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EFFICACY OF DIETARY VITAMIN C, E AND THEIR COMBINATION ON EGG PRODUCTION AND EGG QUALITY OF DOKKI-4 LAYING HENS DURING EGYPTIAN SUMMER SEASON

Hassan, R. A.; El-Samra H. A. Abo Egla*; F. S. A. Ismail* and E.O. Z. Gaber*.**

*** Poultry Prod. Dept., Fac.Agric.,Mansoura Univ.**

****Anim. Prod. Res. Inst., Agric. Res. Center, Ministry of Agriculture.**

ABSTRACT

An experiment was conducted to study the effects of adding vitamin C (L-ascorbic acid), vitamin E (∝- tocopherol acetate) and their combination to diets on productive performance, egg quality and some blood plasma constituents of Dokki-4 laying hens during summer season in Egypt. The experimental period lasted from June to September, 2010. A total of 120, 30 weeks old Dokki-4 hens were randomly divided into four equal groups, each contained 3 equal replications. First group was fed a basal diet (control group).The other groups were fed the basal diet supplemented with 250 mg vitamin C/ kg diet (group 2),150 mg vitamin E /kg diet (group 3) and 250 mg vitamin C plus 150 mg of vitamin E (group 4).The results indicated that supplementation of the basal diet with the combination of vitamin C and E (group 4) resulted in positive effects on final body weight, egg production, egg weight, egg mass, feed intake and yolk index as compared to those of the control group. However, feed conversion was numerically improved for the birds received the vitamin supplemented diets as compared to the control hens. Shell thickness was significantly ($P \leq 0.05$) improved with adding vitamin E alone or in combination with vitamin C as compared to their control counter parts. Blood Plasma protein was significantly increased in hens given vitamin C alone or in combination with vitamin E compared with their controls Plasma cholesterol concentration was significantly decreased, whereas plasma levels of calcium and phosphorus were significantly increased response to dietary single and combined addition of vitamins C and E as compared to those of the control group. Dietary supplementation with 250 mg ascorbic acid plus 150 mg vitamin E proved to be an effective practice for alleviating the adverse effects of heat stress on Dokki-4 laying hens during summer season in Egypt.

Keywords: Vitamin C, vitamin E, heat stress, laying hens, performance

INTRODUCTION

Heat stress in laying hens is prompted by combinations of environmental temperature and humidity that prevent the bird's thermoregulatory process from effectively dissipating the heat produced during metabolism (Webster, 1983). High environmental temperature is the major problem faced by laying hens as well as poultry farmers usually in summer months. The ideal ambient temperature for laying hens is about 20°C (North and Bell, 1990). Heat stress begins when the ambient temperature climbs above 25°C and is readily apparent above 30°C. Heat stress in laying hens reduces their live weight gain, feed intake, feed efficiency, production and quality of eggs and increases mortality (Demir *et*

al., 1995 and Bolleengier-Lee *et al*., 1999). The researchers have tried to minimize the effect of heat stress by changing the environment and diets of laying hens. Environmental approaches include increasing the airflow over birds to increase heat loss, increasing ventilation rates, or using evaporative cooling systems in enclosed houses and lowering stocking densities. Nutritional modifications that usually made are the optimization of diets for covering the altered needs of stressed birds for protein and energy and for providing some additional nutrients. Because it is expensive to cool poultry houses, methods are focused mainly on nutritional modifications. For this aim, vitamin C and vitamin E are used in the poultry diet because of their anti-stress effects and also because of ascorbic acid synthesis is reduced during heat stress (Njoku, 1986 and Gonzalez-Vega-Agirre *et al.,* 1995). Vitamin E serves as a physiological anti-oxidant through inactivation of free radicals. Bolleengier- Lee *et al.* (1998) reported that heat stress impairs the synthesis and release of vitellogenin and that dietary supplementation with Vitamin E facilitates release of vitellogenin necessary for yolk formation. In the same way, under hot climate conditions, birds are not able to synthesize sufficient amounts of ascorbic acid (Kutlu and Forbes 1993) and supplemental ascorbic acid could significantly reduce the body temperature (Pardue *et al*., 1985; Orban *et al.,* 1993). Therefore, mortality rate observed during heat stress with adequate ascorbic acid supply is generally lower (Kafri and Cherry 1984).
David and Brake (1985) found that dietary supplementation with 1000 ppm ascorbic acid to supplementation in broilers reduced mortality by 14.6%. During heat stress, corticosterone increases the conversion of nor-epinephrine to epinephrine, which induces degeneration of ovarian follicles (Moudgal *et al.,* 1985).

