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The Effect of Vitamin E and Vitamin C on the Performance of Japanese Quails (*Coturnix Coturnix Japonica*) Reared under Heat Stress during Growth and Egg Production Period

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ABSTRACT : This study was carried out to determine the effect of vitamin E and vitamin C on the performance of Japanese quails (*Coturnix coturnix japonica*) reared under heat stress during the growth and egg production period. A total of 810 seven-day-old Japanese quails were used in the trial. The birds received a diet with either three levels of vitamin E (DL-α Tocopheryl acetate) (60, 120 and 240 mg/kg of diet) and vitamin C (ROVIMIX STAY-C 35) (60, 120 and 240 mg/kg of diet). Live weight on day 35 and weight gain were the lowest in the group of chicks on a combination of 60 mg of vitamin E and 60 mg of vitamin C, whereas the highest live weight was demonstrated in chicks on a combination of 240 mg of vitamin E and 240 mg of vitamin C ($p<0.01$). The effects of treatments on cumulative feed consumption, feed conversion ratio, age at 5% lay , sexual maturity weight, rate of lay and mean egg weight values were found to be significant ($p<0.01$). The highest feed consumption, feed conversion ratio, age at 5% lay, sexual maturity weight, rate of lay and mean egg weight values were found in the group on a combination of 240 mg of vitamin E and 240 mg of vitamin C. The effect of treatments on the mortality ratio was found to be insignificant ($p>0.01$). The cost of supplementing diets with vitamin E and vitamin C is very low. Therefore such a combination of supplement can offer a potential protective management practice in preventing heat stress related losses in performance of Japanese quails. (**Key Words :** Japanese Quail, Heat Stress, Vitamin E, Vitamin C)

INTRODUCTION

Economic losses in heat-stressed poultry birds such as high morbidity and mortality, immune suppression, poor FCR and reduced growth rate are well known (Utomo et al., 1994; Siegel, 1995). The maximum temperature associated with satisfactory poultry performance is approximately 30°C at high relative humidity (Daghir, 1995). Ambient temperatures above 32°C are considered to have a detrimental effect on the performance of poultry (Kirunda et al., 2001). In quails the ambient temperature is between 18-30°C. However, with the optimal temperature around 21-27°C, cooling is required when temperatures exceed 30°C (Shanaway, 1984).

To reduce the heat stress in poultry provision of clean and cool drinking water, reducing the number of birds per cage, feeding during the cooler times of day, and addition of electrolyte supplements to their dirinking water are being practised (Hillman et al., 1985). Other measures aimed at reducing heat stress in these birds include use of vitamins C and E, and selenium as additives in feeds (Sahin and Kucuk, 2001; Sahin et al., 2002).

Although poultry can synthesize vitamin C, synthesis is inadequate under stressful conditions such as low or high environmental temperature, high humidity, high egg production rate and parasite infestation (Sykes, 1978; McDowell, 1989). Such conditions, particularly in poultry, lead to generation of cytotoxic free radicals damaging the cells and cell membranes, increased protein catabolism, decreased protein biosynthesis and depletion of vitamin C. Vitamin C and E supplementations are reported to be beneficial in alleviating some of the heat stress related physiological responses and improving thermotolerance through their antioxidant effects (Jones et al., 1996; Sahin and Kucuk, 2001; Sahin et al., 2006). Sahin et al. (2003) showed that dietary supplementation of vitamin C and E, particularly as a combination, improved the performance, egg quality and antioxidant status of laying Japanese quails exposed to heat stress. Chee et al. (2005) observed that vitamin C and vitamin E had got effect on egg shell quality of broiler breeder reared under heat stress conditions.

