress in broilers [41]. Furthermore, oxidative damage is a result of heat stress that early exposure to high temperatures in chicks increased their antioxidant status activities when exposed to high temperatures later in life. A robust sign of nutrient efficiency in metabolism, namely protein metabolism, is a rise in plasma TP, GLU, and lipid profile markers. These results are in line with the broiler research conducted by [22]. Heat stress raised the amounts of reactive oxygen species in mitochondria, upsetting the delicate balance among antioxidant and oxidative defense systems and leading to lipid peroxidation and oxidative damage to proteins, DNA, and biological components. GLU, CAT, and T-AOC levels were successfully raised by dietary Gin. Due to its role in GLU establishment, curcumin, as the main components of Gin, has an antioxidant action that shields cells from the harmful oxidative impacts of free radicals. This helps to explain, at least in part, the significance of raising antioxidant enzyme levels including GLU, CAT, and SOD. The MDA levels function as a marker of lipid peroxidation in terms of lipid mobilization. Furthermore, because it functions as a precursor for the crucial antioxidant GLU synthesis, curcumin, a component of the GLU peptide, has key roles in immunology and in the elimination of free radicals. According to **[38],** feed consumption decreased in direct proportion to the intensity of heat stress. This meant that the feed was unable to meet the birds' increasing energy needs, which led to low levels of lipid peroxidation from lipid mobilization and decreased production of free radicals. MDA levels are lowered via reduced free radical levels.

Conclusion

The current study suggests that exposing chickens with EHC (40°C) and supplementing them with Gin (400 or 600 mg/kg diet) during their early life can increase their productivity in the future and help them become more resilient to environmental stressors. This was demonstrated when the birds were exposed to heat stress between the ages of 8 and 35 days. Therefore, to enhance the physiological and productive characteristics of broiler chickens up to market age under heat stress conditions, it was suggested that EHC (40°C) and/or Gin (400 or 600 mg/kg diet) be used as effective heat stress management strategies besides providing well managerial conditions. Given the same circumstances and economic considerations, adding 400 mg ginger oil/kg to broiler meals is preferable to a 600 mg/kg diet, as both supplements had nearly the same effects on the productivity, physiology, and immune systems of broiler chicks subjected to heat stress. To lower the negative effects of heat stress on broiler chicken flocks, broiler breeders should generally implement both strategies EHC (40°C) at 5 days of age and Gin (400 mg/kg diet) supplementation during the rearing period either separately or in combination with the same conditions as described in the current research work.

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Declaration of Conflict of Interest

There is no conflict of interest, according to the authors.

Ethical of approval

This study adheres to the ethical criteria of the Animal Ethics Committee of Poultry Breeding,

Animal Production Research Institute, Ministry of Agriculture., (approval No.: 429/3/5/1).

TABLE 1. Chemical composition and calculation of basal diets for broiler chickens.

Ingredients	Starter (0–21 days of age)	Grower-finisher (22–35 days of age)
Yellow corn (7.3 CP)	54.0	58.9
Soybean meal (44% CP)	34.1	30.3
Corn gluten, 60% (62.5 CP)	6.10	4.90
Soy oil	1.02	1.17
Limestone	1.65	1.60
Monocalcium P	1.65	1.65
Common salt	0.45	0.45
Premix*	0.30	0.30
DL-methionine, 98%	0.15	0.15
Lysine, HCl, 78%	0.30	0.30
$NaCO_3$	0.28	0.28
Calculated chemical composition (%)		
Metabolizable energy (kcal/kg)	2900.47	2950.85
Crude protein	23.02	21.00
Ether extract	3.48	3.78
Crude fiber	3.64	3.47
Calcium	0.99	0.96
Available P	0.45	0.45
Lysine	1.34	1.24
Methionine + Cystine	0.52	0.50

*Vitamin and mineral premix per kg of diet: vitamin A, 4,550 IU; vitamin E, 7.5 IU; vitamin D3, 450 IU; vitamin K, 0.752 mg; riboflavin, 3.75 mg; pantothenic acid, 3 mg; niacin, 15.2 mg; vitamin B12, 0.006 mg; biotin, 0.152 mg; folic acid, 0.376 mg; thiamine, 1.07 mg; pyridoxine, 3.78 mg; choline, 1575 mg; Cu, 12 mg; I, 0.053 mg; Mn, 30.2 mg; Se, 0.09 mg; Zn, 53.0 mg; Fe, 67.8 mg. Compositions were calculated according to (**NRC,1994**).

