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THE EFFECT OF SUPPLEMENTATION OF DIET WITH VITAMIN-E AND SELENIUM AND THEIR COMBINATIONS ON THE PERFORMANCE AND LIPID PROFILES OF LAYER CHICKENS

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ABSTRACT

A biological experiment was conducted to study the effect of vitamin E and selenium supplementation on growth performance and lipid profile with two hundred and ten commercial straight run day-older layer chicks. The chicks were randomly allotted into seven treatment groups with three replicates of ten chicks each. The chicks were fed basal diet (T_1), basal diet with 100mg/kg vitamin E (T_2), basal diet with 200mg/kg vitamin E (T_3), basal diet with 0.2mg/kg selenium (T_4), basal diet with 0.4mg/kg selenium (T_5), basal diet with 100mg/kg vitamin E plus 0.2mg/kg selenium (T_6), and basal diet with 200mg/kg vitamin E plus 0.4mg/kg selenium (T_7) for thirty two weeks period. The results revealed that there was no significant difference in body weight of layer chicks for the first four weeks between treatment groups but the body weight of groups (T_6 and T_7) receiving both vitamin E and selenium supplementation is significantly increased ($P<0.05$) during 5-32 weeks period of age. The feed intake of layer chicks did not vary significantly between treatment groups. Chicks receiving supplements of both vitamin E and selenium produced significantly ($P<0.01$) lower total cholesterol, triglycerides, VLDL and LDL cholesterol and significantly higher ($P<0.01$) HDL cholesterol. Present research suggested that vitamin E and selenium influences lipid metabolism by decreasing total cholesterol, triglycerides, VLDL and LDL cholesterol and increasing HDL cholesterol.

KEY WORDS

Trace elements, layers, cholesterol, antioxidant and lipoproteins

INTRODUCTION

Vitamins and minerals are vital nutrients that are involved in both metabolic and physiological processes, which are critical for human and animal health and animal food production. Efficient poultry production is based on the feeding of well balanced diets to highly productive line of birds. The immune system benefits greatly from proper nutrition of the bird. Thus in many instances, proper nutrition decreases the immune suppression associated with the stress response in the bird. It was reported that when formulating feed, nutritionists have to take into account several factors including stress management and immunity enhancement[1].

In this respect, antioxidants play an important role in maintaining bird health, productive and reproductive performance[2]. In birds, free radical generation and lipid peroxidation are responsible for the development of various diseases as well as for a decrease in bird's productivity and product quality[3, 4]. Vitamin E functions as a chain breaking antioxidant which prevents free radical induced oxidative damage by trapping reactive oxyradicals in biological membranes[5]. Trace elements function as parts of proteins, hormones, enzymes or as cofactors that activate specific enzymes. Selenium is a required nutrient for poultry. NRC in 1994 reported that selenium is an essential component of selenium dependent glutathione peroxidase (GSH-Px), an enzyme involved in cellular antioxidant protection.

Vitamin E and GSH-Px are two molecules that help to prevent the oxidative damage. Vitamin E prevents the dangerous molecules (peroxides) from being formed, but even with adequate vitamin E, some peroxides evade destruction. GSH-Px destroys the peroxides before they have a chance to cause membrane damage. GSH-Px concentration and activity is directly related to the selenium status of the animal[6]. Selenium exists naturally in two chemical forms, organic and inorganic. Traditionally, selenium has been added to poultry diet in the form of inorganic sources such as either sodium selenite or sodium selenate[7]. Results of current researches provided evidence that organic form of selenium is generally safer and better absorbed[8].

Lipid accumulation leads to oxidative stress which may contribute to peroxidation of LDL. These peroxidative fatty acids and reactive oxygen species induce hepatic damage. Some researchers have reported that antioxidant supplementation causes significant improvement in blood lipid parameters of humans[9-11]. However, another study has reported that there were no changes in plasma lipoprotein concentrations after antioxidant supplementation[12]. Organic selenium had an advantage in reducing oxidative stress in birds[13]. Organic selenium is an effective antioxidant and hypolipidemic agent in normal hamsters[14]. Several animal studies have also shown that vitamin E supplementation affects lipoprotein metabolism by reducing serum triacylglycerols[15] and total cholesterol, and increasing HDL-cholesterol levels. Selenium and vitamin E are inter-related; hence complete protection of living cells requires both vitamin E and selenium in the diet.