This research was carried out with the aim of

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Table 1. Composition and feeding value of the diets

Diet composition	Broiler starter diet 0-5 wks	Layer diet 6-24 wks
Dry matter (g/kg)	1,000.0	1,000.0
Organic matters (g/kg)	934.7	912.5
Crude protein (g/kg)	230.0	180.0
Ether exract (g/kg)	71.5	51.3
Crude fibre (g/kg)	88.7	124.0
Crude ash (g/kg)	65.1	87.5
Nitrogen free exract (g/kg)	544.7	469.7
ME (MJ/kg)	12.8	11.3
Vitamin premix[a]	0.27	0.27
Trace mineral premix[b]	0.16	0.16

[a] Ingredients in 2 kg of premix (Rovimix 124/v): vitamin A 15, 000,000 IU; cholecalciferol, 3,000 IU; Vitamin E, 15,000 IU; Menadione, 2,500 mg; vitamin B1 1,000 mg; vitamin B2, 10,000 mg; niacin, 70,000 mg; d-Pantothenic acid, 20,000 mg; vitamin B12 4,000 mg; folic acid, 2,000 mg; biotin, 100 mg.

[b] Premix (Remineral CH) supplied for 2 kg: Mn, 80,000 mg; Fe, 25,000 mg; Zn, 50,000 mg; Cu, 7,000 mg; Iodine, 300 mg; Se, 150 mg; Choline chloride, 350,000 mg.

investigating the effect of vitamin E and vitamin C supplementation as a combination on performance of Japanese quails (C*oturnix coturnix japonica*) reared under heat stress during the growth and egg production period.

MATERIAL AND METHODS

A total of 810 seven-day-old Japanese quails were used in the trial. The chicks were weighed on a digital balance with 0.01 g precision and their weights were between 24.8 g and 26.1 g. The birds were randomly assigned to nine treatment group, with three replicates per treatment. Wing numbers were attached to all chicks. The birds received a diet with either three levels of Vitamin E (DL-α Tocopheryl acetate) (60,120 and 240 mg/kg of diet) or vitamin C (Rovimix Stay-C 35; specifically produced for use as a stabilized source of Vitamin C in feed) (60,120 and 240 mg/kg of diet) in a 3×3 factorial design.

The birds were kept in a storey cage system in which each subcage unit (90×48 cm) contained 30 birds (1:2 male to female ratios). The birds were offered feed and water *ad libitum* under conventional conditions. The room temperature was maintained at 33±2°C during the treatment period. The overhead ruby infrared heat lamp was used to keep the temperature constant. The room humidity was set at 50%±5%. The groups were subjected to continuous lighting for 24 h a day for the first two weeks. The lighting period was gradually reduced to 12 hours a day between weeks 2 and 4. This 12-h lighting was kept constant between weeks 4 and 8. After the 8^{th} week, the lighting period was gradually increased to 17 h. The environmental conditions were the same for all groups.

During the growth period individual chicks in the groups were weighed weekly and increases in live weight were recorded; the weightings were done with 0.01 g precision. The feed that remained in the feeder of each group was weighed at every weekend in order to determine the weekly feed consumption at the group level. Deaths in the groups were recorded daily for determining the weekly mortality ratios.

The age of sexual maturity and the sexual maturity weight were determined when the quails laid their first eggs in each pen. This situation forms 5% productivity. Rate of lay and average egg weights of experimental groups were determined starting from the 8^{th} week through the 24^{th} week at 4 week intervals, according to hen-day.

The composition and feeding value of the diets were ascertained by using the Weende analysis according to the findings of Akyıldız (1984) (Table 1).

Data were analyzed by the general linear model program of SAS (1989) using Duncan’s multiple range test to compare treatment means. The Chi-Square analysis was used in the determination of mortality ratios.

RESULTS AND DISCUSSION

The recorded live weight values of the treatment groups

Table 2. Mean live weights (g) of the treatment groups (mean±standard error of the mean)

