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EVALUATIONS OF SOME NATURAL ANTIOXIDANT SOURCES IN BROILER DIETS: 3-EFFECT OF DIFFERENT GINGER EXTRACT FORMS AND LEVELS ON BROILER PERFORMANCE, IMMUNE RESPONSE AND QUALITY OF CHILLED AND FROZEN MEAT.

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ABSTRACT: This study was conducted to investigate the effects of incorporating different ginger forms and levels on the growth performance, physiological and immunological responses of broiler chickens exposed to chronic heat stress and the consequent effects on antioxidant status and microbiological traits of chilled and frozen meat. Two hundred and eighty broiler chicks were randomly distributed into to 7 dietary groups with 4 replicates (10 chicks each). Group one (control) fed corn-soybean meal basal diets which met the strain requirements during starting, growing and finishing periods. Groups 2, 3 and 4 fed control diet supplemented with 1%, 1.25% and 1.5% ginger aqueous extract respectively. Groups 5, 6 and 7 fed control diet supplemented with 100 mg, 150 mg and 200 mg ginger oil extract/kg diet respectively. Control group had significantly ($P \leq 0.05$) the lowest body weight and body weight gain during grower period. The results indicate the accumulative effect of ginger in improving live body weight. Feed intake was significantly influenced by treatments only during starter period, in contrast feed conversion significantly influenced during the different periods. Neither level nor form of ginger affected hemoglobin, hematocrit, MCHC, heterophilus, heterophilus/lymphocytes ratio (H/L) and antibody titer against NDV and H_5N_1.Ginger aqueous extract caused significant ($P \leq 0.05$) decreases in lymphocytes ratio compared with oil extract. Ginger forms significantly influenced bacterial total count, staphylococcus aureus, total coliform count and faecal coliform of both, chilled and frozen meat, where ginger oil extract recorded significantly ($P \leq 0.05$) lower values than ginger aqueous extract. Influences of ginger forms and levels on antioxidant status of chilled and frozen broiler meat were insignificantly. Experimental treatments had significantly lower 2-thiobarbituric acid-reactive substance TBARS than control treatment of both chilled and frozen broiler meat. Treatment groups recorded significant decrease in total bacterial count and insignificant decrease in staphylococcus aureus, total coliform count and faecal coliform. In conclusion, the results of this study suggested that ginger supplementation in different forms and levels improved broiler performance, physiological and immune responses and quality of chilled and frozen meat. Although, we suggest that more studies are needed to determine the effect of combination of ginger oil and aqueous extracts supplementation.

Key Words: Natural antioxidant, ginger, antioxidant status, broiler and immune response.

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INTRODUCTION

In recent years there has been a rapid increase in organic poultry production. This development is a response to an increase of consumer demand for food that is perceived to be fresh, wholesome and flavorsome, free of hormones, antibiotics and harmful chemicals, and produced in a way that is sustainable environmentally and without the use of gene-modified (**Blair, 2008**). This method is based on the avoidance of usage of chemical compounds in poultry diets at all or in a very low level for sake of consumers (**Saleh *et al.*, 2014).** Due to the detrimental effects of antibiotics as a growth promoter, a wide range of additives had been used to improve the performance of birds. Some of the products that have been tested to try to achieve these goals include probiotics, prebiotics, organic acids, and plant extract (**Griggs and Jacob, 2005).**Various plant extracts have received increased attention as possible antibiotic growth promoter replacements (**Hernandez *et al.*, 2004 and Uddin, 2014)**.Thus herbs could be expected to serve as safer alternatives as growth promoters due to their suitability and preference, lower cost of production, reduced risk of toxicity, minimum health hazards and environment friendliness. Ginger *"Zingiber officinale"* is one of the most widely used spices and it is a common additive and the rhizome of this plant is one of the most commonly used medicinal herbs. Several pharmacological effects of the Zingiber plant had been reported such as antiulcer effect, antioxidant effect, potent antibacterial activity, potent antifungal activity and anthelmintic activity **(Rafiee *et al.*, 2013).**

Ginger contains several compounds including gingerdiol, gingerol, gingerdione and shogaols **(Zhao *et al.*, 2011). Adel and Parkash (2010)** reported that gingerole is the main phenolic compound and once degraded gives shogaols, zingerone, and paradol. Zingerone and shogaols are found in small amounts in fresh ginger and in larger amounts in dried or extracted products. Zingerone is also produced from gingerols during this process**.** Body weight, bodyweight gain and FCR showed significant differences between 0.1% and 0.2% ginger and control (**Mohamed *et al.*, 2012). Ahmed *et al.* (2014)** reported that the highest total body weight gain was obtained by the birds fed 1% ginger root powder. Birds on ginger infusion had a better performance for all traits studies; there was a 29.07, 16.60 and 14.98% significant ($P \leq 0.05$) increase in final body weight. Ginger compounds have been reported to have antimicrobial, antioxidative and pharmacological effects **(Ali *et al.*, 2008)**.Ginger extract (aqueous and acid) possesses antioxidative characteristic, since it can scavenge superoxide anion and hydroxyl radicals **Krishnakantha and Lokesh, (1993).**

