World Journal of Agricultural Sciences 7 (3): 258-269, 2011
ISSN 1817-3047

Influence of Dietary Vitamin E and C Supplementation on Performance and Some Metabolic Response of Broiler Chicks Subjected to Heat Stress

[1]M.M. El- Habbak, [2]A.A. El-Ghamry, [2]G.M. El-Mallah, [1]H.H. Younis and [2]E.M. El-Komy

[1]Department of Poultry Production, Faculty of Agriculture,
Kafr El- Sheikh, Tanta University, Egypt
[2]Department of Animal Production, National Research Center, Dokki, Giza, Egypt

Abstract: A total number of 405 one- day- old commercial Arbor Acer chicks were used to determine if the negative effects of high ambient temperature (42°C for 3 consecutive days, 8h daily at 40 day of age) on broiler growth performance, some physiological responses and digestibility of nutrients could- be alleviated by thermal conditioning (birds were subjected to heat stress (HS) treatment, 42°C for three consecutive days at 5 or 28 days of age, 65%- 70% RH), Supplementing vitamin C (1g/L water), vitamin E (65 IU/L water) or by supplemental dietary vitamins C or E in combination with the thermal conditioning. The results obtained indicated that heat tress negatively affected body weight (BW), body weight gain (BWG), feed intake (FI), feed conversion (FC) (g food/g weight gain) and digestibility of CF, CP, NFE and OM. Heat stress highly significantly increased body temperature and mortality rate. Birds subjected to heat stress twice throughout the experiment at 28 and 40 days of age significantly decreased serum (Triglyceride, AST, ALT and Glucose) concentration and significantly increased serum A/G ratio concentration as compared to those subjected to HS ones at 40 days of age. But no significant differences were observed between two groups, with respect to serum (Total protein, Albumen, Globulin, Cholesterol, T_3, T_4 and T_3/T_4 ratio) concentration. Exposure of broilers to high temperature (42°C for 8h) at 40 days if age resulted in decrease BE, BWG, FI, FC and increased rectal temperature regardless of previous high temperature exposure. Early acclimation significantly deceased mortality rate and improved the efficiency of feed conversion and increased digestibility of nutrients. Vitamin C or E supplementation antagonized the effect of HS, in this respect, vitamin C seemed to be wore potent than vit. E. Both of two vitamins alleviated the negative effect resulting due to HS by increased serum total protein concentration and decreased feed consumption and significantly reduced T_3 level. It can be concluded that early acclimation, vitamins C or E supplementation and combination between vitamins C or E and acclimation were very effective in ameliorating the adverse effect of heat stress.

Key words: Heat stress · Vitamin E · Ascorbic acid · Broilers · Performance

INTRODUCTION

High ambient temperature is one of the most important problems for poultry productions not occur only in tropic and sub-tropic countries. It also occurs in temperate countries including Egypt when peak temperatures during summer months can produce environmental problems in well insulated poultry houses. Large economic losses occur because such as of mortality rate and decreased production. At high ambient temperature, growth decreases as a result of the reduced appetite, food intake and respiratory rate increases, causing respiratory alkalosis [1].High environmental temperatures have adverse impact on the production and physiological responses of broiler [2-6]. Environmental stressed poultry generally have depressed immune function [7]. Several methods are available to alleviate the effect of high environmental temperature on productive performance of poultry. Since it is expensive to cool animal buildings such methods are focused mostly on the dietary manipulation [8]. In this respect, Vitamin E (Vit. E) is used in the poultry diet because of the reported benefits of vit. E supplementation to laying hens during heat stress [9-11] also because of the fact that vit. E levels

Corresponding Author: G.M. Elmallah, Department of Animal Production, National Research Center, Dokki, Giza, Egypt, E-mail: gmelmallah@yahoo.com .

are reduced during heat stress [8]. Also, poultry cannot synthesize vit. E, therefore, vit. E requirements must be met from dietary sources [12]. One of the most important properties of vit. E is its antioxidant function [13].Supplemental vit. E during heat stress may well be beneficial in aiding the optimum function of the immune system [14].

Dietary supplementation of laying hens with antioxidant vitamins (vit. E and vit.C or a combination of the both compounds) can attenuate heat stress induced oxidative damage [15]. Mohiti *et al.* [16] found that dietary supplementation of laying hens with antioxidant vitamins (vitamin E or vitamin C), probiotics or yeast during heat stress conditions can improve the immune response of birds and can leads to improve performance and egg quality. Supplemental Arginine improved the pulmonary vascular performance of hypoxic broiler chickens and its effects were further improved by the addition of the antioxidant VE and vit. C. Arginine and antioxidant vitamins may have played synergistic roles to increase NO bioavailability and reduce oxidative stress damage, thus improving cardiopulmonary performance [17].Improved performance of AA-supplemented, heat-exposed broiler chickens has been shown to correspond with lower plasma corticosterone concentrations [18]. Performance characteristics and immune function of heat-stressed poultry have been shown to be improved significantly by increased fortification of vit. C [19]. Heat tolerance can be increased by acclimation chickens can be acclimated to some degree by reported short exposures to heat stress [20]. Prior exposure (PE) to high environmental temperatures confers a measure of resistance to subsequent exposure (SE) to high temperatures. This has been reported as acclimation when SE closely follows PE [21]. Therefore, the objectives of the present study are to determine:

The adverse effects of heat stress on performance, physiological responses and rate of digestion of broiler chicks.

Some methods to alleviate the adverse effects of heat stress. Supplementation of vit. E (65Iu/L) or vit. C (g/L), early acclimation (exposed broiler chicks to heat stress 42°C for 3 consecutive,8 h/ daily days at 5 days of age or combinations between vit.(E or C) and early acclimation

MATERIALS AND METHODS

A total of four hundreds and five unsexed one day old broiler chicks (Arbor acres) were used in this work. Chicks were randomly assigned to nine treatment groups, (3 replicates) of 45 birds each. The experiment design is shown in Table 1. The birds randomly received either a basal diet (threatmented groups, 7, 8, 9), basal diet supplemented with vit. E (dl-α-tocopherol acetate 65 Iu/l (treatmented groups, 4, 5, 6), or basal diet supplemented with vitamin C (gm/l, treatmented groups, 1, 2, 3). The birds were fed a starter diet until 21d of age followed by a finishing diet from day 21 to 42.at 5d of age treatmented groups (1.4, 7) were exposed to heat stress 42c and 65 to 70 % RH for 3 consecutive days, 8 h/daily. At28 d of age treatmented groups (2, 5, 8) were subjected to the same heat stress treatments. At later of age 42 d all birds were exposed to the same heat stress treatments. Ingredients and chemical composition of the starter and finishing diets are shown in Table 2. The basal diets were formulated using NRC [22] contained 23-20.06 % (starter-finishing) protein and 3160-3200.7(starter- finishing) ME, k.cal/kg diet.

The diets and fresh water were offered *ad-libitium.* During the experiment, light was provided continuously(24 hours) and average room temperature was (32 to 35°C) at one day age then reduced by 3°C per week unit reached to the normal ambient environmental temperature (27-29°C). At weekly intervals, feed intake and body weight were determined, weight gain and feed efficiency of birds were then calculated. Deep body temperature recorded by digital thermometer by means of thermister probe inserted approximately 3 cm into

Table 1: The experimental design.