The objective of this study was to determine the possible beneficial effects of dietary supplementation with vitamin E, vitamin C, and their combinations on egg production and egg quality of Dokki-4 laying hens exposed to a chronic heat stress during summer season in Egypt.

MATERIALS AND METHODS

A total of 120 local laying hens (Dokki-4), 28-week-old, were divided into four groups of 30 hens. Each group was divided into three replicates, each consisted of 10 hens. The laying house was provided with 17 h light per day. The hens were randomly assigned according to initial body weights. Feed and water were given *ad libitum.* The hens were vaccinated against Marek and Newcastle diseases. Similar manageral conditions were maintained for all groups. Values of temperatures and relative humidity were recorded at a particular time daily (at 08.00 h A.M and at 14.00, 20.00 and 02.00 h P.M within the laying house). The experiment was carried out from June to September 2010. The relative humidity ranged between 45-75% and the range of daily temperature in the hen house was between 23 - 38°C.

Treatment groups were fed a basal diet (control group) or the basal diet supplemented with either 150 mg of $\propto$-tocopheryl acetate /kg of diet (Vitamin E group), 250 mg of L-ascorbic acid /kg of diet (Vitamin C group) or

150 mg of∝∝-tocopheryl acetate /kg of diet plus 250 mg of L-ascorbic acid / kg of diet (Vitamin E + C group). Vitamin C (ROVIMIX® STAY-C® 35) and vitamin E (ROVIMIX® E-50 SD) were provided by a commercial company (Roche, Levent-Istanbul, Turkey). The experimental diets were formulated to meet the nutrient requirements of local laying hens according to the Ministry of Agriculture Decree (AMD, 1996). Ingredients and chemical composition of the basal diet are shown in Table 1. Body weights laying hens were recorded at the beginning and at the end of the study to determine body weight changes. During the experimental period, egg number and egg weight were recorded daily. The average daily egg production and the daily feed consumption per replicate were calculated for the entire experiment period.

Table (1): Composition and calculated analysis of the basal diet:

Ingredients	%
Yellow corn	66.00
Soybean meal (44%)	24.00
Limestone	7.59
Di-calcium phosphate	1.71
Sodium chloride	0.30
Vit.& Min. Mixture*	0.30
DL.Methionine	0.10
Total	100
Calculated analysis	
Metabolizable energy (kcal/kg)	2750
Crude Protein, %	16.43
Crude fiber, %	3.20
Ether extract, %	2.70
Calcium, %	3.33
Available P, %	0.45
Total P , %	0.66
Lysine, %	0.86
Methionine, %	0.39

***Supplied per kg of diet: vit.A, 10000 IU; D_3, 2000 IU; Vit.E, 10mg; Vit.K_3,1mg; vit.B_1, 1mg; vit. B_2, 5mg; vit.B_6, 1.5mg; vit. B_{12}, 10µg; Niacin, 30mg; Pantothenic acid, 10mg; Folic acid, 1mg; Biotin, 50µg; Choline, 260mg; Copper, 4mg; Iron; 30mg; Manganese, 60mg; Zinc, 50mg; Iodine, 1.3mg; Selenium, 0.1mg; Cobalt, 0.1mg.**