Habibi, *et al.* (2014) suggested that ginger powder and essential oils may be a suitable replacement for synthetic antioxidants in broiler diets. Ginger contains volatile oils and have medicinal properties are chemicals responsible for the taste. Ginger oil has been characterized to have a high content of sesquiterpene hydrocarbons, including β-sesquiphellandrene (27.16%), caryophyllene (15.29%), zingiberene (13.97%), α-farnesene (10.52%) and ar-curcumin (6.62%) **(El-Baroty *et al.*, 2010). Zhou, *et al.* (2006)** suggested that the volatile oil of ginger influences both cell-mediated immune response and nonspecific proliferation of T lymphocyte, and may exert beneficial effects in a number of clinical conditions, such as chronic inflammation and autoimmune diseases. Ginger stimulates an organ of bursa Fabricius to make an antibody of viral attack **(Herawati, 2010).** Moreover, antibody titer against new castle vaccine increased significantly in ginger treated groups compared to the control group (**Valiollahi *et al.*, 2014b and Rafiee *et al.*, 2014). Chen *et al.* (2013)** Indicated that

dietary ginger powder could improve antioxidant performance and serum antibody titer against Newcastle disease virus and avian influenza virus. More than that, fed the diets supplemented with the suitable level of ginger powder had a higher avian influenza H_9 and H_5Re-5 antibody titer in the serum and the number of granulocyte in the blood **(Weiren, and Zhaoyun, 2011).**

MATERIALS AND METHODS

Twelve hours after receiving new hatched chicks, two hundred and eighty broiler chicks were allotted to 7 dietary groups with 4replicates (10 chicks each).Group one(control) fed corn-soybean meal basal diets which met the strain requirements during starting (1-10 days), growing (11-24 days) and finishing (25-40 days) periods (Table, 1). Groups 2, 3 and 4 fed control diet supplemented with1%, 1.25% and 1.5% ginger aqueous extract respectively. Groups 5, 6 and 7 fed control diet supplemented with 100mg, 150mg and 200mg ginger oil extract respectively. Experimental groups were approximately kept under the same environmental conditions (temperature and relative humidity) which were daily recorded at noon during the experimental periods from 25th May to 3 July and their averages/period were calculated and shown in table (3).Live body weights and residual feed of chicks were recorded at 10, 24 and 40 days of age. Live body weight gain, feed intake and feed conversion were calculated. Chicks vaccinated with the Hitchner Bl strain at 6th day and with LaSota strain live virus at 15thday, 25thday and 35th day of age against Newcastle disease. At 10th day of age chicks vaccinated with lethal H_5N_1 virus challenges against avian influenza.

Ginger aqueous and oil extract:

Aqueous extract of ginger was prepared in Poultry Nutrition Department Labs, Animal production research institute before starting the growth trail. It was prepared according to the method reported by **Kishk and El-Sheshtawy (2010)** to reach the maximum free radical scavenging activity (94.4%) and 0.94 protecting factor, by extracting the dried ginger powder with water (0.72:100, W:V) at 60°C/24.5 min. Total phenols contents of the prepared ginger aqueous extract (GAE) was determined using Folin-Ciocalteu assay according to the method of **Wright *et al.* (2000)** and **Atoui *et al.* (2005)** and was 44 µg/mL in Gallic acid equivalent. Oil extract of ginger was obtained from local commercial company. Chemical composition of ginger oil and aqueous extract were summarized in Table (2).

Physiological traits:

From each replicate one blood sample was collected from wing vein in heparinized test tubes at 40 days of age. Fresh blood samples were taken to determine hemoglobin (Hb), hematocrit (Ht), total count of red blood cells (RBCs), total count of white blood cells (WBCs) and their differentiations (Heterophils(H%), lymphocytes(L%), and H/L ratio) according to **Clark *et al.* (2009).** Auto Hematology Analyzer (BC-2800) that is a compact and fully automatic hematology analyzer was used to measure total count of RBC's and WBC's differentiation. The values of heterophils and lymphocytes were expressed as relative counts of the whole all white blood cell population (%H and % L) and then H/L ratios. Also from each replicate one blood samples was collected from wing vein in non-heparinized test tubes to examine the immune response to Newcastle Disease Virus (NDV) and Avian Influenza by measuring titer against these viruses using preventing from hemangontinasion method and manual of diagnostic tests and vaccines for terrestrial animals, respectively. These examinations were carried out in Reference Laboratory for Veterinary Quality Control on Poultry Production, Egypt.

Slaughtering and sampling:

At 40 days of age, 28 birds (4 birds per treatment which were around the average

body weight) were slaughtered and carcass characteristics including dressing % and abdominal fat% were recorded. After slaughtering thighs of each carcass were taken to antioxidant examinations. The first thigh was refrigerated (up to 4 days at 4°C) while the second thigh was frozen (60 days at -20°C) to carry out assays of total phenols content, antioxidant activity [through two scavenging assays: 1,1-Diphenyl-2- Picrylhydrazyl radical-scavenging assay (DPPH) and 2-thiobarbituric acid-reactive substances assay (TBARS)] and microbiological status. Samples of breast muscles were collected and stored for 24 h at 4°C to estimate pH then stored up to 4 days at 4°C to estimate lipid profile of meat.

Measurements of antioxidant status:

Measurements of antioxidant status included total phenol content (TPh), DPPH and TBARS, as indicator of Malondialdehyde content, were determined in refrigerated (4 days at 4°C) and frozen (60 days at -20°C) broiler thigh samples (4 samples/treatment/storing condition).

TPh: Samples of broiler thigh were prepared and analyzed for TPh according to procedures of **Jang *et al.* (2007).** Gallic acid was used as the standard and theobtained results were expressed as mg gallic acid/100g meat.

DPPH: DPPH assay is widely used in plant biochemistryto evaluate the properties of plant constituents for scavenging free radicals. The method is based on the spectrophotometric measurement of the DPPH concentration change resulting from the reaction with an oxidant **(Pyrzynska and Pêkal, 2013).** The DPPH radical scavenging activity was estimated with the aqueous supernatant obtained from thigh meat according to the method of **Blois (1958)** and with modifications and calculation equation of the percentage of DPPH radical scavenging reported by **Jang *et al.* (2007)** as: Radical scavenging activity = [1-(absorbance value of testing solution/absorbance value of control solution)]×100.