Treatmented group						
Vit.C	Vit. E	Non-Vit.	Treatment day high temperature	Temperature (Ta)	Temperature humidity (rh)	Duration
1	4	7	5, 6 and 7 in addition 40, 41 and 42	42°C	65- 70%	8h/ day
2	5	8	28, 29 and 30 in addition 40, 41 and 42	42°C	65- 70%	8h/ day
3	6	9	40, 41 and 42	42°C	65- 70%	8h/ day

Table 2: Composition and calculated analysis of the used ration.

Ingredients	Starter	Finisher.
Yellow Corn.	54.3	63.9
Soybean (44%CP).	29.6	21
Broiler concentrate (52% CP)	10	10
Plant oil.	5	4
Lime stone	0.47	0.47
Common slat	0.3	0.3
Primex*	0.3	0.3
Methonine.	0. 03	0.03
Total	100%	100%
Calculated analysis**		
- M. E (K. cal/Kg. diet)	3160.33	3200.65
- CP %	23	20.063
- Calory: protein ratio	137.4	159.53
- Ca % (calcium %)	0.9744	0.9498
- P % (available phosphorus %)	0.4847	0.471
- Meth % (methionine %)	0.4719	0.364

* Vitamins and minerals premix were free from folic acid: each kg contains vit A 12000 Iu, vit.D3 3000 Iu, vit. E 12 mg, vit. K 1mg, vit B12 0.02mg, vit B1 1mg, vit B2 4mg, vit B6 5mg, Nicotinic acid 20 mg, Biotin 0.05 mg, Choline chloride 0.16 mg, cupper 3 mg, iron 30 mg, manganese 40 mg,.zinc 45 mg and selenium 3 mg..

** According to N.R.C.[22]

the cloacae for 1 min. At the end of day 42, 9 birds randomly chosen from each treatment (3 birds per each replicate) were slaughtered and 5 ml blood was collected two blood samples were taken at every slaughter individually collected. One was taken up in heparinsed capillary tubes for hematocrit measurements. Another one collected to separate serum which kept at- 20°C in deep freeze until used for hormones and biochemical estimates. Triiodothyronine (T_3) and thyroxin (T_4) concentration (ng/ml serum) was determined by using stat fax. 2100. Serum total protein, Triglyceride, Albumen, serum aspartate aminotransferase (SAST), serum alanine aminotransferase (SALT), Glucose diagnostic kits by Analyzer Au 400 (Olympus Au 400).

Digestion traits were conducted at 45th day of age to estimate the digestion coefficients and nitrogen retention of the experimental diets. Total number of 270 chicks, 10 chicks for each replicate. Feeds and fresh water were offered *ad libitum* during 3 days collection period. The feed consumption was recorded and the excreta, which fall on polyethylene sheets, were collected quantitatively every 24 hours. Feathers and scattered feed were separated or taken out of excreta. The excreta of each replicate were dried at 60°C constant weight. The dried excreta for successive three days were left few hours to get equilibrium with it in the atmosphere then weighted, ground, well mixed and stored for analysis. The analysis of feed, ash, nitrogen, ether extract, crude fiber and nitrogen free extract according to A. O.A.C [23]. Fecal nitrogen and fecal protein was determined according to Jakobson *et al.* [24]. Data were analyzed according to SAS program [25], by the application of the least square procedure.

RESULTS AND DISCUSSION

Body Weight and Body Weight Gain: Results concerning BW and BWG records of broiler chicks as influenced by heat stress treatments and supplemental dietary vitamin C or E are presented in Tables 3 and 4, respectively. Regarding the effect of HS treatments on BW and BWG result obtained clearly showed that exposure of chicks to HS treatment early at the age of 5 days resulted in decreased BW and BWG during first two weeks of age. However, birds quickly restored their growth efficiency and by the end of five week were almost equal to (HS_3) chicks and recorded even higher BW gain than those of (HS_2) group. The superiority of (HS_1) chicks in BWG was also noticed during the periods (3- 5) and (5- 6). Similarly, Arjona *et al.* [21] who reported that early heat stress (35° to 37.8°C for 24 h at 5-d of age) decreased significantly body weight until day 28 of age by 42 days of age, no significant differences remained between control and early heat-stressed birds in body weight. Also, Yahav and Hurwitz [20], Yahav *et al.* [26] and Yahav and I. Plavnik [27] reported that thermal conditioning (TC) at an early

Table 3: The effect of vitamin treatments, heat stress and their interactions on body weight (g) during different periods.

Group	Treatments	1 wk	2 wk	3 wk	5 wk	6 wk
1	C-HS_1	154.4±2.1	388.9±5.7	737.4±10.1^{B}	1245.5±18.6	1788.9±29.8
2	C-HS_2	163.5±2.2	409.6±5.7	764.9±10.5^{A}	1243.7±19.5	1767.3±30.9
3	C-HS_3	162.7±2.1	407.2±5.9	751.7±9.9^{AB}	1257.3±18.4	1839.0±28.9
4	E-HS_1	157.5±2.2	407.6±5.8	758.7±10.3^{AB}	1249.9±19.1	1853.4±30.2
5	E-HS_2	167.5±2.2	419.5±5.8	768.7±10.2^{A}	1245.5±19.1	1774.1±30.6
6	E-HS_3	166.0+2.2	427.2±5.8	768.8±10.2^{A}	1263.9±18.8	1836.3±31.3
7	HS_1	147.3±2.1	387.7±5.7	726.6±15.1^{B}	1213.2±18.8	1809.8±30.6
8	HS_2	162.9±2.1	409.6±5.7	749.7±10.^{AB}	1210.7±20.8	1734.5±33.6
9	HS_3	158.9±2.1	418.0±5.7	758.7±10.1^{AB}	1252.1±18.8	1819.0±33.1
Vitamin treatments						
	C	160.2±1.2^{A}	401.9±3.3^{B}	751.3±5.9^{B}	1248.8±10.9	1798.4±17.3
	E	163.7±1.3^{A}	418.1±3.4^{A}	765.4±5.9^{A}	1253.1±10.9	1821.3±17.7
	Unsuppl.	156.4±1.2^{B}	405.1±3.3^{B}	745.0±5.8^{B}	1225.3±11.3	1787.8±18.7
Heat stress						
	HS_1	153.1±1.2^{B}	394.7±3.3^{B}	740.9±5.9	1236.2±10.9	1817.4±17.9
	HS_2	164.6±1.3^{A}	412.9±3.4^{A}	761.1±5.9	1233.3±11.4	1758.6±18.3
	HS_3	162.5±1.2^{A}	417.5±3.3^{A}	759.7±5.8	1257.8±10.8	1831.4±17.9

A and B Means within the same column having different letters are significantly different ($P \leq 0.05$), HS_1= Heat stress (42°C for 3 consecutive days, 8 h/daily at 5 and 40 day of age), HS_2= Heat stress (42°C for consecutive 3 days, 8 h/daily at 28 and 40 day of age),HS_3= Heat stress (42°C for consecutive 3 days, 8 h/daily at 40 day of age), C= Vitamin C (1g/ liter) E= Vitamin E (65 IU), Unsuppl.= no vit. supplementation NS= Non- significant.

Table 4: The effect of vitamin treatments, heat stress and their interactions on body weight gain (g/ bird / period) during different periods.