The value of feed conversion ratio (g feed: g egg) was calculated. Egg quality measurements were performed monthly using all eggs produced and freshly collected at the last two consecutive days of each month of the experimental period. These measurements included egg shell thickness, haugh units, indices of yolk, albumen and egg shape, and components. Shell thickness (without membranes) was measured by a special micrometer, as an average of three readings at the equator, sharp and large ends of the egg. Haugh units (HU) were calculated with the HU formula (Eisen *et al*., 1962) based on egg weight and the height of albumen determined by a tripod micrometer. Yolk height was also determined by the same micrometer while yolk and thick albumen diameters as well as width and length of the egg were measured using a steel vernier caliper Yolk index was calculated as yolk height times 100 divided by yolk diameter (Walls, 1968). Albumen index was estimated as albumen height times 100 divided by average albumen width and albumen length (Kul and Seker, 2004). Egg shape index was measured as egg width time 100 divided by egg length. Blood samples were collected, at the end of the experiment, from 3 hens per treatment (5 ml / hen) from the brachial vein and transferred into heparanized test tubes. Samples were centrifuged at 3200 rpm for 15 minutes and plasma was separated in clean dry vials and then stored at -20^{0}C until they were analyzed. Blood plasma total protein (g/dl) was measured according to Weichselbaum (1946). Albumin concentration (g/dl) was determined according to Doumas *et al*. (1977). Globulin concentration (g/dl) was calculated as the difference between total protein and albumin. Plasma total cholesterol (mg/dl) was determined according to the method of Watson (1960). Calcium (mg/dl) and phosphorus (mg /dl) were determined calorimetrically using computerized spectrophotometer (Milton Roy Spectronic, 1201). All data were analyzed using the SAS General linear Model procedure (SAS, 1996). Mean values were compared using Duncan multiple range test (Duncan, 1955) when significant differences were existed.

RESULTS

During the experiment, laying house temperature ranged between 23 and 38°C, while the maximum and minimum values of its relative humidity were 45% and 78%. Table 2 shows the effects of dietary supplementation with vitamin E and vitamin C supplementation singly or in combination, on productive performance of Dokki-4 laying hens during summer. Final body weight, feed intake, egg weight, egg mass and hen-day egg production rate were significantly greater ($P<0.05$) in the group of hens fed the diet supplemented with vitamin E + Vitamin C compared to those of the control group, however, feed conversion ratio was numerically improved in this group compared with their control counterparts.

Table (2) : Productive performance of laying hens as affected by dietary vitamin C and vitamin E supplementation during summer season

Parameters	Control	Vit. C	Vit. E	Vit.C+vit.E	SEM	P-value
Initial body weight (g)	1410.00	1400.00	1403.33	1421.66	4.77	0.439
Final body weight (g)	1480.00^b	1510.00^{ab}	1516.66^{ab}	1570.00^a	11.10	0.006
Egg production %*	54.33^b	57.00^{ab}	58.00^{ab}	61.00^a	1.07	0.017
egg weight (g)	47.83^b	48.60^{ab}	49.00^{ab}	49.50^a	0.436	0.016
Egg mass kg/hen/16wk	2.80^b	3.00^{ab}	3.00^{ab}	3.10^a	0.039	0.027
Feed intake g/hen/dag	81.33^b	85.66^{ab}	85.00^{ab}	86.00^a	0.633	0.005
Feed conversion ratio(g feed/g egg)	3.25	3.20	3.21	3.10	0.028	0.344

Overall means, within a row , followed by different superscripts differ significantly ($P<0.05$).
***Hen day egg production.**

The effect of supplemental dietary vitamin C and / or Vitamin E during summer condition on egg components and egg quality are shown in Table 3. Dietary supplementation with vitamin C + vitamin E for laying hens reared under heat stress improved the egg quality of Dokki-4 hens in the terms of yolk index and shell thickness as compared to those of the controls. However, Haugh unit values were similar to the control birds.