TBARS: Each meat sample (5 g) of broiler thigh meat was homogenized in 15 mL of distilled water. Sample homogenate (5 mL) was transferred to a test tube and lipid oxidation was determined as the 2-thiobarbituric acid-reactive substance (TBARS) value by the described method of **Ahn *et al.* (1999).** Lipid oxidation was reported as milligrams of malondialdehyde per kilogram of meat **(Jang *et al.*, 2007).**

Microbiological traits:

To investigate the effect of examined natural antioxidant on the safety of broiler meat stored by chilling or freezing the count of total bacteria and Staphylococcus aureus in refrigerated (4 days at 4°C) and frozen (60 days at -20°C) breast meat samples were carried out according to **Gouda (2002).** Count of total bacteria and Staphylococcus aureus in small intestine were carried out according to **Gouda, (2002)** also total coliform and faecal coliform count were carried out according to **Mercuri and Cox (1979).**

Statistical analysis:

Data of experimental treatments were statistically analyzed by using the two ways analysis of variance to detect the effects of ginger forms and supplementation levels. Also data of all experimental treatments were analyzed by using one way analysis of variance to detect the best treatment between them. Variables showed significant differences at F-test ($P \leq 0.05$) were compared to each other's using Duncan's Multiple Range Test **(Duncan, 1955).** The statistical procedures were computed using **SPSS (2007).**

RESULTS AND DISCUSSION

Growth performance:

Results from this study indicated insignificant differences in body weight and body weight gain concerning ginger forms and levels during the different periods (Table, 4).These results were agree with **Fakhim *et al.* (2013)** who stated that

body weight gain of the chicks fed diet containing different concentrations of ginger extract (0.25, 0.5, 0.75 and 1%) in the starter period was not significantly different. Body weight of control treatment recorded significantly the lowest body weight during grower and finisher periods. Body weight gain significantly influenced by dietary treatments during grower and overall periods. Control group had significantly ($P \leq 0.05$) the lowest body weight and body weight gain during grower period. Our results agree with **Zhang *et al.* (2009); Herawati (2010); Valiollahi *et al.* (2014a)** and **Mohammed (2015)** who reported that there was a tendency of broilers consuming a ginger supplemented diet to grow faster during the grower phase as compared with broilers fed the control diet. Similar results obtained by **Ahmed *et al.* (2014)** who reported that, body weight significantly influenced by dietary treatments during grower and finisher periods. Generally, the results indicated the cumulative effect of ginger in improving live body weight. This postulate is in full agreement with postulate of (**Mohamed *et al.*, 2012).** This may be due to ginger showed cumulative inhibition of lipid peroxidation thus exhibiting their synergistic antioxidant activity **(Shobana and Naidu, 2000).** The improvement on growth and health may be due to the biological functions of ginger to enhanced digestibility, anti-oxidant, anti-helmitic and anti-microbial, anti-fungal activities and properties and the prevention of gastric toxicity **(Rafiee *et al.*, 2013).**

According to the data in Table 5 feed intake and feed conversion was not significantly affected by ginger form during the different periods. Moreover a significant difference in feed intake and feed conversion were not observed in response to ginger level during grower and finisher periods. These results agree with **Dieumou *et al.* (2009)** who found that insertion of different levels of ginger oils in diet had no effect on feed intake, similarly **Fakhim *et al.* (2013)** found no significant difference in feed intake of broilers fed different levels of ginger aqueous extract. Moreover different levels of ground ginger root had no significant effect in feed intake (**Mohammed, 2015).** Feed intake was significantly influenced by treatments only during starter period, while feed conversion significantly influenced during the different periods except for finisher period. Only supplementation of 150mg in the form of oil extract during starter period significantly decreased feed intake but other treatment groups did not significantly differ from control group during the different periods. The different responses of feed intake during the different periods can be explained by the average of ambient temperature during starter period which was 39.20°C (recoded at 12 at noon), although this temperature was slightly higher than optimal temperature during this period. In contrast the average ambient temperature during grower and finisher periods were 38.5°C and 37.85°C respectively, which were too high than optimal temperatures. This result was in accordance with the general trend observed in heat stress broilers where, impacts of heat stress in chickens exhibit less feed intake **(Gao *et al.*, 2015).** For every 10 °C increase in ambient temperature above 20 °C, there is a 17 % reduction in feed intake **(Habibian, *et al.*, 2014).**

Feed conversion significantly improved by experiment treatments and this improvement was clearly between ginger treatments and control for overall rearing period. These results agree with **Ademola *et al.* (2009) and Oleforuh-Okoleh *et al.* (2015).** Recently **Fakhim *et al.* (2013)** demonstrated this improvement in feed conversion, they supposed that the improvement in feed conversion efficiency is resulted from the increase in appetite due to the stimulation of salivary and gastric glands by ginger, decreased levels in

pathogenic bacteria, formation of more stable intestinal flora and hence, a better digestibility. Moreover, ginger reduce flatulence, colic, and gastrointestinal spasms, and generally act as a digestive aid **(Blumenthal *et al.*, 2000)**and so on ginger speeds digestion, stimulates flow of bile and enhances protein digesting enzyme (**Zomrawi *et al.*, 2013).** The major component of ginger is Zingiberen and Zingerol that can stimulate the digestive systems by controlling the digestive pH and the activity of digestive enzyme and the microbial activity and the improved performance may be attributed to the two types of digestive enzymes in ginger, protease and lipase **(Herawati, 2010).**

Hematological parameters and immune response

Neither level nor form of ginger affected hemoglobin, hematocrit, MCHC, heterophilus, H/L ratio and antibody titer against NDV and H_5N_1 (Table, 6). In contrast aqueous extract caused significant decreases in lymphocytes ratio compared with oil extract. Increasing levels of dietary ginger up to level 3 significantly increased ($P \leq 0.05$) count of red blood cells and lymphocytes. On the other hand, significant decreases ($P \leq 0.05$) in MCV and MCH were observed with increasing ginger level. Experimental treatments caused irregular responses in hematological indices where, red blood cell count, MCV and MCH values increased significantly ($P \leq 0.05$) by some experimental treatments and decreased significantly ($P \leq 0.05$) by others with significant middle values for control.