		Periods					
Group	Treatments	0- 1 wk	1- 2 wk	2- 3 wk	3- 5 wk	5 - 6 wk	Total
1	C-HS_1	102.7±1.9	234.5±4.6	348.5±7.1	508.1±13.9^{A}	543.4+19.4^{B}	1737.2
2	C-HS_2	113.8±1.9	246.1±4.5	355.3±6.9	478.8±14.6^{B}	523.6+20.1^{C}	1717.6
3	C-HS_3	114.6±1.8	244.5±4.4	344.5±6.9	505.6±14.6^{A}	581.7+18.7^{AB}	1790.9
4	E-HS_1	106.2±1.9	250.1±4.5	351.1±7.2	491.2±14.3^{AB}	603.5+19.6^{A}	1802.1
5	E-HS_2	116.0±1.9	259.2±4.5	349.2±7.1	476.8±14.3^{B}	528.6+19.9^{C}	1729.8
6	E-HS_3	115.1±1.9	261.2±4.5	341.6±7.1	495.1±14.1^{AB}	572.4+20.4^{AB}	1785.4
7	HS_1	97.4±1.9	240.4±4.5	338.9±7.1	486.6±14.1^{AB}	596.6+19.9^{A}	1759.9
8	HS_2	111.5±1.9	246.7±4.5	340.1±7.1	461.0±15.6^{C}	523.8+21.9^{C}	1683.1
9	HS_3	107.4±1.9	259.1±4.5	340.7±7.1	493.4±14.1^{AB}	566.9+21.5^{ABCD}	1767.5
Vitamin treatments							
	C	110.4±1.1^{A}	241.7±4.1^{C}	349.4±4.1	497.5±8.2	549.6±11.2	1748.6
	E	112.4±1.1^{A}	256.8±4.1^{A}	347.3±4.1	487.7±8.2	568.2±11.5	1772.4
	Unsuppl.	105.4±1.1^{B}	248.7±4.1^{B}	339.9±4.1	480.3±8.5	562.4±11.2	1736.8
Heat stress							
	HS_1	102.1±1.1^{B}	241.7±2.6^{B}	346.2±4.1	495.3+8.2^{A}	581.2+11.4^{A}	1766.4
	HS_2	113.8±1.1^{A}	250.7±2.6^{A}	348.2±4.1	472.2+8.6^{B}	525.3+11.9^{B}	1710.2
	HS_3	112.4±1.1^{A}	254.9±2.6^{A}	342.3±4.1	498.0+8.1^{A}	573.7+11.7^{A}	1781.3

A, B, C and D Means within the same column having different letters are significantly different ($P \leq 0.05$).

age has been reported to result in reduced significantly body weight and weight gain during the 1st week of life. Complete growth and compensation was obtained by the 2nd week of age.

In case of HS_2 treatment, it was observed that exposure of birds to heat stress twice during the last two weeks resulted in significantly lower BW gain during the last week and consequently less, but insignificantly, final BW records. All previous workers generally reported that subjecting broiler chicks to either acute or chronic heat stress depressed BW and BWG especially between 4 and 8 weeks of age. The growth rate of 4-to8 Wk old broiler chickens is maximal at environmental temperature of 18° to 20°C [28] and declines progressively at higher temperatures [3-6, 29-31]. Results show no significant effects of either vit. C or vit. E was observed on BW and BWG although vitamin E-treated groups showed higher BWG than anther groups. Total BW and BWG were not affected by vitamins X heat stress interaction. The same result was obtained by

Table 5: Effect of vitamin treatments, heat stress and their interactions on feed consumption (g / bird / period) during different periods.

		Periods					
Group	Treatments	0- 1 wk	1- 2 wk	2- 3 wk	3- 5 wk	5 - 6 wk	0 - 6 wk
1	C-HS_1	144.5	338.9	466.7^{B}	910.0	1397.0	3257.1
2	C-HS_2	151.1	333.4	471.7^{B}	932.3	1466.3	3354.8
3	C-HS_3	152.2	342.2	475.6^{B}	933.1	1511.9	3415.0
4	E-HS_1	144.4	353.5	484.8^{AB}	950.3	1478.6	3411.6
5	E-HS_2	153.3	351.7	489.9^{A}	917.4	1526.1	3438.4
6	E-HS_3	156.8	357.0	488.9^{A}	922.9	1581.7	3507.3
7	HS_1	144.4	345.5	484.8^{AB}	959.7	1567.1	3501.5
8	HS_2	154.6	348.9	490.9^{A}	944.0	1548.5	3486.9
9	HS_3	153.3	352.2	486.6^{A}	1008.9	1600.9	3601.9
SEM*		1.8	7.9	6.3	41.69	52.7	78.4
Vitamin treatment							
	C	149.3	338.2	471.3^{B}	925.1^{B}	1458.4^{B}	3342.3^{B}
	E	151.5	354.1	487.9^{A}	930.2^{B}	1528.8^{B}	3452.4^{B}
	Unsuppl.	150.8	348.9	487.4^{A}	970.9^{A}	1572.2.^{A}	3530.1^{A}
Heat stress							
	HS_1	144.4^{B}	345.9	478.8	940.0^{B}	1480.9^{B}	3390.1^{B}
	HS_2	153.0^{A}	344.7	484.2	931.2^{B}	1513.6^{B}	3426.7^{B}
	HS_3	154.1^{A}	350.5	483.7	955.0^{A}	1564.8^{A}	3508.1^{A}

A and B Means within the same column having different letters are significantly different ($P \leq 0.05$).

Table 6: Effect of vitamin treatments, heat stress and their interactions on feed conversion (g food/g weight gain) during different periods.

		Periods					
Group	Treatments	0- 1 wk	1- 2 wk	2- 3 wk	3- 5 wk	5 - 6 wk	0 - 6 wk
1	C-HS_1	1.41^{BC}	1.45	1.34^{B}	1.79^{C}	2.57	1.87
2	C-HS_2	1.33^{E}	1.35	1.33^{B}	1.95^{AB}	2.80	1.95
3	C-HS_3	1.33^{E}	1.40	1.38^{B}	1.85^{B}	2.60	1.90
4	E-HS_1	1.36^{DE}	1.41	1.38^{AB}	1.93^{AB}	2.45	1.89
5	E-HS_2	1.32^{E}	1.36	1.40^{AB}	1.92^{AB}	2.89	1.99
6	E-HS_3	1.36^{DE}	1.37	1.43^{A}	1.86^{B}	2.76	1.96
7	HS_1	1.48^{A}	1.44	1.43^{A}	1.97^{AB}	2.63	1.99
8	HS_2	1.39^{CD}	1.41	1.44^{A}	2.05^{A}	2.96	2.07
9	HS_3	1.43^{B}	1.36	1.43^{A}	2.04^{A}	2.82	2.04
SEM *		0.01	0.04	0.05	0.06	0.14	0.03
Vitamin treatment							
	C	1.36^{B}	1.40	1.35^{B}	1.86^{B}	2.66^{B}	1.91^{B}
	E	1.35^{B}	1.38	1.40^{A}	1.90^{B}	2.70^{AB}	1.95^{B}
	Unsuppl.	1.43^{A}	1.40	1.43^{A}	2.02^{A}	2.80^{A}	2.03^{A}
Heat stress							
	HS_1	1.42^{A}	1.43^{A}	1.38	1.90^{B}	2.55^{B}	1.92^{B}
	HS_2	1.35^{B}	1.37^{B}	1.39	1.97^{A}	2.88^{A}	2.00^{A}
	HS_3	1.37^{B}	1.38^{B}	1.41	1.92^{B}	2.73^{AB}	1.97^{AB}

A, B, C and D Means within the same column having different letters are significantly different ($P \leq 0.05$).