TABLE 2. Indoor maximum and minimum temperature (°C), relative humidity (RH), and temperature humidity index (THI).

Week	Temperature (°C)		RH (%)	Temperature Humidity Index (THI)	
	Minimum	Maximum		Minimum	Maximum
1	29.8	33.6	70.0	81.1	86.8
2	30.2	35.1	69.0	81.6	88.9
3	30.3	34.8	75.2	81.5	89.6
4	30.4	35.4	75.6	81.7	90.7
5	30.7	35.7	76.5	82.4	91.3

TABLE 3. Effect of the early heat conditioning (HC) at 5 days of age and dietary ginger oil (Gin; mg/kg diet) supplementation during the first week of age at body weight and feed conversion rates in the cobb-500 broiler chicks.

Treatments	Body Weight (BW, g) at			Feed Conversion Ratio (FCR, g: g)		
	1 day	21 days	35 days	1-21 days	21-35 days	1-35 days
HC, °C						
EHC 32°C	44.6	626.0^{b}	1847^{b}	1.437	1.989^{a}	1.811^{a}
EHC 40°C	44.5	635.1^{a}	1901^{a}	1.449	1.949^{b}	1.790^{b}
Gin, mg/kg						
Gin 200	44.7	626.6	1854	1.442	1.984^{a}	1.810^{a}
Gin 400	44.3	634.5	1884	1.437	1.968^{b}	1.797^{b}
Gin 600	44.6	630.7	1885	1.450	1.955^{c}	1.794^{b}
SEM (n=5)	5.56	6.40	19.1	0.0143	0.0213	0.0527
P values						

P values						
HC, °C	0.7606	0.0230	0.0001	0.1790	0.0001	0.0001
Gin, mg/kg	0.6402	0.2379	0.0499	0.4231	0.0001	0.0013
HC x Gin	0.0509	0.7717	0.9778	0.1956	0.3800	0.3331

[a b, c] averages with different superscript within the main effects means significant at P<0.05. SEM (n=5) = Standard error of the mean.

TABLE 4. Effects of early heat conditioning (EHC) at 5 days of age and dietary ginger oil (Gin; mg/kg diet) supplementation during the first week of age on plasma growth hormone, tri-iodo-thyroxine (T3), thyroxine (T4), glucose, total protein (TP), albumin (ALB), and hepatic heat shock protein (HSP70) in Cobb-500 broiler chickens at 35 days of age.

Treatments	Growth Hormone (ng/ml)	T3 (ng/ml)	T4 (ng/ml)	Glucose (g/dL)	TP (g/dL)	ALB (g/dL)	HSP70 (ng/mg TP)
HC, °C							
EHC 32°C	3.65	4.36^{b}	24.28	338.0	4.768^{b}	1.474^{b}	4.234^{b}
EHC 40°C	4.16	4.87^{a}	25.03	337.7	5.365^{a}	1.663^{a}	4.995^{a}
Gin, mg/kg							
Gin 200	3.60	3.84^{b}	23.89	336.1^{b}	4.612^{b}	1.483	4.385
Gin 400	4.09	4.86^{a}	24.82	337.8^{ab}	5.366^{a}	1.651	4.727
Gin 600	4.04	5.21^{a}	23.89	339.9^{a}	5.222^{ab}	1.571	4.732
SEM (n=5)	0.487	0.173	1.080	1.78	0.3583	0.1052	0.5701
P values							
HC, °C	0.0844	0.0015	0.2401	0.7486	0.0092	0.0055	0.0315
Gin, mg/kg	0.3138	0.0002	0.2121	0.0210	0.0174	0.1019	0.6216
HC x Gin	0.9983	0.9885	0.7599	0.7636	0.6687	0.5785	0.8488

[a b, c] averages with different superscripts within the main effects means significant at P<0.05. SEM (n=5) = Standard error of the mean.