Increasing erythrocyte count with increasing ginger levels agree with **Isika *et al.* (2012), Morsy *et al.* (2013) and Najafi and Taherpour (2014).** The slight increase in the blood constituents of chicks with increased concentration of ginger may be associated with the effects of ginger bioactive compounds on improving antioxidant status of the bird **(Kehinde *et al.*, 2011).** Ginger oil inhibited erythrocyte oxidation damage and has protective effect on DNA damage induced by H_2O_2 moreover ginger oil might act as a scavenger of oxygen radical and might be used as an antioxidant (**Lu *et al.*, 2003)**. In general improving hematological parameters may be due to ginger may facilitate the better absorption of iron **(Kulkarni *et al.*, 2012)** and ginger helps in the regulation of iron metabolism **(Kumar *et al.*, 2013).** Moreover **Maizura *et al.* (2011)** determined antioxidant activity of ginger on the basis of the ability of antioxidant in this plants extracts to reduce ferric (III) iron to ferrous (II) iron in reagent ferric-reducing antioxidant power assay (FRAP) and they found improvement in FRAP. Improvement cellular and humeral immunity observed by ginger supplementation in the two forms of oil and water extract than control with no clear differences in vision between them. This may be due to each of which had specific chemical components. The improvement in lymphocyte ratio in response to dietary ginger supplementation was in agreement with the results of **George *et al.*, (2015).** The significant improvement in lymphocytes ratio with oil extract supplementation may be due to herbal oils such as ginger oil increase immunoglobulins levels in the blood as well as the ability to destroy microbial cells by leukocytes due to terpinolen **(Najafi, and Taherpour, 2014).** Volatile oil of ginger influences both cell-mediated immune response and nonspecific proliferation of T lymphocyte **(Zhou *et al.*, 2006). Al-Murrani *et al.* (1997)** concluded that H/L indicator could be used as a criterion to select for heat stress resistance. Heat stress produced significantly raised H/L ratio **(Maxwell 1993**). The results obtained in this study show that H/L reduced significantly by different levels and forms of ginger compared with control group, this may be due to dietary supplementation of ginger may induce HSP70 reaction in broiler chickens exposed to heat stress **(Hasheimi *et al.*, 2013).** We

can recommend supplementing ginger in oil or water aqueous extract to overcome the harm effects of chronic heat stress**.** Ginger efficiency in its oil and aqueous forms with three different levels to improve antibody titer against NDV and H_5N_1 was observed. Our results agree with **Chen *et al.* (2013)** who indicated that dietary ginger could improve antibody titer against Newcastle disease virus and antibody titer against avian influenza virus were significantly enhanced compared with control group. Improving the immunological profile of broiler chicks throughout stimulation of cellular immunity and humoral immunity is in line either with the findings of **Saleh *et al.*(2014).**

Quality of chilled and frozen meat:

Carcass characteristics and antioxidant status of chilled and frozen meat:

The results in Table 7showed that ginger forms and levels had no significant differences among them with respect to carcass characteristics and antioxidant status of chilled (4 days at 4°C) and frozen (60 days at -20°C) broiler meat except for the effect of ginger level in dressing%. Experimental treatments had significant effect on dressing% and TBARS for chilled and frozen meat. Experimental treatments had significantly lower TBARS than control treatment. Significant decrease in TBARS depending on ginger levels and forms in chilled and frozen meat agree with several authors. Where, dietary ginger supplementation decreased Malondi-aldehyde (MDA) concentrations in plasma **(Sadeghi *et al.*, 2012),** liver and serum **(Zeng *et al.*, 2015)** and in seminal plasma **(Akhlaghi *et al.*, 2014).** The reduction of MDA concentration in the plasma could partially be attributed to an increase in antioxidant enzymatic activity associating with ginger supplementation **(Sadeghi *et al.*, 2012).** With regard to our experiment improving antioxidant parameters during summer season may be due to oxidative stress caused by excessive levels of reactive oxygen species that are induced by heat exposure, and inclusion of ginger in the diet enhanced oxidative stability **(Zhang *et al.*, 2009).**

Microbiological properties:

Ginger form significantly influenced bacterial total count, Staphylococcus aureus, total coliform count and faecal coliform of both chilled and frozen meat(Table, 8), where oil extract recorded significantly ($P \leq 0.05$) lower values than aqueous extract. The only significant treatment and level effects were observed in total bacterial count of frozen meat. Contrariwise, treatments had no significant effect on other bacterial parameters of chilled and frozen meat. Total bacterial count of frozen meat and all bacterial types of both chilled and frozen meat had no significant differences in response to levels and treatments effect. The significant decrease in a number of bacteria was very obviously when ginger oil supplemented. This result is in agreement with **Sudrashan *et al.* (2010),** who reported that essential oil isolated from ginger resulted in a significant reduction in the bacterial counts of E coli. The ginger oil showed significant antimicrobial against Escherichia coli, Staphylococcus aureus, and Bacillus subtilis and the fungus strains Aspergillus flavus, Aspergillus niger, Aspergillus fumigatus and Candida albicans **(Sultana and Ali 2015).** This may be due to essential oil constituents of ginger decreased growth rate of a variety of bacteria and fungi **(Tan and Vanitha 2004).**

CONCLUSION

In conclusion, the results of this study suggested that ginger supplementation in different forms and levels improved broiler performance, physiological and immune responses and quality of chilled and frozen meat. Although, we suggest that more studies are needed to determine the effect of combination of ginger oil and aqueous extracts supplementation.