Mckee *et al.* [32] and Xiang *et al.* [33] who reported that no significant effects of vitamin C was observed on weight gains of broiler chicks subjected to heat stress. Incase vit. E, studies on meat quality do not indicate that additional vitamin E, at concentrations up to 60 mg/kg diet, improved weight gain [34].On the other hand, Sahin *et al.* [8] found that a 250 mg/kg of vitamin E reducing the negative effects of heat stress (32°C constant) as increasing live body weight gain.

Feed Consumption and Efficiency of Feed Utilization: Average amounts of feed consumed and efficiency of feed utilization per bird during two periods as influenced by heat stress treatments and supplemental dietary vitamins are shown in Tables 5 and 6. It seems that subjecting birds to heat stress reduced insignificantly feed consumption and efficiency of feed utilization during first period (0-3 wk) and significantly reduced feed consumption during second period (3-6 wk).

Table 7: The effect of vitamin treatments, heat stress and their interactions on nutrients digestibility at 45 days of age.

Group	Treatments	CP	C.F	EE	NFE	OM
1	C-HS$_1$	96.74±0.73	30.12±3.30^{A}	79.76±3.34^{A}	77.09±2.56^{A}	80.65±1.97^{A}
2	C-HS$_2$	95.45±0.73	15.79±3.30^{BCD}	72.64±3.34^{AB}	68.81±2.56^{BC}	74.96±1.97^{ABcC}
3	C-HS$_3$	95.43±0.73	21.40±3.30^{ABC}	70.33±3.34^{ABCD}	66.25±2.56^{C}	72.48±1.97^{BC}
4	E-HS$_1$	94.34±0.73	18.54±3.30^{BCD}	65.99±3.34^{BCDE}	64.60±2.56^{C}	70.77±1.97^{C}
5	E-HS$_2$	94.75±0.73	12.47±3.30^{CD}	61.37±3.34^{CDE}	65.29±2.56^{C}	70.45±1.97^{C}
6	E-HS$_3$	96.09±0.73	25.51±3.30^{AB}	67.36±3.34^{BCDE}	75.21±2.56^{AB}	78.06±1.97^{AB}
7	HS$_1$	95.47±0.73	13.76±3.30^{CD}	58.40±3.34^{E}	62.98±2.56^{C}	69.15±1.97^{C}
8	HS$_2$	94.35±0.73	9.80±3.30^{D}	71.02±3.34^{ABC}	63.14±2.56^{C}	70.80±1.97^{C}
9	HS$_3$	94.78±0.73	13.86±3.30^{CD}	59.66±3.34^{DE}	61.85±2.56^{C}	68.54±1.97^{C}
Vitamin treatment						
	C	95.87±0.42	22.44±1.90^{A}	74.24±1.93^{A}	70.72±1.47^{A}	76.03±1.14^{A}
	E	95.06±0.42	18.84±1.90^{A}	64.91±1.93^{B}	68.37±1.47^{A}	73.09±1.14^{A}
	Unsuppl.	94.87±0.42	12.47±1.90^{B}	63.03±1.93^{B}	62.66±1.47^{B}	69.50±1.14^{B}
Heat stress						
	HS$_1$	95.52±0.42	20.81±1.90^{A}	68.05±1.93	68.22±1.47	73.52±1.14
	HS$_2$	94.85±0.42	12.69±1.90^{B}	68.34±1.93	65.75±1.47	72.07±1.14
	HS$_3$	95.43±0.42	20.26±1.90^{A}	65.78±1.93	67.77±1.47	73.03±1.14

A, B, C and D Means within the same column having different letters are significantly different ($P \leq 0.05$).

Numerous investigations have shown that feed consumption and efficiency of feed utilization of the domestic fowl are greatly affected by ambient environment temperature. According NRC [22] broiler feed intake will be depressed by about 1.5% for each raise of 1C° above thermoneutral. Other studies, Kadim *et al.* [4], Roussan *et al.* [5], Ihsan *et al.* [6], Tollba and Hassan [31] and El-Moslimany [35] reported that high environmental temperature depressed feed consumption efficiency of feed utilization of birds. Birds that received no supplemental vitamins consumed significantly more food than those given supplemental vit. C or E. Besides, vit. C groups consumed less food than their corresponding vitamin E groups. Supplemented dietary vitamins C or E were found to cause significant improvement in efficiency of feed utilization during the periods but vitamins C was slightly better than vitamins E. Similarly, [33] found that vit. C supplementation (500 mg/kg diet of broiler chicks) reduced feed intake from 5 to 6 week of age. Also, El-Gabeary [36] and Attia *et al.* [37] reported that through the hot summer of Egyptian using 400 mg ascorbic acid/kg diet was enough to get the best performance and economical efficiency. In case of vitamin E, the same result was nearly obtained by Swain *et al.* [38] who reported that chicks given supplementary vitamin E consumed significantly less food and best efficiency of food utilization than those fed the basal diet. Somehow vit. E supplementation might have helped broilers to respond to heat stress, yielching a better performance, perhaps due to increased heat shock proteins (Hsp) synthesis. Also, serum concentration of T_3 and T_4 were greater with greater result could have been due to negative effects of heat stress [8].

Nutrients Digestibility: Digestion coefficients of the experimental treatments are shown in Table 7. The results indicated that crude protein (CP) digestibility of experimental birds was not significantly affected by different treatments. Treating chickens with heat without vit. addition caused obvious decrease in CF, EE, NFE and digestibility.

Concerning the overall mean data of effects of the tested vitamins and heat stress programs on nutrients digestibility, it is clear that neither the added vitamins nor heat stress treatments had significant effects on CP digestibility. Vit. C supplementation tented to enhance CF, EE, NFE and OM digestibility compared to vitamin E supplementation. Furthermore, both vitamins significantly enhanced these digestibility values compared to the unsupplemented birds. Several researches reported that heat stress have negative effects on nutrients digestibility of broiler chicks [39], while, Sahin *et al.* [8] reported that the decrease in nutrients digestibility caused by heat exposure can be elevated by supplemental vitamin E. Also, Sahin and Kucuk [39] reported that digestibility of nutrients (DM, OM, CP and EE) were higher with a combination of dietary vit. C and vitamin E in Japanese quails reared under chronic heat stress. In addition, AL-Homidan [40] reported that raising broiler chicks in hot climate (up to 25°C) during 5 to 7 weeks of age had negative effect on productive performance which can be prevented by using 250mg vit C/ liter of drinking

Table 8: Effect of vitamin treatments, heat stress and their interaction on body temperature before and after heat stress during different ages.