Data given in Table 4 show that dietary supplementation with vitamin E had no significant effect on blood plasma levels of total protein, albumin or globulin, However, supplemental vitamin C singly or in combination with vitamin E significantly reduced levels of plasma albumin and increased concentrations of plasma protein and globulin (Table 4). Supplemental Vitamin C, vitamin E or their combination to heat-stressed hens significantly reduced the levels of plasma cholesterol and significantly increased the concentrations of plasma calcium and phosphorus as compared to those of the control group.

Table (3): Egg components and egg quality of laying hens as affected by dietary vitamin C and vitamin E supplementation during summer season

parameters	control	Vit. C	Vit. E	Vit.C+Vit.E	SEM	p-value
Yolk(%)	32.20	32.50	32.40	32.40	0.151	0.926
Albumin (%)	58.0	57.5	57.6	57.5	0.179	0.780
Shell weight (%)	9.8	10.0	10.0	10.2	0.096	0.603
Yolk index (%)	57.8^{b}	58.0^{b}	58.2^{b}	58.8^{a}	0.135	0.019
Albumin index (%)	11.0	11.3	11.6	11.6	0.115	0.202
Egg shape index	79.13	79.0	79.5	79.8	0.176	0.412
Shell-thickness (mm)	0.330^{b}	0.346^{ab}	0.350^{a}	0.356^{a}	0.005	0.041
Haugh unit	83.5	83.80	84.2	83.85	0.105	0.111

Means in the same row bearing different superscripts differ significantly (P<0.05).

Table (4) : Some blood plasma constituents of laying hens as affected by dietary vitamin C and vitamin E supplementation during summer season

Parameters	control	Vit. C	Vit. E	Vit.C+ Vit. E	SEM	p-value
Total protein (g/dl)	4.30^{b}	4.80^{a}	4.50^{ab}	4.96^{a}	0.111	0.012
Albumin (g/dl)	2.85	2.35	2.81	2.33	0.096	0.062
Globulin (g/dl)	1.45	2.45	1.69	2.63	0.121	0.055
Cholesterol (mg/dl)	145.33^{a}	130.30^{b}	127.66^{b}	123.00^{b}	2.69	0.001
Calcium (mg/dl)	9.50^{b}	12.25^{a}	12.38^{a}	13.00^{a}	0.458	0.005
Phosphorus (mg/dl)	7.23^{b}	9.00^{a}	8.95^{a}	9.30^{a}	0.272	0.003

Means in the same row bearing different superscripts differ significantly (P<0.05).

DISCUSSION

Significant negative effects on egg weight, egg production, feed intake , feed conversion ratio and some egg quality occurred in the experimental laying hens when exposed to the high ambient temperature during summer season (Tables 2 and 3). In the present study, dietary supplementation with vitamins C and E supplementation increased feed intake and improved the productive performance indicating a synergistic effect for the two supplements via alleviating the negative effects of the heat stress. Performance and feed intake of birds have been found to decrease when ambient temperature rises above the thermo neutral zone (Siegel, 1995 and Ensminger *et al*., 1990). The reduced feed intake in the present study (Table 2) during summer season may be caused by a direct effect on various regions of the brain acting on feed intake control mechanism. Also, the blood flow and the motility of the intestine may be decreased, leading to a decrease in the rate of food passage and delaying the thermogenic effect of food intake (Van-Handel – Hruska *et al.,* 1977). El–Tantawy *et al*. (1998) found that feed consumption was lower in high environmental temperature by about 36 – 43%.