Table(1): Composition and calculated analysis of control basal diets (Con).

Composition (per 100 Kg)	Starter (1-10 day)	Grower (11-24 day)	Finisher (25-40 day)
Yellow corn	52.28	59.05	63.19
Soybean meal (44% CP)	34.00	26.70	22.50
Corn gluten (60% CP)	6.00	7.00	6.30
Soy bean oil	3.00	3.00	4.00
Di-calcium phosphate	1.84	1.67	1.59
Lime stone	1.43	1.20	1.10
L-Lysine HCl	0.32	0.31	0.28
Dl-Methionine	0.26	0.20	0.17
Sodium chloride	0.24	0.24	0.24
Sodium bicarbonate	0.23	0.23	0.23
Vitamins premix*	0.10	0.10	0.10
Minerals premix**	0.30	0.30	0.30
Total	100.00	100.00	100.00
Calculated analysis (%)			
Crude protein	23.17	21.25	19.04
Metabolizable energy (Kcal/Kg)	3100	3110	3207
Ether extract	5.63	5.08	6.88
Crude fiber	3.80	3.45	3.22
Calcium	1.04	0.90	0.84
Av. Phosphorus	0.50	0.45	0.43
Lysine	1.44	1.24	1.09
Methionine	0.68	0.60	0.54
Methionine+cystine	1.06	0.95	0.86
Sodium	0.15	0.16	0.17

*Supplied per kg of diet: Vit. A, 11000 IU; Vit. D3, 5000 IU; Vit. E, 50 mg; Vit K3, 3 mg; Vit. B1, 2 mg; Vit. B2, 6 mg; B6, 3 mg; B12, 14 mcg; Nicotinic acid 60 mg; Folic acid 1.75 mg; Pantothenic acid 13 mg and Biotine 120 mcg.

**Supplied per kg of diet: Choline 600 mg; Copper 16 mg; Iron 40 mg;Manganese 120 mg; Zinc 100 mg; Iodine 1.25 mg and Selenium 0.3 mg.

Table(2) : Chemical composition (%) of ginger oil and aqueous extract.

Chemical composition (%) of ginger oil extract			
Component	%	Component	%
Ocimene	0.49	Cedren-13-ol,8-	0.22
Limonene oxide, cis-	0.21	(+)-Ledene	0.90
Camphene	1.01	γ -HIMACHALENE	1.99
Isopinocarveol	0.27	α- Guaiene	0.24
p-Cymene	0.13	Vitamin A aldehyde	0.18
Carveol	0.45	Copaene	0.80
Terpinolen	1.24	SE±ychellene	1.33
Eucalyptol	6.67	5-Chlorovanillic acid	30.60
Isopulegol	4.27	α- Elemene	0.86
Camphor	2.18	Ylangene	2.58
Bergamotol, Z-α-Trans-	0.53	α-Amorphene	32.41
Borneol	0.04	Geranyl isovalerate	1.75
Isobornyl propionate	1.02	δ -Cadinol	1.69
D-Verbenone	1.89	3,5-Di-t-Bbutylcatechol	4.05
Chemical composition (%) of ginger aqueous extract			
Component	%	Component	%
1,6-Methanol(10) annulene	8.67	Isolongifolene	6.16
(+,-)-E-Nuciferol	12.19	24,25-Dihydroxyvitamin D	4.9
γ -HIMACHALENE	4.63	Palmitic acid, methyl ester	36.22
β -Guaiene	2.56	6-Octadecenoic acid	9.83
α-Copaene	3.4	Stearic acid, methyl ester	11.45

Table (3): Environmental temperatures and relative humidity during experimental period from 25thMay to 3rd July.

Period	**Temperature °C**	**Relative humidity (%)**
Starting (1-10 day)	39.20	24.50
Growing (11-24 day)	38.50	28.57
Finishing (25-40 day)	37.85	30.38
Overall period (1-40 day)	38.46	28.11

Table (4): Effect of ginger aqueous extract (GAE) and ginger oil extract (GOE) on body weight and body weight gain of broiler chicks.