		Age					
		5 day		28 day		42 day	
Group	Treatments	Before	After	Before	After	Before	After
1	CHS 1	40.37^{B}	$^{b}41.79^{A}$	41.25 (av.)	-	41.38^{B}	$^{c}42.02^{A}$
4	EHS 1	40.38^{B}	$^{b}41.85^{A}$	41.67 (av.)	-	41.51^{B}	$^{bc}42.27^{A}$
7	HS 1	40.43^{B}	$^{a}42.26^{A}$	41.66 (av.)	-	41.45^{B}	$^{ab}42.45^{A}$
General mean of HS1		40.39	41.97	41.53	-	41.45	42.25
	SEM*	0.07	0.08	0.09	-	0.09	0.09
2	CHS 2	40.83 (av.)	-	41.33^{B}	$^{b}42.28^{A}$	41.36^{B}	$^{bc}42.13^{A}$
5	EHS 2	40.86 (av.)	-	41.30^{B}	$^{a}42.67^{A}$	41.53^{B}	$^{bc}42.32^{A}$
8	HS 2	40.88 (av.)	-	41.39^{B}	$^{a}42.86^{A}$	41.59^{B}	$^{ab}42.40^{A}$
General mean of HS2		40.72	-	41.34	42.60	-	41.49
	SEM*	0.08	-	0.09	0.09	-	0.08
3	CHS 3	40.78 (av.)	-	41.51 (av.)	-	41.47^{B}	$^{bc}42.12^{A}$
6	EHS 3	40.86 (av.)	-	41.59 (av.)	-	41.60^{B}	$^{bc}42.27^{A}$
9	HS 3	40.84 (av.)	-	41.68 (av.)	-	41.64^{B}	$^{a}42.67^{A}$
General mean of HS3		40.83	-	41.59	-	-	41.57
	SEM*	0.09	-	0.09	-	-	0.08
Vitamin treatment							
	C	-	-	-	-	41.40^{B}	$^{c}42.09^{A}$
	E	-	-	-	-	41.54^{B}	$^{b}42.28^{A}$
	Unsuppl.	-	-	-	-	41.61^{B}	$^{a}42.52^{A}$
	SEM*	-	-	-	-	0.04	0.07

Shaded columns refer to the incidence of HS at this age, meanwhile unshaded records represent the averages of normal body temperature at this age, A, B, C and D Means within the same column having different letters are significantly different ($P \leq 0.05$).

Body Temperature: Records Rectal temperature (Rt) of birds in the different experimental group throughout the experiment before and after exposure to heat stress are shown in Table 8. Subjecting birds to Hs treatment at different ages caused a significant increase in birds Rt. The increase in body temperature in response to high environmental was reported by El-Nabarawy [41] they reported that rectal temperature is a good indicator of heat stress. The results was consistent with those of Yahav and Hurwitz [20] and Yahav and I. Plavnik [27] who noted that cloacal temperature of the broiler chicks increased significantly the end of a 24-h exposure to heat (36°± 1C°) during the 1 St wk of live. Other studies, Yahav *et al.* [26], El-Moslimany [35], El-Gendy and Washburn [42], Altan *et al.* [43] and Sandercock *et al.* [44] suggesting that exposing birds to heat stress at later age resulted in significant increase in body temperature. Body temperature increased as the age increased both in control as well as broilers under HS. The same result was obtained in broiler chicks by Sandercock *et al.* [44] and in quails by El-Nabarawy [41] who found that deep-body temperature increased as the age increased. Exposure of birds to HS at early ages (5 or 28 days) did not make birds more capable of overcoming heat shocks later. Birds of HS_3 did not suffer hyperthermia more than their partners which previously experienced exposure to heat stress. The result was consistent with those of Arjona *et al.* [45] and Altan *et al.* [43], who noted that exposure of broilers to high temperature at later of age resulted in an increase in RT regardless of previous high temperature experience. Supplemental dietary vitamins showed a significantly positive effect and made birds more capable of facing HS conditions and conserving their body temperature as it reduced the relative change in their Rt. In this respect vitamin C showed detectably better effect than vit. E. these results nearly similar to that obtained by El-Moslimany [35], who demonstrated that supplementation of vit. C a limited body temperature in crease during the period of elevated environmental temperature. Also the vit. C increases the activity of chicks body and metabolic function therefore increase in efficiency of body temperature balance [46].

Table 9: Effect of vitamin treatments, heat stress and their interactions on mortality % during different periods.

Group	Treatments	M1% (1- 39 day)	M2% (39- 42 day)	M3 (1- 42 day)
1	C-HS_1	0.00±4.32	6.67±6.57^A	6.67±6.92
2	C-HS_2	4.44±4.32	3.33±6.57^C	7.78±6.92
3	C-HS_3	2.22±4.32	6.67±6.57^B	8.89±6.92
4	E-HS_1	4.45±4.32	3.33±6.57^C	7.78±6.92
5	E-HS_2	4.45±4.32	6.67±6.57^B	11.11±6.92
6	E-HS_3	2.22±4.32	16.67±6.57^A	18.89±6.92
7	HS_1	2.22±4.32	10.00±6.57^{AB}	12.22±6.92
8	HS_2	20.22±4.32	6.67±6.57^B	26.67±6.92
9	HS_3	4.44±4.32	23.33±6.57^A	27.78±6.92
Vitamin treatment				
	C	2.22±2.49^B	5.56±3.80^B	7.78±3.99^C
	E	3.71±2.49^B	8.89±3.80^B	12.59±3.99^B
	Unsuppl.	8.9±2.496^A	13.33±3.80^A	22.22±3.99^A
Heat stress				
	HS_1	2.22±2.49^B	6.67±3.80^B	8.89±3.99^B
	HS_2	9.70±2.49^A	5.56±3.80^B	15.19±3.99^A
	HS_3	2.96±2.49^B	15.56±3.80^A	18.52±3.99^A

A, B and C Means within the same column having different letters are significantly different ($P\leq 0.05$).

Mortality Rate: Results regarding mortality records in the different experimental groups throughout the experiment are presented in Table 9. Mortalities occurred during the period 1-39 days are referred to as M_1, meanwhile M_2 refers to mortalities occurred thereafter up to the end of the experiment. Concerning the result of M_1 it could be observed that birds early subjected to heat at the age of five days (group 7, HS_1) showed less mortality record than that obtained in groups 8 (HS_2) which was exposed to HS later at the age of 28 days. The same results nearly similar to that obtained by Pardue *et al.* [19] and Cooper and Washburn [29] who found that exposed broiler chicks to heat stress at 4 wk of age resulted in significant increase mortality rate as compared with control. Mortalities records during late exposure to heat stress (M2) and collective date of mortality (M3) proved that birds previously subjected to heat stress earlier at the age of 5d (HS_1) or 28 d (HS_2) showed an effective role in decreasing mortality as compared with HS_3 treatment. In this respect, HS_1 treatment was significantly better than HS_2. Early aye thermal conditioning significantly reduced mortality during subsequent exposure to high ambient temperature later in life [20, 21, 45, 35]. The lowest mortality exhibited by acclimated groups may be attributed to lower T3 and Corticosterone levels, lower haematocrit value, lower body temperature and higher water consumption [35].As for the effect of supplemented vitamins, it has been found that supplemental vit. C resulted in significantly lower mortality than did vitamin E and both had significantly lower mortality records than groups not receiving any supplemental vitamins. Earlier studies showed that vit. C supplementation could be effective in reducing mortality in broilers [35] reared under environmental stress. Performance characteristics and immune of heat- stressed poultry have been shown to be improved significantly by increased fortification of vitamin C [6,19, 46], vitamin E [47]. This result may be explained reduce mortality of broiler chicks supplemented vitamins subjected to heat stress.