In our study, the simultaneous dietary supplementation with vitamin E and vitamin C of laying hens exposed to heat stress caused significantly improved performances (increases in egg production, feed conversion ratio, and feed intake, and body weight change) and egg qualities (egg weight, shell thickness and yolk index). Additions of vitamin E or vitamin C singly into diets appeared to be less beneficial for laying hens during heat stress. Desoky (2008) reported that supplementation of the diet with vitamin C and vitamin E resulted in positive effects on final body weight, egg production and mortality as compared to the control group. Combination of 125 ppm Vitamin E and 200 ppm Vitamin C in diets of laying hens that exposed to a chronic heat stress increased significantly their body weight gain (Ciftci *et al.,* 2005). The improvement of growth rate by Vitamin E supplementation might be a result of stimulating thyroid hormones secretion in laying hens exposed to high ambient temperature. Thyroid hormones are major regulators of development, metabolism and homeostasis in birds. They influence body weight and the growth of muscles, chondrocytes and the bones (King and May, 1984). Vitamin E has been demonstrated to be an antioxidant that scavenges the free radicals generated in cell membranes (Bartov and Frigg 1992 and Zuprizal *et al.,* 1993). In this respect, Degkwitz, (1987) reported that body weight was improved by ascorbic acid due to action in increasing metabolic rate in the body.

In addition, vitamin C itself plays important roles in cellular anti-oxidant defenses, not only by reacting with all oxygen species through formation of dehydroascorbyl, a particular inert radical, but also by transferring radical equivalents from lipid phases to aqueous compartment (Halliwell and Guttwridge, 1989). As a complement, ascorbate participates in the regeneration of reduced glutathione from oxidized form in the cytoplasm and allows tocopherol regeneration through a non-enzymatic reaction (Luadicina and Marnett, 1990). The synergic effects between these two vitamins are particularly efficient for reducing production of reactive oxygen species. Heat stress leads to generation of free radicals, such as O2- and HO. These free radicals can damage cell membranes by inducing lipid peroxidation of polyunsaturated fatty acids in the cell membrane (NRC, 1994). Because radical reactions are exergonic, they contribute to the failure of thermoregulation process leading to the increase of body temperature observed during heat stress. Consequently, dietary supplementation of birds with vitamin E, vitamin C or a combination of these 2 anti-oxidant compounds would attenuate the deleterious heat-induced oxidative stress.