In the light of lack of information on the influence of vitamin E and selenium on lipid profiles in chicken, this study was undertaken to investigate the influence of vitamin E and selenium either independently or simultaneously on growth performance and lipid profile parameters in chicken.

MATERIALS AND METHODS

Two hundred and ten commercial straight run day-old layer chicks belonging to a single hatch were purchased from a local

hatchery, wing banded, weighed and randomly allotted into seven treatment groups with three replicates of ten chicks each. The chicks were fed basal diet (T_1), basal diet with 100mg/kg vitamin E (T_2), basal diet with 200mg/kg vitamin E (T_3), basal diet with 0.2mg/kg selenium (T_4), basal diet with 0.4mg/kg selenium (T_5), basal diet with 100mg/kg vitamin E plus 0.2mg/kg selenium (T_6), and basal diet with 200mg/kg vitamin E plus 0.4mg/kg selenium (T_7).

The chicks of all treatment groups were reared in cages under standard managemental condition throughout the investigation period of 32 weeks. The investigation diet was formulated according to the standard prescribed in Bureau of Indian standards[16]; expect the vitamin E and selenium level in basal diet. Vitamin E in the form of dl-α-tocopheryl acetate (Promix E) and selenium in the form of Sel-plex were incorporated either independently or simultaneously in the basal diet. The chicks were fed with weighed quantity of feed ad libitum and have free access to whole some water.

(i) Growth rate study:

Individual body weight and total feed consumption in each replicate in all the treatment groups were recorded at the end of every 28 days period.

(ii) Collection of blood sample for lipid profile parameters:

Blood samples from all the seven treatment groups were collected on 32nd week of age from the wing vein of the birds for lipid profile studies. Blood was collected in clean glass vials using heparin as an anticoagulant. Plasma was separated and used for the analysis of various lipid parameters.

(iii) Lipid profile studies:

(a) Total plasma cholesterol:

Estimation of total cholesterol in plasma was carried out according to the instruction manuals accompanying the diagnostic kits obtained from Qualigens Diagnostics, Mumbai, India, using enzymatic (Cholesterol esterase, Cholesterol oxidase and Peroxidase) method. The results are expressed as mg/dl of plasma.

(b) Triglycerides in plasma:

Triglycerides estimation in plasma was carried out according to the instruction manuals accompanying the diagnostic kits obtained from Qualigens Diagnostics, Mumbai, India, using enzymatic (Lipoprotein lipase, Glycerol kinase, Glycerol-3-phosphate oxidase, Peroxidase, 4-Aminoantipyrine and ATP) colorimetric method. The results are expressed as mg/dl of plasma.

(c) High Density Lipoprotein Cholesterol (HDL-C) in plasma:

HDL-C estimation in plasma was carried out according to the instruction manuals accompanying the diagnostic kits obtained from Qualigens Diagnostics, Mumbai, India, using phosphotungstate method. The results are expressed as mg/dl of plasma.

(d) Very Low Density Lipoprotein Cholesterol (VLDL-C) in plasma:

The plasma VLDL-C was estimated by employing the Friedwald formula (1972). The results are expressed as mg/dl of plasma.

$$\text{VLDL-C} = \frac{\text{Triglycerides}}{5}$$

(e) Low Density Lipoprotein Cholesterol (LDL-C) in plasma:

The plasma LDL-C was estimated as the difference between total cholesterol and the sum of VLDL-C and HDL-C. The results are expressed as mg/dl of plasma.

LDL-Cholesterol = Total Cholesterol-(VLDL-C + HDL-C)

(iv) Statistical analysis

The collected data on various parameters were subjected to analysis of variance for statistical significance as per the methods of Snedecor and Cochran[17].