Treatments		7^{th} Day	14^{th} Day	21^{st} Day	28^{th} Day	35^{th} Day
Vitamin E (mg/kg)	Vitamin C (mg/kg)					
		NS	*	**	**	**
60	60	26.1±1.2	60.8^{d}±1.8	85.8^{d}±3.1	127.5^{c}±6.2	151.2^{d}±5.8
	120	25.3±1.3	63.4^{c}±1.6	90.4^{c}±3.5	130.1^{c}±5.3	165.4^{c}±6.1
	240	24.9±1.2	65.0^{bc}±1.8	94.8^{b}±3.2	137.0^{b} ±5.7	167.4^{c}±6.4
120	60	25.5±1.2	67.2^{b}±1.3	96.1^{b}±4.0	137.4^{b}±6.1	169.2^{c}±6.0
	120	26.1±1.3	72.8^{ab}±1.5	95.1^{b}±4.2	141.8^{b}±6.4	177.2^{b}±6.8
	240	26.0±1.1	68.1^{b}±1.1	96.8^{b}±4.1	139.1^{b}±6.0	170.3^{c}±5.9
240	60	25.3±1.1	74.0^{a}±1.6	97.2^{b}±4.0	140.5^{b}±5.4	178.4^{b}±7.0
	120	24.8±1.2	73.8^{a}±1.5	108.8^{a}±6.1	148.1^{a}±6.4	177.2^{b}±5.8
	240	25.1±1.2	75.7^{a}±1.6	110.1^{a}±5.8	151.0^{a}±7.1	185.6^{a}±7.6

[a, b, c] Values within columns with no common letter differ significantly * p<0.05; ** p<0.01. NS: Not significant.

Table 3. Mean cumulative increase in live weight (g) of the treatment groups (mean±standard error of the mean)

Treatments					
Vitamin E (mg/kg)	Vitamin C (mg/kg)	14th Day	21st Day	28th Day	35th Day
		*	**	**	**
60	60	34.7^{d}±1.8	59.7±3.1	101.4^{c}±6.2	125.1^{d}±5.8
	120	38.1^{c}±1.6	65.1^{c}±3.5	104.8^{c}±5.3	140.1^{c}±6.1
	240	40.1^{bc}±1.8	69.9^{b}±3.2	112.1^{b}±5.7	142.5^{c}±6.4
120	60	41.7^{b}±1.3	70.6^{b}±4.0	111.9^{b}±6.1	143.7^{c}±6.0
	120	46.7^{ab}±1.5	69.0^{b}±4.2	115.7^{b}±6.4	151.1^{b}±6.8
	240	42.1^{b}±1.1	70.8^{b}±4.1	113.1^{b}±6.0	144.3^{c}±5.9
240	60	48.7^{a}±1.6	71.9^{b}±4.0	115.2^{b}±5.4	153.1^{b}±7.0
	120	49.0^{a}±1.5	84.0^{a}±6.1	123.3^{a}±6.4	152.4^{b}±5.8
	240	50.60^{a}±1.6	85.0^{a}±5.8	125.9^{a}±7.1	160.5^{a}±7.6

$^{a, b, c}$ Values within columns with no common letter differ significantly * p<0.05; ** p<0.01.

Table 4. Average cumulative feed consumption values (g) at the 35th day, feed conversion and mortality ratio (%) related to treatment groups (mean±standard error of the mean)

Treatments				
Vitamin E (mg/kg)	Vitamin C (mg/kg)	Cumulative feed consumption for 35th d	Feed conversion (0-35 d)	Mortality ratio (0-35 d)
		**	*	NS
60	60	488.4^{e}±7.8	3.90^{a}±0.2	6.6
	120	518.3^{d}±8.9	3.70^{b}±0.2	5.5
	240	525.8^{c}±10.2	3.69^{b}±0.2	3.3
120	60	534.3^{c}±13.1	3.72^{b}±0.2	4.4
	120	550.2^{b}±14.8	3.64^{c}±0.2	5.5
	240	540.0^{bc}±13.9	3.74^{b}±0.2	3.3
240	60	556.8^{b}±15.1	3.64^{c}±0.2	6.6
	120	551.0^{b}±14.7	3.61^{c}±0.2	4.4
	240	568.8^{a}±15.0	3.54^{e}±0.2	4.4

$^{a, b, c}$ Values within columns with no common letter differ significantly * p<0.05; ** p<0.01.
NS: Not significant.

are given in Table 2, and the mean increases in live weight are given in Table 3. The effect of treatments on the live weight and weight gain were found to be significant (p<0.01). The live weight on day 35 and the weight gain were determined to be the lowest with the group on a combination of 60 mg of vitamin E and 60 mg of vitamin C,, whereas the highest live weight was demonstrated in the group on a combination of 240 mg of vitamin E and 240 mg of vitamin C.