The beneficial protective effects of vitamin E and C and their combination were evidenced by increases of body weight gain and egg production and qualities in supplemented laying hens in comparison to control birds. In the same way, previous reports have shown that elevated dietary vitamin E can enhance disease resistance in pullets raised under heat stress conditions of 34°C for 14 h/day and 24°C for 10 h/day (Ward, 1995). Other reports have indicated that supplemental ascorbic acid was able to significantly reduced the body temperature of heat – stressed animals (Cheng, *et al.,* 1990 and Gey, 1998). Besides, Scheidler and Froning (1996) have demonstrated that egg production was significantly improved in hens fed various flaxseed diets supplemented with a high level of vitamin E (50 IU/kg diet) compared to hens fed the same diets containing a low level of vitamin E (27 IU/kg diet). During heat stress, hepatic synthesis of vitellogenin, a protein precursor for yolk formation, and its release into blood were impaired (Bolleengier-Lee *et al*., 1998 and Whitehead *et al.,* 1998) leading to decreases in plasma vitellogenin concentrations and in plasma/liver vitellogenin ratio. Dietary supplementation with vitamin E can improve egg production by facilitating the release of vitellogenin from the liver and by increasing its concentration into blood (Bolleengier-Lee *et al*., 1998). In experiments conducted by Whitehead *et al.* (1998), layers were maintained in environmentally controlled houses at 22°C, then held for 1 month at 32°C, and finally returned to 22°C. Dietary vitamin E levels of 315 IU/kg resulted in higher rates of lay and better feed conversion efficiency during the hot period and in the following months, suggesting that the NRC (1994) recommendations of 5 IU/kg for laying hens is too low for birds held in hot climates. In addition, the possible benefits of higher vitamin E supplementation on performance of birds subjected to long-term exposure to high temperatures (tropical heat conditions) have to be explored. Because heat stress increases the needs to anti-oxidant vitamins and because birds cannot synthesize enough ascorbate during hot climate conditions (Gey, 1998, Cheng, *et al*., 1990, and Orban, *et al.* 1993), dietary supplementation with high dosages of vitamins E and/or C would be conducted. In our study, we observed positive effects of supplementation with ascorbate alone on bird performances (growth and egg production). Nijoku and Nwazota (1989) demonstrated that high dietary vitamin C (200, 400 and 600 mg/kg) supplementation significantly increased egg production in hens exposed to heat stress. Similarly, Demir *et al.* (1995) reported that vitamin C supplementation in feed (200 mg/kg) during heat stress increased feed intake and eggshell thickness. On the other hand, some reports indicated that nutrient digestibility and absorbability are affected by heat stress. Zuprizal *et al.* (1993) have shown that true digestibility of proteins and amino acids from two different protein sources (rapeseed and soybean meals) decreased as the temperature increased from 21 to 32°C. Activities of trypsin, chymotrypsin, and amylase significantly decreased at high temperature (32°C) (Haib, *et al*., 2000). The reason for the decrease in activity of these digestive enzymes is uncertain. But it is probable that the optimal temperatures for enzymatic functions were below 32°C. Several studies (Osman and Tanios, 1983, Wallis and Balnave, 1984 and Puthpongsiriporn *et al.,* 2001) have demonstrated that dietary supplementation with vitamin E and/or vitamin C alleviates the heat stress negative effects on apparent nutrient digestibility. Mckee and Harrison (1995) also detected an improvement in feed conversion ratio of broilers as a result of vitamin C supplementation during heat stress. It is well known that vitamin C improves iron assimilation by reducing the ferric ion (Fe3+) into ferrous ion (Fe2+) , which is more assimilated in intestine and thereby vitamin C improves resistance to infections. Within the intestinal lumen the oxidative lesions lead to conformational modifications of proteins could induce pancreatic enzyme inhibition and/or resistance of dietary protein to digestion. Consequently, the presence of anti-oxidants (vitamin E and/or C) could partially interfere with the oxidative protein denaturation and would improve digestibility of nutrients and feed efficiency. The current data showed that Vitamin E, Vitamin C or their combination could significantly increased the egg shell thickness as compared to that of the control group reared under high environmental temperature this improvement in egg shell quality, as measured by shell thickness, could be due to an enhancement of calcium bioavailability by the action of supplemental Vitamin E and/or Vitamin C. These facts confirm the higher blood plasma Ca concentrations of laying hens that has been established in the present study in response to dietary supplementation with vitamin E, vitamin C or their combintion (Table 3). Vitamin C, vitamin E, or their combination reduced the levels of plasma cholesterol and increased the plasma concentrations of phosphorus significantly compared to the control group reared under high environmental temperature. Even though high environmental temperature depresses the concentration of plasma calcium in broiler chicks (Kutlu and Forbes, 1993), dietary supplementation with vitamin C improves calcium metabolism via increasing plasma calcium concentration (Shahin *et al*., 2002), Moreover, the supplementation of diets containing polyunsaturated fatty acids with vitamin E results in reducing the cholesterol level and maximizing fat burning (Zanini *et al*., 2003 and Bourre and Galea, 2006).

Vitamin E supplementation was claimed to influence the oestradiol dependent mechanisms by exerting a direct effect on oestradiol or an indirect effect through maintaining normal functioning of cellular processes regulating oestradiol and restoration of estrogen secretion (Bolleengier-Lee et *al.,* 1998). Oestradiol has an effect on circulating calcium through its regulating role of synthesis of 1,25 dihydroxy cholecalciferol that regulates calcium absorption (Taylor and Dacke, 1984) . Circulating calcium and estrogen concentrations are highly correlated in laying hens (Tojo and Huston, 1980) and oestradiol concentration has been shown to be depressed in hens subjected to heat stress (Tojo and Huston, 1980 and Mahmoud *et al*., 1995).