RESULTS

1. Growth performance:

The mean body weight gain of layer chicks from 1 to 16 and 17 to 32 weeks of age as influenced by supplementation of vitamin E and selenium independently and simultaneously is presented in Table 1 and Table 2 respectively. The mean body weight of layers during the first 4 week growth period did not differ significantly among the treatment groups. The body weight of layer birds was significantly ($P<0.05$) higher in T_6 and T_7 throughout the study period as compared to control and other treatment groups. No significant difference was observed between T_2, T_3, T_4 and T_5.

Table 1

Mean (± S.E) body weight of layer birds as influenced by supplementing vitamin E and selenium from 0-16 weeks of age.

Treatment groups	0-4 weeks	5-8 weeks	9-12 weeks	13-16 weeks
T_1	187.15±7.83	512.65±8.73^{a}	816.06±14.06^{a}	1020.19±10.88^{a}
T_2	198.92±4.83	528.95±11.87^{ab}	834.94±14.15^{ab}	1031.61±15.44^{ab}
T_3	204.73±6.23	538.13±10.50^{abc}	842.52±11.33^{abc}	1040.71±11.42^{abc}
T_4	200.29±6.55	530.29±9.69^{ab}	837.73±9.70^{ab}	1033.55±10.77^{ab}
T_5	202.60±7.80	532.63±9.08^{abc}	840.27±10.78^{abc}	1037.41±9.12^{ab}
T_6	209.44±4.34	551.89±12.43^{bc}	861.21±8.97^{bc}	1060.09±8.55^{bc}
T_7	212.71±5.08	560.26±11.41^{c}	870.91±6.95^{c}	1068.63±9.65^{c}

Value given in each cell is the mean of fifteen observations.

$^{a-c}$ Means within a column with no common superscript differ significantly ($P<0.05$).

Table 2

Mean (± S.E) body weight of layer birds as influenced by supplementing vitamin E and selenium from 17-32 weeks of age.

Treatment groups	17-20 weeks	21-24 weeks	25-28 weeks	29-32 weeks
T_1	1253.86±15.24^{a}	1273.58±13.09^{a}	1296.25±13.75^{a}	1314.45±13.18^{a}
T_2	1268.86±13.96^{ab}	1290.85±14.21^{ab}	1308.55±12.86^{ab}	1330.69±12.62^{ab}
T_3	1278.67±9.90^{abc}	1303.91±10.55^{abc}	1326.01±9.86^{abc}	1344.47±11.01^{abc}
T_4	1270.11±13.32^{ab}	1291.61±14.06^{ab}	1310.09±14.55^{ab}	1331.71±14.64^{ab}
T_5	1273.01±13.00^{ab}	1294.56±13.36^{ab}	1317.79±13.38^{ab}	1335.45±15.02^{ab}
T_6	1298.89±11.41^{bc}	1319.54±11.76^{bc}	1340.01±12.39^{bc}	1362.03±14.75^{bc}
T_7	1308.27±10.04^{c}	1330.56±10.55^{c}	1353.28±10.25^{c}	1374.40±10.26^{c}

Value given in each cell is the mean of fifteen observations.

$^{a-c}$ *Means within a column with no common superscript differ significantly ($P<0.05$).*

Table 3

Mean (± S.E) feed consumption per bird per day (g) of layer birds as influenced by supplementing vitamin E and selenium from 0-16 weeks of age.

Treatment groups	0-4 weeks	5-8 weeks	9-12 weeks	13-16 weeks
T_1	22.35±0.06	45.52±0.15	53.63±0.12	61.62±0.14
T_2	22.20±0.11	45.44±0.12	53.46±0.10	61.51±0.03
T_3	22.21±0.07	45.35±0.06	53.55±0.05	61.48±0.04
T_4	22.25±0.12	45.39±0.13	53.41±0.05	61.46±0.05
T_5	22.32±0.06	45.48±0.04	53.40±0.13	61.57±0.12
T_6	22.05±0.09	45.31±0.06	53.30±0.19	61.38±0.08
T_7	22.14±0.33	45.28±0.07	53.27±0.09	61.36±0.10

Value given in each cell is the mean of three observations.

Table 4

Mean (± S.E) feed consumption per bird per day (g) of layer birds as influenced by supplementing vitamin E and selenium from 17-32 weeks of age.