TABLE 5. Effect of early heat conditioning (EHC) at 5 days of age and dietary ginger oil (Gin; mg/kg diet) supplementation during the first week of age on total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, very low-density lipoprotein (VLDL) cholesterol, triglycerides in cobb-500 broiler chicks at 35 days of age

Treatments	Cholesterol (mmol/L)				Triglycerides (mmol/l)
	Total	HDL	LDL	VLDL	
HC, °C					
EHC 32°C	3.340	2.144[b]	0.985[a]	0.231	1.198[a]
EHC 40°C	3.315	2.239[a]	0.854[b]	0.221	1.162[b]
Gin, mg/kg					
Gin 200	3.364	2.122[b]	1.010[a]	0.232	1.199
Gin 400	3.306	2.241[a]	0.850[b]	0.216	1.165
Gin 600	3.342	2.212[ab]	0.899[ab]	0.232	1.177
SEM (n=5)	0.039	0.055	0.076	0.017	0.020
P values					
HC, °C	0.065	0.0067	0.0080	0.336	0.006
Gin, mg/kg	0.146	0.0155	0.0229	0.339	0.081
HC x Gin	0.261	0.7410	0.8574	0.941	0.677

[a b, c] averages with different superscript within the main effects means significant at P<0.05. SEM (n=5) = Standard error of the mean.

TABLE 6. Impacts of early heat conditioning (EHC) at day 5 of age and dietary ginger oil (Gin; mg/kg diet) supplementation during the first week of age on interleukin 1β (IL1β), interferon-gamma (IFN-γ), interleukin 10 (IL10), and complement 3 (C3), and lysozyme in cobb-500 broiler chicks at 35 days of age.

Treatments	IL1β (µg/ml)	IFN- γ (pg/ml)	IL-10 (pg/ml)	C3 (g/L)	Lysozyme (µg/ml)
HC, °C					
EHC 32°C	149.37 b	10.423 b	3.2333 b	1.2243 b	144.50 b
EHC 40°C	158.60 a	12.087 a	4.1133 a	1.3047 a	151.80 a
Gin, mg/kg					
Gin 200	151.25 a	10.345 a	3.350 a	1.2390 a	141.35 b
Gin 400	156.00 a	11.765 a	3.810 a	1.2995 a	152.25 a
Gin 600	154.70 a	11.655 a	3.860 a	1.2550 a	150.85 a
SEM (n=5)	5.6410	0.9689	0.5298	0.0391	4.0305
P values					
HC, °C	0.0102	0.0075	0.0093	0.0021	0.0052
Gin, mg/kg	0.4818	0.0946	0.3439	0.1015	0.0020
HC x Gin	0.6552	0.5317	0.7374	0.7415	0.7142

[a b, c] averages with different superscripts within the main effects means significant at P<0.05. SEM (n=5) = Standard error of the mean.

TABLE 7. Impact of dietary ginger oil (Gin; mg/kg diet) supplementation during the first week of life and early heat conditioning (EHC) at day 5 on plasma levels of malondialdehyde (MDA), glutathione (GLU), total antioxidant capacity (TAC), catalase (CAT) activity, superoxide dismutase (SOD), and catalase activity in COBB-500 broiler chicks at 35 days of age.