	Body weight			Bodyweight gain			
	Starter 10 days	**Grower 24 days**	**Finisher 40 days**	**Starter (1-10)**	**Grower (11-24)**	**Finisher (25-40)**	**Overall (1-40)**
Form effect							
GAE	218.21	887.19	2033.77	165.71	668.98	1146.58	1981.27
GOE	211.75	883.67	2060.16	159.04	671.92	1176.50	2007.45
±SEM	3.09	9.36	28.53	3.05	9.37	25.04	28.55
P value	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Level effect							
Level 1	214.56	873.56	1990.63	162.44	659.00	1117.07	1938.51
Level 2	218.44	888.60	2066.47	165.50	670.16	1177.87	2013.53
Level 3	211.94	894.13	2083.80	159.19	682.19	1189.67	2031.05
±SEM	3.79	11.46	34.94	3.74	11.47	30.66	34.96
P value	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Treatment effect							
Control	213.13	817.50^{b}	1912.07^{d}	160.13	604.38^{b}	1094.57	1859.07^{d}
GAE 1%	216.88	871.63^{a}	1933.47^{c}	164.88	654.75^{a}	1061.85	1881.47^{c}
GAE 1.25%	224.13	894.83^{a}	2080.38^{b}	171.13	670.70^{a}	1185.56	2027.38^{ab}
GAE 1.5%	213.63	895.13^{a}	2087.45^{a}	161.13	681.50^{a}	1192.33	2034.95^{a}
GOE 100mg	212.25	875.50^{a}	2047.80^{bc}	160.00	663.25^{a}	1172.30	1995.55^{b}
GOE 150mg	212.75	882.38^{a}	2052.55^{bc}	159.88	669.63^{a}	1170.18	1999.68^{b}
GOE 200mg	210.25	893.13^{a}	2080.14^{b}	157.25	682.88^{a}	1187.02	2027.14^{ab}
±SEM	1.87	7.06	20.24	1.85	7.00	16.37	20.23
P value	N.S.	0.022	0.045	N.S.	0.026	N.S.	0.047

a,b,...:Means in the same column with different superscripts, differ significantly ($P \leq 0.05$); N.S. = Not Significant ($P > 0.05$).

Table(5): Effect of ginger aqueous extract (GAE) and ginger oil extract (GOE) on feed intake and feed conversion ratio of broiler chicks.

	Feed intake				Feed conversion			
	Starter (1-10)	**Grower (11-24)**	**Finisher (25-40)**	**Overall (1-40)**	**Starter (1-10)**	**Grower (11-24)**	**Finisher (25-40)**	**Overall (1-40)**
Form effect								
GAE	221.72	1066.12	1885.11	3172.94	1.34	1.60	1.62	1.59
GOE	212.98	1049.43	1891.38	3153.79	1.34	1.56	1.61	1.57
±SEM	4.58	12.88	41.56	41.27	0.03	0.02	0.02	0.01
P value	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Level effect								
Level 1	225.85^{a}	1047.53	1857.58	3130.95	1.39^{a}	1.59	1.63	1.60
Level 2	204.20^{b}	1086.23	1885.81	3176.23	1.23^{b}	1.63	1.60	1.58
Level 3	222.00^{a}	1039.56	1921.35	3182.92	1.40^{a}	1.52	1.62	1.57
±SEM	5.61	15.77	50.90	50.55	0.03	0.03	0.02	0.01
P value	0.03	N.S.	N.S.	N.S.	0.01	N.S.	N.S.	N.S.
Treatment effect								
Control	217.38^{a}	1065.13	1917.29	3199.79	1.36^{a}	1.76^{a}	1.75	1.72^{a}
GAE 1%	224.35^{a}	1054.28	1846.11	3124.74	1.37^{a}	1.61^{bc}	1.66	1.62^{b}
GAE 1.25%	218.33^{a}	1081.55	1880.12	3180.00	1.28^{ab}	1.62^{bc}	1.58	1.57^{bc}
GAE 1.5%	222.48^{a}	1062.53	1929.10	3214.10	1.38^{a}	1.56^{bc}	1.62	1.58^{bc}
GOE 100mg	227.35^{a}	1040.78	1869.05	3137.17	1.42^{a}	1.57^{bc}	1.60	1.57^{bc}
GOE 150mg	190.08^{b}	1090.90	1891.49	3172.47	1.19^{b}	1.63^{b}	1.62	1.59^{bc}
GOE 200mg	221.53^{a}	1016.60	1913.61	3151.74	1.41^{a}	1.49^{c}	1.61	1.56^{c}
±SEM	3.35	8.29	26.45	25.99	0.02	0.02	0.02	0.01
P value	0.038	N.S.	N.S.	N.S.	0.029	0.008	N.S.	0.0001

a,b,...:Means in the same column with different superscripts, differ significantly ($P \leq 0.05$); N.S. = Not Significant ($P > 0.05$).

Table(6): Effect of ginger aqueous extract (GAE) and ginger oil extract (GOE) on blood hematological parameters and immune response of broiler chicks.

	Hematological parameters						Immune parameters				
	RBC(x10^6 /mm^3)	**Hb (g/dL)**	**Ht %**	**MCV**	**MCH**	**MCHC**	**H**	**L**	**H/L ratio**	**NDV**	**H5N1**
Form effect											
GAE	3.69	13.78	35.93	97.68	37.44	38.37	28.50	64.46^{b}	0.44	8.94	7.87
GOE	3.82	13.83	36.41	95.45	36.25	37.99	27.49	65.94^{a}	0.42	8.87	7.96
±SEM	0.06	0.18	0.36	1.02	0.41	0.46	0.53	0.39	0.01	0.04	0.06
P value	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.02	N.S.	N.S.	N.S.
Level effect											
Level 1	3.53^{b}	13.50	35.73	101.20^{a}	38.23^{a}	37.80	28.50	63.58^{b}	0.45	8.88	7.82
Level 2	3.80^{a}	14.00	36.52	96.30^{b}	36.89^{b}	38.33	27.63	65.77^{a}	0.42	8.93	7.95
Level 3	3.93^{a}	13.92	36.27	92.20^{c}	35.41^{b}	38.40	27.85	66.25^{a}	0.42	8.90	7.97
±SEM	0.07	0.22	0.44	1.25	0.50	0.56	0.65	0.48	0.01	0.05	0.07
P value	0.001	N.S.	N.S.	0.001	0.01	N.S.	N.S.	0.001	N.S.	N.S.	N.S.
Treatment effect											
Control	3.70^{abc}	13.50	35.50	96.11^{bc}	36.50^{bc}	38.00	30.97	60.87^{f}	0.51^{a}	8.80	7.53^{b}
GAE 1%	3.50^{c}	13.67	35.97	102.78^{a}	39.06^{a}	38.04	29.37	62.90^{d}	0.47^{b}	9.00	7.67^{ab}
GAE 1.25%	3.70^{abc}	13.83	36.17	98.03^{abc}	37.44^{ab}	38.23	28.10	64.57^{bcd}	0.43^{bc}	8.90	7.97^{a}
GAE 1.5%	3.87^{ab}	13.83	35.67	92.23^{c}	35.81^{bc}	38.83	28.03	65.90^{abc}	0.43^{bc}	8.93	7.97^{a}
GOE 100mg	3.57^{bc}	13.33	35.50	99.62^{ab}	37.41^{ab}	37.56	27.63	64.27^{cd}	0.43^{bc}	8.77	7.97^{a}
GOE 150mg	3.90^{ab}	14.17	36.87	94.57^{bc}	36.33^{bc}	38.43	27.17	66.97^{a}	0.41^{c}	8.97	7.93^{a}
GOE 200mg	4.00^{a}	14.00	36.87	92.16^{c}	35.01^{c}	37.97	27.67	66.60^{ab}	0.42^{bc}	8.87	7.97^{a}
±SEM	0.06	0.12	0.24	1.00	0.34	0.26	0.39	0.50	0.01	0.03	0.05
P value	0.04	N.S.	N.S.	0.01	0.02	N.S.	N.S.	0.001	0.01	N.S.	0.02