Values related to cumulative feed consumption on day 35 and feed conversion ratios are given in Table 4. The effect of treatments on cumulative feed consumption was found to be significant (p<0.01). The highest feed consumption was found in the group on a combination of 240 mg of vitamin E and 240 mg of vitamin C. The effect of treatments on feed conversion ratio was significant (p<0.01). The worst feed conversion ratio was determined in the group on a combination of 60 mg of vitamin E and 60 mg of vitamin C. The effect of treatments on the mortality ratio was found to be insignificant.

High ambient temperature reduces feed intake, live weight gain and feed efficiency (Donkoh, 1989; Siegel, 1995), thus negatively influencing the performance of poultry. The results of high ambient temperature obtained in this study were similar to these reports. For this reason, vitamin C and vitamin E are used in poultry diets because of their antistress effects, and also because their synthesis is reduced during heat stress (Sykes, 1978; Sahin et al., 2001). Also vitamin E has got an effect on immune system (Lin and Chang, 2006).

The age at 5% lay and sexual maturity weight values determined in the treatment groups are given in Table 5. The difference between the treatment groups with respect to the age at 5% lay and sexual maturity weight were found to be significant (p<0.01). The age at 5% lay, which is a determinant of egg production in quails, was evaluated as the age when the first egg was laid. Age at first egg is of importance since it indicates the sexual maturity age. Nazlıgul et al. (2001) determined that the age when the first egg was laid in combine type quails was the 43rd day which was lower than other work. Testik et al. (1993) determined the sexual maturity age as the 48th and the 49th days in

Table 5. Age at 5% lay (day) and sexual maturity weight (g) related to treatment groups (mean±standard error of the mean)

Treatments: Vitamin E (mg/kg)	Vitamin C (mg/kg)	Age at 5% lay (d)	Sexual maturity weight (g)
		**	**
60	60	42.0^{a}±1.2	165.8^{d}±5.7
	120	42.3^{a}±1.2	165.2^{d}±5.4
	240	42.0^{a}±1.2	176.0^{c}±6.0
120	60	42.3^{a}±1.2	165.4^{d}±5.6
	120	41.6^{a}±1.1	166.3^{d}±5.3
	240	42.0^{a}±1.2	187.1^{b}±6.8
240	60	41.6^{a}±1.2	172.9^{c}±5.8
	120	42.3^{a}±1.2	188.5^{b}±6.2
	240	40.6^{b}±1.1	201.4^{a}±7.4

[a, b, c] Values within columns with no common letter differ significantly.
** p<0.01.

German bred quails and as 60.05 days in quails from France. Koçak et al. (1995) determined this age as 58 days. The age at 5% lay obtained from the present research was earlier compared with the results of these researchers.

The rate of lay and egg weight values of the experimental groups are given in Table 6. The differences determined between the treatment groups with regard to these parameters, beginning from the 8th week to the 24th week, were found to be significant (p<0.01). The highest rate of lay and mean egg weight values were determined in the quails on the highest combination of 240 mg of vitamin E and 240 mg of vitamin C at all weeks.

Several studies have indicated some benefit of dietary vitamin E supplementation to laying hens during heat stress (Whitehead et al., 1998; Bollengier–Lee et al., 1998; Sahin et al., 2001). Considered separately, vitamin C and vitamin E are primary antioxidants in biological systems and break the chain of lipid peroxidation in cell membranes. However, overall antioxidant potential has been reported to possibly be more efficient and crucial than single antioxidant nutrients (Gallo-Torres, 1980). In this respect, vitamin C and vitamin E work together such that vitamin E is the major chain breaking antioxidant in lipid phases such as cellular membrane or low density lipoproteins, and the oxidizing free radical chain reactions are terminated in aqueous compartments, with vitamin C as the terminal reductant (Gey, 1998).