Blood Analysis: The effect of heat stress treatments and/or supplemental dietary vitamins C or E on Blood analysis are shown in Tables 10, 11 and 12. Exposure of birds to heat stress twice during the last two weeks (at 28 d and 40 d, group8, HS2) caused a significant increase in blood triglycerides, A/G ratio while decrease total protein,albumin, globulin, AST and ALT concentration as compared to HS_1 (group 7) and HS_3 (group 9) treatments. Similar to results of the present study, Sahin *et al.* [8] found that stress (34°C) tended to elevate plasma triglycerides concentration. Early exposure to heat stress at 5(HS_1, group 7) and28 day (group 8, HS2) of age reduce insignificant serum glucose and T4 concentration and increase serum cholesterol. The increase of plasma cholesterol concentration under HS has been reported by Tollba and Hassan [31] broiler chicks. Similarly, McCormick *et al.* [48] found that subjected the broiler cockerels during fourth week (25 to 28 days of age) to

Table 10: Effect of vitamin treatments, heat stress and their interactions on serum, triglycerides, cholesterol and glucose.

Group	Treatments	Triglycerides (mg / dl)	Cholesterol (mg / dl)	Glucose (mg / dl)
1	C-HS$_1$	74.00±1.91^{A}	93.00±7.35^{B}	260.00±9.32
2	C-HS$_2$	30.00±1.91^{D}	117.00±7.35^{B}	250.00±9.32
3	C-HS$_3$	46.00±1.91^{C}	113.00±7.35^{B}	265.00±9.32
4	E-HS$_1$	73.00±1.91^{A}	141.50±7.35^{A}	228.00±9.32
5	E-HS$_2$	61.00±1.91^{B}	109.00±7.35^{B}	239.00±9.32
6	E-HS$_3$	78.00±1.91^{A}	139.00±7.35^{A}	274.00±9.32
7	HS$_1$	65.00±1.91^{B}	115.00±7.35^{B}	228.00±9.32
8	HS$_2$	75.00±1.91^{A}	112.00±7.35^{B}	251.00±9.32
9	HS$_3$	60.00±1.91^{B}	95.50±7.35^{B}	278.00±9.32
Vitamin treatment				
	C	50.00±1.11^{C}	107.67±4.24^{B}	258.33±5.33
	E	70.67±1.11^{A}	129.83±4.24^{A}	247.00±5.33
	Unsuppl.	66.67±1.11^{B}	107.50±4.24^{B}	252.33±5.33
Heat stress				
	HS$_1$	70.67±1.11^{A}	116.50±4.24	238.67±5.33^{B}
	HS$_2$	55.33±1.11^{C}	112.67±4.24	243.00±5.33^{B}
	HS$_3$	61.33±1.11^{B}	115.83±4.24	272.33±5.33^{A}

A, B, C, D and E Means within the same column having different letters are significantly different ($P \leq 0.05$).

Table 11: Effect of vitamin treatments, heat stress and their interactions on serum proteins

Group	Treatments	Total protein (g / dl)	Albumen (g / dl)	Globulin (g / dl)	A / G ratio
1	C-HS$_1$	1.99±0.14^{DE}	1.06±0.05^{ABC}	0.93±0.09^{D}	1.14±0.05^{B}
2	C-HS$_2$	2.68±0.14^{B}	1.12±0.05^{ABC}	1.56±0.09^{B}	0.72±0.05^{D}
3	C-HS$_3$	1.98±0.14^{DE}	1.00±0.05^{C}	0.98±0.09^{D}	1.02±0.05^{BC}
4	E-HS$_1$	2.56±0.14^{BC}	1.11±0.05^{ABC}	1.45±0.09^{B}	0.77±0.05^{D}
5	E-HS$_2$	2.34±0.14^{BCD}	1.11±0.05^{BC}	1.33±0.09^{BC}	0.83±0.05^{D}
6	E-HS$_3$	2.51±0.14^{BC}	1.16±0.05^{AB}	1.36±0.09^{BC}	0.85±0.05^{CD}
7	HS$_1$	3.70±0.14^{A}	1.20±0.05^{A}	2.50±0.09^{A}	0.48±0.05^{E}
8	HS$_2$	1.64±0.14^{E}	1.03±0.05^{BC}	0.61±0.09^{E}	1.69±0.05^{A}
9	HS$_3$	2.13±0.14^{BC}	1.04±0.05^{BC}	1.09±0.09^{CD}	0.95±0.05^{C}
Vitamin treatment					
	C	2.22±0.08^{B}	1.06±0.03	1.16±0.06^{B}	0.98±0.03^{A}
	E	2.47±0.08^{A}	1.13±0.03	1.38±0.06^{A}	0.82±0.03^{B}
	Unsuppl.	2.49±0.08^{A}	1.09±0.03	1.40±0.06^{A}	0.78±0.03^{B}
Heat stress					
	HS$_1$	2.75±0.08^{A}	1.12±0.03	1.63±0.06^{A}	0.69±0.03^{B}
	HS$_2$	2.22±0.08^{B}	1.0±0.035	1.17±0.06^{B}	0.93±0.03^{A}
	HS$_3$	2.21±0.08^{B}	1.07±0.03	1.14±0.06^{B}	0.94±0.03^{A}

A, B, C, D and E Means within the same column having different letters are significantly different ($P \leq 0.05$).

Table 12: Effect of vitamin treatments, heat stress and their interactions on thyroid hormones and AST, ALT.

Group	Treatments	T_3 n g / L	T_4 n mol / L	T_3 /T_4 ratio	AST (U/L)	ALT (U/L)
1	C-HS$_1$	258.00±8.04^{CD}	32.60±1.68	7.91±0.82^{CD}	192.00±7.87^{D}	2.00±0.22^{B}
2	C-HS$_2$	260.00±8.04^{CD}	31.60±1.68	8.23±0.82^{CD}	254.00±7.87^{A}	1.30±0.22^{C}
3	C-HS$_3$	236.00±8.04^{D}	31.20±1.68	7.56±0.82^{D}	266.00±7.87^{A}	2.80±0.22^{A}
4	E-HS$_1$	284.00±8.04^{C}	28.00±1.68	10.14±0.82^{AB}	225.00±7.87^{B}	0.85±0.22^{C}
5	E-HS$_2$	315.00±8.04^{B}	26.00±1.68	12.12±0.82^{AB}	220.00 ±7.87^{BC}	2.90±0.22^{A}
6	E-HS$_3$	350.00±8.04^{A}	25.00±1.68	14.00±0.82^{A}	249.00±7.87^{A}	1.03±0.22^{C}
7	HS$_1$	280.00±8.04^{C}	24.00±1.68	11.67±0.82^{AB}	264.00±7.87^{A}	2.40±0.22^{AB}
8	HS$_2$	317.00±8.04^{B}	25.20±1.68	12.58±0.82^{AB}	198.00±7.87^{CD}	1.23±0.22^{C}
9	HS$_3$	271.00±8.04^{C}	27.70±1.68	9.78±0.82^{BCD}	266.00±7.87^{A}	3.00±0.22^{A}
Vitamin treatment						
	C	251.33±4.64^{C}	31.80±0.97^{A}	7.90±0.47^{B}	237.33±4.54	2.0±0.13^{A}
	E	316.33±4.64^{A}	26.33±0.97^{B}	12.01±0.47^{A}	231.33±4.54	1.59±0.13^{B}
	Unsuppl.	289.33±4.64^{B}	25.63±0.97^{B}	11.29±0.47^{A}	242.67±4.54	2.21±0.13^{A}
Heat stress						
	HS$_1$	274.00±4.64^{B}	28.20±0.97	9.72±0.47	227.00±4.54^{B}	1.75±0.13^{B}
	HS$_2$	297.33±4.64^{A}	27.60±0.97	10.77±0.47	224.00±4.54^{B}	1.81±0.13^{B}
	HS$_3$	285.67±4.64^{AB}	27.97±0.97	10.21±0.47	260.33±4.54^{A}	2.27±0.13^{A}