a,b,...:Means in the same column with different superscripts, differ significantly (P≤0.05); N.S. = Not Significant (P>0.05).
RBC: Red blood cell count – Hb: hemoglobin concentration – Ht: hematocrit %– H%: heterophilus% – L%: lymphocytes%
MCV: Mean Corpuscular Volume – MCH: Mean Corpuscular Hemoglobin– MCHC: Mean Corpuscular Hemoglobin Concentration
NDV: Antibody titer against Newcastle disease – H5N1: Antibody titer against Avian Influenza disease H5N1

Table(7): Effect of ginger aqueous extract (GAE) and ginger oil extract (GOE) on Carcass characteristics and antioxidant status of chilled (4 days at 4°C) and frozen (60 days at -20°C) broiler meat.

	Carcass characteristics		Antioxidant status					
			Chilled meat (4 days at 4°C)			Frozen meat (60 days at -20°C)		
	Dressing %	Abdominal fat%	TPh mg/100g	TBARS mg/kg	DPPH (%)	TPh mg/100g	TBARS mg/kg	DPPH (%)
Form effect								
GAE	69.83	1.84	0.60	32.83	8.55	0.12	39.98	16.54
GOE	69.54	1.56	0.51	27.02	5.87	0.10	33.28	13.11
±SEM	0.25	0.12	0.03	3.15	1.18	0.01	3.01	1.97
P value	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Level effect								
Level 1	69.56^{b}	1.79	0.63	35.85	6.58	0.12	43.61	10.35
Level 2	70.48^{a}	1.50	0.53	23.92	9.50	0.10	30.46	18.09
Level 3	69.01^{b}	1.81	0.50	30.00	5.54	0.10	35.82	16.03
±SEM	0.31	0.14	0.04	3.86	1.44	0.01	3.68	2.41
P value	0.01	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Treatment effect								
Control	70.41^{ab}	2.09	0.609	59.333^{a}	3.450	0.113	72.480^{a}	6.857
GAE 1%	68.98^{b}	1.81	0.744	44.800^{b}	7.700	0.143	51.770^{b}	14.400
GAE 1.25%	71.34^{a}	1.84	0.527	25.657^{c}	11.637	0.101	34.007^{c}	18.580
GAE 1.5%	69.18^{b}	1.87	0.527	28.033^{bc}	6.320	0.102	34.173^{c}	16.633
GOE 100mg	70.14^{ab}	1.77	0.518	26.900^{bc}	5.467	0.100	35.457^{bc}	6.290
GOE 150mg	69.63^{b}	1.16	0.539	22.183^{c}	7.367	0.100	26.907^{c}	17.597
GOE 200mg	68.84^{b}	1.74	0.478	31.967^{bc}	4.767	0.098	37.473^{bc}	15.433
±SEM	0.23	0.09	0.025	3.265	0.814	0.005	3.617	51.463
P value	0.015	N.S.	N.S.	0.004	N.S.	N.S.	0.001	N.S.

a,b,...: Means in the same column with different superscripts, differ significantly (P≤0.05); N.S. : Not Significant (P>0.05).
TPh: Total phenols – TBARS: 2-thiobarbituric acid-reactive substance – DPPH: 1,1-Diphenyl-2- Picrylhydrazyl

Table (8): Effect of ginger aqueous extract (GAE) and ginger oil extract (GOE) on total bacteria, staph. Aureus, total Coliform and Faecal coliform count of chilled (4 days at 4 EC) and frozen (60 days at -20°C) broiler meat.