The rates of lay values determined in research based on hen-day were 67.5 to 75.9% for 21-24 wks of age. The rate of lay values determined in research on Japanese quails for different ages and periods based on hen-day were 90.2% for 5-28 weeks of age (Gerken et al., 1988) and 87.5-96.0% for 8-24 weeks of age (Vilcez et al., 1991). Darden and Marks (1988) reported the average egg weight between the generations 1 and 11 as 71.1% and 75.5% for the light and heavy lines, respectively. Nestor and Bacon (1982) stated that both light and heavy lines had rate of lay values inferior to the control line, while Praharaj et al. (1990) reported that the heavy line at 16 weeks of age gave 3.8 less eggs than the control line. Kocak et al. (1995) determined the rate of lay in quails as 83.97 in 25 weeks- period, whereas Jonda (1977) determined this value as 245 annually.

CONCLUSIONS

The results show that vitamin E and C can be used to attenuate the negative effects of heat stress. Stress increases vitamin E and C requirements of poultry. A combination of 240 mg of Vitamin E and 240 mg of vitamin C supplementation may also be useful for live weight, weight gain, cumulative feed consumption, feed conversion ratio, age at 5% lay, sexual maturity weight, rate of lay and mean egg weight of poultry reared under heat stress conditions. Such a combination supplement can offer a potential protective management practice in preventing heat stress related losses in performance of Japanese quails

Table 6. The rate of lay (%)[1] and egg weights (g) related to treatment groups (mean±standard error of the mean)

Treatments		Rate of lay[1] (%)				Egg weight (g)			
Vitamin E	Vitamin C	Age (Weeks)				Age (Weeks)			
(mg/kg)	(mg/kg)	9-12	13-16	17-20	21-24	8	12	16	20
		**	**	**	*	*	**	**	**
60	60	25.7^{d}±1.2	59.4^{c}±1.3	64.7^{d}±1.3	67.5^{d}±1.1	7.2^{d}±0.1	8.1^{c}±0.2	8.7^{c}±0.1	8.8^{c}±0.1
	120	28.0^{c}±1.4	63.2^{b}±1.6	70.4^{c}±2.4	70.1^{c}±1.8	8.5^{c}±0.1	10.4^{b}±0.2	10.2^{b}±0.3	10.1^{b}±0.3
	240	28.1^{c}±1.3	63.0^{b}±1.4	70.6^{c}±2.2	70.3^{c}±1.7	8.2^{c}±0.1	10.5^{b}±0.3	10.4^{b}±0.2	10.3^{b}±0.3
120	60	28.4^{c}±1.3	63.8^{b}±1.5	70.7^{c}±1.8	70.8^{c}±2.1	8.1^{c}±0.2	10.6^{b}±0.2	10.8^{b}±0.2	10.5^{b}±0.2
	120	30.4^{b}±1.2	64.^{b}±1.5	73.6^{b}±1.7	71.8^{b}±1.6	8.5^{b}±0.1	10.5^{b}±0.2	10.6^{b}±0.1	10.7^{b}±0.2
	240	28.7^{c}±1.5	61.^{1}c±1.61	72.4^{b}±1.6	70.5^{b}±1.8	8.1^{c}±0.1	10.7^{b}±0.2	10.5^{b}±0.1	10.7^{b}±0.2
240	60	30.5^{b}±1.3	62.5^{b}±1.5	72.4^{b}±1.7	70.4^{b}±1.5	8.5^{b}±0.1	10.7^{b}±0.3	10.6^{b}±0.1	10.9^{b}±0.2
	120	30.3^{b}±1.3	63.7^{b}±1.4	73.2^{b}±1.8	71.7^{b}±1.8	8.3^{b}±0.1	10.4^{b}±0.2	10.3^{b}±0.1	10.6^{b}±0.2
	240	35.1^{a}±1.7	66.7^{a}±1.5	77.4^{a}±2.4	75.9^{a}±2.0	9.5^{a}±0.2	11.6^{a}±0.3	11.2^{a}±0.3	11.8^{a}±0.3

[a, b, c] Column means within parameter with common superscripts do not differ * p<0.05; ** p<0.01.
[1] Hen day.

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