A, B, C and D Means within the same column having different letters are significantly different ($P \leq 0.05$).

high ambient temperature (41° ± 0.5°C for 90 minutes each day significantly de creased plasma glucose. Exposure of birds to heat stress at early age (HS_1, group 7) significantly decreased T3 concentration and A/G ratio while increase total protein, albumin, globulin as compared to control HS_3 (group 9) treatments during thermal challenge at day 42 of age. These results suggested that early exposure may promote broilers ability to cope with the subsequent heat load by altering thermoregulatory physiological responses and behavioral pattern, resulting in alleviation of heat stress. The same result was nearly obtained by Yahav and Hurwitz [20] and Yahav and Plavnik [27] who found that an early age temperature conditioning resulted in a significant reduction in plasma T3-levels. Dietary vit. (C or E) had significant effects on most blood parameters measured at the present study. Supplemental dietary vitamins C or E antagonized the effect of HS and had a beneficial effect in reducing blood triglycerides content and A/G ratio significantly increased total protein and globulin. Statistical analysis proved a significant increase plasma cholesterol concentration due to supplemented vitamin E especially with HS_1 and HS_3 treatments. Vit.C supplementation significantly reduced T3 level especially under HS2 and HS3 condition by about 18% and 13% consequently. In this respect, vit. E supplementation did not affect T_3 level under HS_1 and HS_2 conditions; however it significantly raised T_3 level under HS_3 condition by about 29.2%. These results are nearly similar to that obtained by Sahin *et al.*[8] who showed that, serum concentration of T_3 (P= 0.001) and T_4 (P= 0.05) of broilers during HS increased as dietary vit. E increased. Vitamin C supplementation did not exert any significant effect on ALT levels but significantly reduced AST levels under HS_1 while a significant increase was observed under HS_2 conditions. With respect to the effect of vitamin E supplementation, it was found to cause a significant decrease in the activities of both enzymes especially under HS_1 and HS_2 conditions. Similarly, Sahin *et al.* [8] reported that increased supplementation Vit. E resulted in linear decrease serum triglycerides and cholesterol concentration an increased significantly blood total protein and concentration of T3and T4 in broiler chicks reared under heat stress (32°C). Blood cholesterol content was not significantly affected by heat stress treatments. Also, Mckee *et al.*[32] reported that ascorbic acid supplementation to heat stressed broilers enhance the liver function and decreased blood AST levels, which confirm the results of the present study.

CONCLUSIONS

It can be concluded that under the condition of the study, early acclimation, vitamins C or E supplementation and combination between vitamins C or E and acclimation were very effective in ameliorating the adverse effect of heat stress. Also it can be concluded that the best alleviation method achieved by combination between vitamin C supplementation and early acclimation as well as reduced mortality rate.

REFERENCES

1. Hillerman, P.E., N.R. Scolt and A. Tienhoven, 1985. Physiological Responses and Adaptations to Hot and Cold Environments, in: Yousef, M. K. (Ed) Stress Physiology in Livestock. V. 3. Poultry (Boca Raton, CRC Press Florida), pp: 1- 71.
2. Balnave, D. and A.G. Oliva, 1991. The influence of NaHCO3 and sulfur amino acid on the performance of broiler at moderate and high temperatures. Aust. J. A. Res., 42: 1385- 1397.
3. Farooq, H.A.G., M.S. Khan, M.A. Khan, M. Rabbani, A. Pervez and J.A. Khan, 2005. Evaluation of betaine and vitamin C in alleviation of heat stress in broiler. Int. J. Agric. Biol., 7: 744-746.
4. Kadim, I.T., B.H.A. Al-Qamshui, O. Mahgoub, W. Al- Marzooqi and E.H. Johnson, 2008. Effect of Seasonal Temperatures and Ascorbic Acid Supplementation on Performance of Broiler Chickens Maintained in Closed and Open-Sided Houses. Int. J. Poult. Sci., 7: 655-660.
5. Roussan, D.A., G.Y. Khwaldeh, R.R. Haddad, I.A. Shaheen, G. Salameh and R. Al Rifai, 2008. Effect of ascorbic acid, acetylsalicylic acid, sodium bicarbonate and potassium chloride supplementation in water on the performance of broiler chickens exposed to heat stress. J. Appl. Poult. Res., 17: 141-144.
6. Ihsan, T., Tayeb, Johnny S. Yokhana and Valel J.A. Amedy, 2011. Effect of ascorbic acid and potassium chloride supplementation on performance and some physiological parameters in broiler chicks reared under summer condition. Int. J. Poult. Sci., 10(3): 247-250.
7. Brake, J.T., 1989. Role of ascorbic acid in Poultry Production: ascorbic acid, stress and immunity. Zootech. Int., pp: 37-40.