In conclusion, dietary supplementation of laying hens with anti-oxidant vitamins (vitamin E or vitamin C or a combination of the both compounds) can attenuate heat stress induced oxidative damage. These positive effects were evidenced by increases of final body weight, egg production and improvements in egg qualities in comparison to non-supplemented birds. Moreover, supplementation with both vitamin E and vitamin C is the most efficient dietary treatment probably because these two anti-oxidant compounds act synergetically for intactivating the reactive oxygen species.

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كفاءة التغذية على فيتامين ج أو فيتامين هـ أو اتحادهما معا على انتاج البيض وجودة البيض للدجاج البياض المحلى خلال موسم الصيف فى مصر

رضا على حسن، السمرة حسن على ابو عجله* ، فوزى صديق عبد الفتاح اسماعيل* و اسراء اسامة زكى جابر***

*** قسم انتاج الدواجن_ كلية الزراعة جامعة المنصورة**

****معهد بحوث الانتاج الحيوانى _ مركز البحوث الزراعية _ وزارة الزراعة**

تهدف هذة الدراسة الى دراسة تأثير اضافة فيتامين ج و فيتامين هـ منفردا او كلاهما الى علائق الدجاج البياض على الكفاءة الانتاجية وجودة البيض وبعض مكونات بلازما الدم فى الدجاج البياض المحلى خلال موسم الصيف فى مصر. واجريت هذه التجربة من شهر يونيو حتى سبتمبر٢٠١٠. تم استخدام ١٢٠ دجاجة بياضة من سلالة دقى -٤ عمر ٣٠ أسبوع وتم توزيعها عشوائيا الى اربعة مجاميع وكل مجموعة تتكون من ثلاث مكررات وكل مكررة تتكون من ١٠ دجاجات .تم تغذية المجموعة الأولى على عليقة اساسية (الكنترول) وتغذت المجاميع الاخرى على عليقة اساسية مضاف اليها ٢٥٠ مليجرام فيتامين ج / كجم علف (مجموعة ٢) و ١٥٠مليجرام فيتامين هـ / كجم علف (مجموعة٣) و ٢٥٠ مليجرام فيتامين ج / كجم علف + ١٥٠مليجرام فيتامين هـ / كجم علف(مجموعة ٤) على التوالى. اظهرت النتائج ان اضافة فيتامين ج مع فيتامين هـ (مجموعه ٤) لها تأثيرات ايجابية على وزن الجسم النهائى وانتاج البيض ووزن البيض وكتلة البيض والعلف المستهلك ودليل الصفار بالمقارنة بمجموعة الكنترول بينما الكفاءة الغذائية تحسنت فى الطيور التى تناولت الفيتامينات فى العلف بالمقرنه بمجموعة الكنترول . تحسن معنويا سمك القشرة باضافة الفيتامينات منفردة او متحدة معا بالمقارنة بمجموعة الكنترول. زاد البروتين فى بلازما الدم معنويا فى الدجاج الذى يتناول الفيتامينات منفردة او متحدة معا بالمقارنه بمجموعة الكنترول . وانخفضت قيم تركيز الكوليسترول فى حين حدوث زيادة فى قيم الكالسيوم والفوسفور كاستجابة لاضافة الفيتامينات منفردة او متحدة معا. ومن هنا نجد ان التغذية على اضافة ٢٥٠ مليجرام حمض اسكوربيك مع ١٥٠ مليجرام فيتامين هـ لها تأثير ايجابى لتقليل التأثيرات السلبية للاجهاد الحرارى للدجاج البياض خلال فصل الصيف فى مصر.

قام بتحكيم البحث

أ.د / عبد البصير حمزه ابو ريا	**كلية الزراعة – جامعة المنصورة**
أ.د /حسن صابر زويل	**كلية الزراعة – جامعة الأسكندريه**