	Chilled meat (4 days at 4°C)				**Frozen meat (60 days at -20°C)**			
	Total bacterial count×10^5	Staph. aureus count×10^4	Total coliform×10^4	Faecal coliform×10^4	Total bacterial count×10^5	Staph. aureus count×10^4	Total coliform×10^4	Faecal coliform×10^4
Form effect								
GAE	285.56[a]	352.22[a]	380.222[a]	358.89[a]	527.78[a]	647.78[a]	523.33[a]	353.33[a]
GOE	5.38[b]	4.98[b]	18.833[b]	5.93[b]	26.19[b]	6.62[b]	83.89[b]	45.86[b]
±SEM	54.10	83.24	111.48	118.16	70.39	137.15	135.60	104.90
P value	0.003	0.01	0.04	0.048	0.001	0.01	0.04	0.04
Level effect								
Level 1	272.67	287.33	278.167	209.50	541.67[a]	555.00	431.67	250.00
Level 2	101.83	166.33	200.167	172.25	233.33[a]	268.83	289.00	242.00
Level 3	61.90	82.13	120.250	165.48	55.95[b]	157.77	190.17	106.78
±SEM	66.25	101.94	136.54	144.71	86.21	167.98	166.07	128.48
P value	N.S.	N.S.	N.S.	N.S.	0.01	N.S.	N.S.	N.S.
Treatment effect								
Control	2600.0	3833.33	1366.67	863.33	4666.67[a]	19300.0	2500.0	1700.0
GAE 1%	533.33	566.67	516.66	406.67	1033.33[b]	1100.0	693.34	410.0
GAE 1.25%	200.0	326.67	386.67	340.0	440.0[b]	530.0	520.0	446.67
GAE 1.5%	123.33	163.33	237.34	330.0	110.0[b]	313.33	356.67	203.34
GOE 100mg	12.0	8.0	39.66	12.33	50.0[b]	10.0	170.0	90.0
GOE 150mg	3.67	6.0	13.66	4.5	26.68[b]	7.67	58.0	37.36
GOE 200mg	0.46	0.93	3.17	0.96	1.90[b]	2.20	23.67	10.23
±SEM	283.71	393.55	284.37	112.26	450.40	2371.90	284.37	192.58
P value	N.S.	N.S.	N.S.	N.S.	0.02	N.S.	N.S.	N.S.

a,b,...:Means in the same column with different superscripts, differ significantly (P≤0.05); N.S. = Not Significant (P>0.05).

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الملخص العربي

تقييم إستخدام بعض مضادات الأكسدة الطبيعية في علائق كتاكيت التسمين:
٣- تأثيرصور و مستويات مختلفة من مستخلص الزنجبيل على أداء بدارى التسمين والإستجابة المناعية وجودة اللحم المبرد والمجمد.

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أجريت هذه الدراسة لمعرفة تأثير اضافة صور ومستويات مختلفة من مستخلص الزنجبيل على الأداء الإنتاجي والاستجابات الفسيولوجية والمناعية لدجاج بدارى التسمين المعرض للإجهاد الحراري المزمن وما يترتب عليه من آثار على حالة مضادة للأكسدة والصفات الميكروبيولوجية للحوم المبردة والمجمدة. وزعت مائتان وثمانون كتكوت بدارى تسمين عشوائيا إلى ٧ مجموعات تحتوي كل مجموعة على ٤ مكررات (١٠ كتاكيت لكل منهما). عوملت المجموعة الاولى على أنها مجموعة المقارنة وغذيت على العليقة القاعدية بدون اضافات والتي تغطي احتياجات السلالة خلال فترة البادي والنامي والناهي.بينما غذيت المجموعات ٢ و ٣ و٤ بعليقة المقارنة مضاف اليها ١٪، ١,٢٥٪ و ١,٥٪ مستخلص الزنجبيل المائي على التوالي. وغذيت المجموعات ٥ و ٦ و ٧ بعليقة المقارنة مضاف اليها ١٠٠ ملجم و ١٥٠ ملجم و ٢٠٠ ملجم مستخلص الزنجبيل الزيتي على التوالي. واظهرت النتائج انخفاضاً معنوياً ($P \leq 0.05$) في وزن الجسم والزيادة في وزن الجسم خلال فترة النامي وأشارة النتائج الى وجود أثر تراكمي جيد للزنجبيل على الوزن الحي للطيور. وقد تأثر استهلاك العلف بالمعاملات خلال فترة البادي، في المقابل تأثر معامل التحويل الغذائي خلال الفترات المختلفة. لم يوثرمستوى أو صورة الزنجبيل على الهيموجلوبين، الهيماتوكريت، MCHC، الخلايا المتعادلة،و النسبة بين الخلايا المتعادلة / اللمفاويات (H / L) ومنحنى المناعة ضد مرض النيوكاسل ومرض انفلونزا الطيور H5N1. كما ادى استخدام المستخلص المائي للزنجبيل الى نقص معنوي ($P \leq 0.05$) في نسبة الخلايا اللمفاوية مقارنة بالمستخلص الزيتي.

أثرت صور مستخلص الزنجبيل بشكل ملحوظ على العد البكتيري الكلي، المكورات العنقودية الذهبية، العد الكلي لبكتريا القولون وبكتريا القولون البرازية في كل من اللحوم المبردة و المجمدة، حيث اعطى مستخلص الزنجبيل الزيتي قيم أقل معنوياً ($P \leq 0.05$) من المستخلص المائي للزنجبيل. في حين انه لم تتأثر حالة مكونات مواد الأكسدة للحوم المبردة والمجمدة معنوياً بصور المستخلص او مستوياته، في حين كانت قيم (2-thiobarbituric acid-reactive substance(TBARS)) لكل المعاملات بمستوياتها وصورها المختلفة أعلى معنويا ($P \leq 0.05$) من معاملة المقارنة للحوم المبردة والمجمدة.

وعموماً أوضحت النتائج ان إضافة الزنجبيل بمستوياته و صوره المختلفة ادى لتحسن الآداء الإنتاجي و والفسيولوجي والاستجابة المناعية وكذلك جودة اللحم المبرد والمجمد. ونقترح أنه هناك حاجة الى تجارب إضافية لتوضيح الرؤية بشأن التداخل بين صورتي مستخلص الزنجبيل المائي والزيتي.