Treatments	GLU (ng/ml)	TAC (U/ml)	CAT (U/ml)	SOD (U/ml)	MDA (nmol/ml)
HC, °C					
EHC 32°C	3.294[b]	11.70[b]	3.668[b]	139.9[b]	3.230[a]
EHC 40°C	3.702[a]	12.43[a]	4.509[a]	147.6[a]	2.668[b]
Gin, mg/kg					
Gin 200	3.129[b]	11.60	3.516[b]	140.6	3.198
Gin 400	3.715[a]	12.33	4.388[a]	146.9	2.832
Gin 600	3.651[a]	12.27	4.362[ab]	143.7	2.817
SEM (n=5)	0.282	00.48	0.4753	4.02	0.2978
P values					
HC, °C	0.0209	0.0161	0.0061	0.0034	0.0039
Gin, mg/kg	0.0151	0.0799	0.0270	0.1133	0.1482
HC x Gin	0.6420	0.9775	0.9792	0.5758	0.2741

[a b, c] averages with different superscripts within the main effects means significant at P<0.05. SEM (n=5) = Standard error of the mean.

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تأثير المعالجة الحرارية وإضافة زيت الزنجبيل للعليقة في سن مبكرة على الإنتاجية وحالة الإجهاد التأكسدي والاستجابة المناعية لبداري التسمين

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الملخص

يعد الإجهاد الحراري من أهم العناصر البيئية التي تؤثر سلبًا على أداء دجاج التسمين. أجريت تجربة للتحقيق في تأثيرات مستويين من التكييف الحراري في سن مبكرة (HC؛ 32 درجة مئوية و 40 درجة مئوية) و 3 مستويات غذائية من زيت الزنجبيل (Gin؛ 200 و 400 و 600 ملجم/كجم عليقة) على الإنتاجية وحالة الإجهاد التأكسدي والاستجابة المناعية في دجاج التسمين. تم تقسيم 300 فرخ إلى 6 معاملات ضمن تصميم عاملي تام العشوائية مع 5 مكررات (10 طيور في كل قفص/مكرر). خلال 5 أسابيع من فترة التجربة، تم جمع بيانات الصفات الإنتاجية. وتم قياس بعض خصائص بلازما الدم بما في ذلك الكوليسترول الكلي والجلوكوز وبعض المقاييس المناعية (IL1β و IFN-γ و IL10 و C3)، وبعض مؤشرات مضادات الأكسدة (TAC و CAT و SOD و MDA). أشارت النتائج إلى أن EHC وإضافة Gin إلى علائق بدارى التسمين أدى إلى تحسين معامل التحويل الغذائي وكذلك هرمون التمثيل الغذائي T3 مع البروتين الكلي والألبيومين في بلازما الدم. في حين أدى إلى انخفاض إجمالي الكوليسترول منخفض الكثافة LDL وزيادة الكوليسترول عالي الكثافة HDL في بلازما الدم بشكل ملحوظ. ومع ذلك، لم تتأثر مستويات هرمونات النمو والثيروكسين T4. أدت المعاملة الحرارية في بداية العمر EHC إلى تحسين وزن الجسم على عمر 21 و 35 يوم. كما أدت العلائق المكملة بـ 400 أو 600 ملجم زيت الزنجبيل/كجم من العليقة إلى تحسن ملحوظ في مستوى الجلوكوز في بلازما الدم. وأكدت الدراسة على أن العليقة المكملة بـ 400 ملجم Gin / كجم لها نفس تأثير العليقة الذي يحتوي على 600 ملجم Gin / كجم تقريبًا. كخلاصة لهذه الدراسة، تشير النتائج إلى أن كلا من EHC (40 درجة مئوية) وإضافة زيت الزنجبيل (إلى 400 ملجم Gin / كجم عليقة) يحسن كفاءة الإنتاج والحالة التأكسدية والمناعية في دجاج التسمين كاستراتيجيات جيدة لمواجهة ظروف الإجهاد الحراري.

الكلمات الدالة: زيت الزنجبيل، دجاج التسمين، الإجهاد الحراري، الانتاجية، الاجهاد التأكسدي، الحالة المناعية.