8. Sahin, K., O. Kucuk, N. Sahin and M.F. Gursu, 2002. Optimal dietary concentration of vitamin E for alleviating the effect of heat stress on performance, thyroid status ions in broilers. Vet. Med. Czech, 47: 110- 116.
9. Bollenger-Lee, S., M.A. Mitchell, D.B. Utomo, P.E.N. Williams and C.C. Whitehead, 1998. Influence of high dietary vitamin supplementation on egg and plasma characteristics in hens subjected to heat stress. Br. Poultry Sci., 39: 106- 112.
10. Bollengier-Lee, S., P.E.N. Williams and C.C. Whitehead, 1999. Optimal dietary concentration of vitamin E for alleviating the effect of heat stress on egg production in laying hens. Br. Poultry Sci., 40: 102- 107.
11. Sahin, K., N. Sahin, M. Onderci, S. Yaralioglu and O. Kucuk, 2001. Protective role of supplemental vitamin E on lipid peroxidation and some mineral concentration of broilers reared under heat stress. Vet. Med. Czech., 46: 140- 144.
12. Chan, K.M. and E.A. Decker, 1994. Endogenous skeletal muscle antioxidants. Crit. Rev. Food Sci. Nutr., 34: 403- 426.
13. McDowell, L.R., 1989. Vitamins in Animal Nutrition in: McDowell, L. R. (Ed) Comparative Aspects to Human Nutrition. Vitamin C, Folacin, pp: 365- 387, 298- 322. (London, Academic Press).
14. Meydani, S.N. and J.B. Blumberg, 1993. Vitamin E and the Immune Response. In: Nutrient Modulation of the Immune Response. S. Cunningham Rundles, ed. Marcel Dekker, New York, N.Y., pp: 223-238.
15. Ciftci, M., O. Nihat Ertas and T. Güler, 2005. Effects of vitamin E and vitamin C dietary supplementation on egg production and egg quality of laying hens exposed to a chronic heat stress. Review Med. Vet., 156(2): 107-111.
16. Mohiti, M.A., S.A. Hosseini, H. Lotfollahian and F. Shariatmadari, 2007. Effect of probiotics, yeast, vitamin e and vitamin c supplements on performance and immune response of laying hen during high environmental temperature. International J. Poult. Sci., 6(12): 895-900.
17. Bautista-Ortega, J. and C.A. Ruiz-Feria, 2010. L-arginine and antioxidant vitamins E and C improve the cardiovascular performance of broiler chickens grown under chronic hypobaric hypoxia. Poult. Sci.. 89(10): 2141-6.
18. Mckee, J.S. and P.C. Harrison, 1995. Effect of supplemental ascorbic acid on the performance of broiler chickens exposed to multiple concurrent Stressors. Poultry Sci., 74: 1772-1785.
19. Pardue, S.L., J.P. Thexton and J. Brake, 1985. Role of ascorbic acid in chicks exposed to high environmental temperature. J. Appl. Physiol., 58: 1511-1516.
20. Yahav, S. and S. Hurwitz, 1996. Induction of thermo-tolerance in male broiler chickens by temperature conditioning at an early age. Poultry Sci., 75: 402-406.
21. Arjona, A.A., D.M. Denbow and W.D. Weaver, 1988. Effect of heat stress early in life on mortality of broilers exposed to high environmental temperatures just prior to marketing. Poultry Sci., 67: 226-231.
22. National Research Council. (NRC), 1994. Nutrient Requirement of Poultry. National Academy Press, Washington, D.C.,
23. A.O.A.C. 1990. Official Methods of Analysis 15th ed. (Arlington, VA, Association of Official Analytical Chemists).
24. Jakobson, P.E., S.G. Kirston and H. Nelson, 1960. Digestibility trails with poultry.322 berthing fraforsgs laboratories Udgevet of Satens. Husdyrbugsudvaly Kabenhavn. C.F. Soliman. 1983.
25. SAS. Institute, 1994, SAS® User's GUIDE: Statistics V.6. 04 ED. NS, SAS Institute Inc. Cary, NC, USA.
26. Yahav, S., A. Straschnow, I. Plavnik and S. Hurwitz, 1997. Blood system response of chickens to changes in environmental temperature. Poultry Sci., 76: 627-633.
27. Yahav, S. and I. Plavnik, 1999. Effect of early- age thermal conditioning and food restriction on performance and physiological response of chickens. Br. Poultry. Sci., 40: 120- 126.
28. Hurwitz, S., M. Weiselberg, U. Eisner, I. Bartov, G. Riesenfeld, M. Sharvit, A. Niv and S. Bornstein, 1980. The energy requirements and performance of growing chickens and turkeys as affected by environmental temperature. Poulty Sci., 59: 2290-2299.
29. Cooper, M.A. and K.W. Washburn, 1998. The relationships of body temperature to weight gain, feed consumption and feed utilization in broiler under heat stress. Poultry Sci., 77: 237-242.
30. Yalcin, S., S. Ozkan, Z. Acikgoz and K. Ozkan, 1998. Influence of dietary energy on bird performance, carcass parts yields and nutrient composition of breast meat of heterozygous naked neck broilers reared at natural optimum and summer temperatures. Br. Poultry Sci., 39: 633- 638.

31. Tollba, A.A.H. and M.S.H. Hassan, 2003. Using some natural additives to improve physiological and productive performance of broiler chicks under high temperature conditions. Egypt. Poultry Sci. J., 23(II): 327- 340.
32. Mckee, J.S., C. Harrison and G. L. Riskowski, 1997. Effect of supplemental ascorbic acid on the energy conversion of broiler chicks during heat stress and feed withdrawal. Poultry Sci. 76: 1278-1286.
33. Xiang, R.P., W.D. Sun, J.Y. Wang and X.L. Wang, 2002. Effect of Vitamin C on pulmonary hypertension and musculorsation of pulmonary arterioles in broilers. Br. Poultry Sci., 43: 705- 712.
34. Allen, P.C. and R.H. Fetterer, 2002. Interaction of dietary vitamin E with eimeria maxima infections in chickens. Poultry Sci., 81: 41- 48.
35. El-Moslimany, A.M., 2000. Broiler behaviour and management in hot climate. M. Sc. Thesis, Fac. of Vet. Med. Tanta Univ.,
36. El-Gabeary, I.G., 1999. Studies in role of vitamin C on the performance of poultry raised under stress and parasitic diseases. M. Sc. Thesis, Fac. of Vet. Med. Tanta Univ.,
37. Attia, A.I., I.I. Hassan, A.A. El Zaiat and A.A. Abed El Maksoud, 2003. Effects of dietary oil and ascorbic acid on the performance of broiler chicks under Egyptian summer conditions. (Abst) Egyp. J. Nutr. & Feeds (special Issue) 6: 3- 4.
38. Swain, B.K., T.S. Johri, S. Majumdar, 2000. Effect of supplementation of vitamin E, selenium and their different combinations on performance and immune response of broilers. Br. Poultry Sci., 41(3): 287- 292.
39. Sahin, K. and O. Kucuk, 2001. Effects of vitamin C and vitamin E on performance, digestion of nutrients and carcass characteristics of Japanese quails reared under chronic heat stress (34°C). J. Anim. Physiol. Anim. Nutr., 85: 335- 342.
40. AL-Homidan, A.A., 2000. Effect of vitamin C in water for broilers raised under two different ambient temperatures on growth performance and water consumption. Egypt. Poultry Sci., 20(II): 327-346.
41. El-Nabarawy, N.H.M., 1997. Study of physiological and genetic bases of the tolerance to heat stress in Japans Quail. M.Sc. Thesis, Fac. of Agric. Ain-Shams Univ.,
42. El-Gendy, E. and K.W. Washburn, 1995. Genetic variation in body temperature and its response to short term acute heat stress in broilers. Poultry Sci., 74: 225- 230.
43. Altan, O., A. Altan, I. Oguz, A. Pabuccuolu and S. Konyalioug lu, 2000. Effects of heat stress on growth, some blood variables and lipid oxidation in broilers exposed to high temperature at an early age. Br. Poultry Sci., 41: 489- 493.
44. Sandercock, D.A., R.R. Hunter, G.R. Nute, M.A. Mitchell and P.M. Hocking, 2001. Acute heat stress-induced alterations in blood acid- base status and skeletal muscle membrane integrity in broiler chickens at two ages: implications for meat quality. Poultry Sci., 80: 418-425.
45. Arjona, A.A., D.M. Denbow and W.D. Weaver, 1990. Neonatally-induced thermotolerance: Physiological responses. Comp. Bio. Chem. Phsiol., 95: 393- 399.
46. Tayeb T. Ihsan, 2009. Evaluation of productive and physiological performance of broiler subjected to different methods to relieve heat stress. Ph.D Thesis, Animal Resources Dept. College of Agriculture and Forestry University of Mosul.
47. El-Boushy, A.R., 1988. Vitamin E affects viability, immune response of poultry Feedstuffs, 60: 20-26.
48. McCormick, C.C., J.D. Garlich and F.W. Edens, 1979. Fasting and diet affect the tolerance of young chickens exposed to acute heat stress. Nutr. J., 109: 1797-1809.