Treatment groups	17-20 weeks	21-24 weeks	25-28 weeks	29-32 weeks
T_1	78.55±0.18	95.06±0.11	105.58±0.23	112.27±0.21
T_2	78.36±0.11	94.64±0.30	105.53±0.11	112.23±0.11
T_3	78.31±0.07	94.43±0.06	105.48±0.20	112.13±0.14
T_4	78.35±0.12	94.34±0.14	105.34±0.06	112.03±0.10
T_5	78.22±0.14	94.45±0.15	105.46±0.10	111.99±0.06
T_6	77.78±0.43	94.33±0.11	105.05±0.08	111.96±0.13
T_7	78.21±0.09	94.27±0.19	105.16±0.12	111.82±0.19

Value given in each cell is the mean of three observations.

2. Feed consumption:

The effects of different levels of vitamin E and selenium supplementation on daily feed consumption of layer birds are shown in Table 3 and Table 4. The feed intake of birds during the study period did not differ significantly among treatment groups. However, numerically the lowest feed consumption was observed in all supplemented groups compared to control. Among the treatments, the groups T_6 and T_7 that received combination of vitamin E and selenium had lower feed consumption throughout the study period.

3. Lipid profiles:

The lipid profiles of layer chickens are shown in Table 5. The mean cholesterol and LDL-Cholesterol levels were significantly ($P<0.01$) lower in both vitamin E and selenium supplemented birds. There was a also significant ($P<0.01$) decrease in the level of VLDL-Cholesterol and triglycerides in T_3, T_6 and T_7 groups as compared to control and other treatment groups. The mean HDL-Cholesterol was significantly ($P<0.01$) higher in layer birds receiving both vitamin E and selenium in the diet.

Table 5

Mean (± S.E) lipid profiles of layer chickens as influenced by supplementing vitamin E and selenium.

Treatment groups	Total Cholesterol (mg/dl)	TG (mg/dl)	HDL-C (mg/dl)	VLDL-C (mg/dl)	LDL-C (mg/dl)
T_1	155.3 ± 1.16^{E}	113.3 ± 1.13^{C}	30.1 ± 0.70^{A}	22.7 ± 0.22^{C}	102.6 ± 1.38^{F}
T_2	148.2 ± 1.17^{C}	108.8 ± 1.19^{B}	35.0 ± 0.89^{B}	21.8 ± 0.23^{B}	91.5 ± 1.73^{C}
T_3	146.3 ± 1.03^{B}	107.3 ± 1.28^{A}	35.7 ± 0.68^{B}	21.5 ± 0.25^{A}	89.1 ± 1.03^{B}
T_4	151.1 ± 1.05^{D}	110.9 ± 1.15^{B}	31.9 ± 0.90^{A}	22.2 ± 0.23^{B}	97.1 ± 1.01^{E}
T_5	149.8 ± 1.12^{C}	109.3 ± 1.00^{B}	32.5 ± 0.54^{A}	21.9 ± 0.21^{B}	95.4 ± 1.59^{D}
T_6	143.4 ± 1.10^{A}	105.5 ± 1.25^{A}	37.9 ± 1.04^{C}	21.1 ± 0.25^{A}	84.5 ± 1.69^{A}
T_7	140.9 ± 1.17^{A}	103.9 ± 1.27^{A}	39.2 ± 1.03^{D}	20.8 ± 0.26^{A}	81.0 ± 1.28^{A}

Value given in each cell is the mean of six observations.
$^{A-F}$ Means within a column with no common superscript differ significantly ($P<0.01$).

DISCUSSION

The supplementation of vitamin E (100 & 200 mg/kg) and selenium (0.2 & 0.4 mg/kg) independently and simultaneously in the basal diet improved the body weight gain of layers chicks from 0-32 weeks of age. However, higher body weight gains were recorded in combination of vitamin E and selenium supplemented groups (T_6 & T_7) than vitamin E and selenium alone fed groups. The present findings are in agreement with Arvind et al., [18] and Sahin et al., [19] who also observed that vitamin E and selenium supplementation increased body weight in broilers and Japanese quails respectively. It was also reported that vitamin E supplementation at 250mg/kg in Japanese quails significantly increased body weight gain[20]. Significant improvement in body weight of white Leghorn birds was observed due to vitamin E and selenium supplementation[21]. It has been found that maximum body weight gain were obtained in broiler chicks fed diets containing 0.5mg/kg selenium and 300IU/kg vitamin E[22].

On contrary, no significant difference in body weight gain was observed in Golden Montazah laying hens fed vitamin E and selenium[23]. It was also reported that E-Care-Se-Herbal supplementation into the diet has no effect on body weight gain in broilers[24]. The body weight gain of vitamin E and selenium supplemented groups may due to the fact that vitamin E is an excellent biological chain breaking antioxidant that protects cells and tissues from lipoperoxidative damage induced by free radicals. Vitamin E interacts with selenium containing enzyme glutathione peroxidase to prevent the oxidative breakdown to tissue membranes and cell integrity and cell membrane damage [25].

Different levels of vitamin E and selenium supplementation either alone or in combination in layer chicks did not show any significant difference on feed consumption from 0 to 32 weeks of age. These findings were supported by previous studies which also reported that dietary

supplementation of vitamin E did not show any significant effect on feed consumption in broilers[22, 26]. It has also been found that combined supplementation of vitamin E and selenium in drinking water did not alter the feed intake in broilers[24]. Dietary supplementation of combination of probiotics, yeast, vitamin E and vitamin C in laying hens also shows no significant difference on feed consumption[27]. On the other hand, it was reported that supplementation of vitamin E (150 and 300 IU/Kg) in the basal diet resulted in significantly lesser feed in take in broilers[28]. Naylor et al., [29] observed that broilers fed basal diet supplemented with selenium as sel-plex or sodium selenite (0.1 and 0.25 ppm) for 38 days had lower feed intake. The variation in feed intake may be due to genetic selection of bird, dosages, season, housing designs and weather patterns prevailed at the time of experiment.

In the present study, the effects of dietary vitamin E and selenium supplementation on plasma lipid profiles in layer birds were investigated. In comparison to the control diet and other treatment groups, enrichment of diet with combination of vitamin E and selenium significantly decreased ($P<0.01$) the total cholesterol and triglyceride content and also the VLDL and LDL cholesterol levels. Vitamin E is an effective chain breaking lipid-soluble antioxidant in biologic membranes and has been widely used in the defense against oxidative stress. Long-term supplementation of vitamin E reduced ex vivo low-density lipoprotein (LDL) oxidizability and in vivo lipid peroxidation level[30]. Iizuka et al. [31] studied the effects of inorganic selenium on lipid metabolism in rats fed a high-cholesterol diet and reported that selenium suppressed the triacylglycerol, total cholesterol and free fatty acid concentrations in the serum and inhibited the amount of liver triacylglycerol and cholesterol. Selenium seems to have a hypocholesterolemic activity and an in vivo study showed that selenium supplementation decreases total cholesterol and triglyceride levels in rabbits [32]. It was also reported that combination of dietary lycopene and vitamin E supplementation reduced serum cholesterol concentrations ($P \leq 0.05$) in Japanese quails[33].

On contrary, the chickens fed on standardized diet with antioxidant vitamin supplementation (vitamin C-200 mg/kg/day and vitamin E-100 mg/kg/day) resulted significant reduction ($P<0.005$) in plasma triglyceride but the total cholesterol remain unchanged[34]. Supplementation of Se, Zn and vitamin E (0.42, 68 and 60 mg /day, respectively) in the diet of lamb significantly decreased the cholesterol content of blood plasma but found no changes in the blood plasma content of triglycerides[35]. Administration of cholesterol with vitamin E offers protection against oxidative damage but had no effect on the lipid levels in rabbits[36].

In this study, dietary supplementation of vitamin E and selenium in treatment groups 6 and 7 was found to cause a significant ($P < 0.01$) increase in the mean values of HDL-Cholesterol (HDL-C) as compared to control and other treatment groups. It has been reported that vitamin E supplementation in rabbits affects the lipoprotein metabolism by increasing the levels of HDL cholesterol[15]. Antioxidant vitamins supplementation significantly increased ($P<0.005$) HDL-cholesterol in the broiler chickens compared with control group and also caused significant elevation ($P<0.01$) in serum HDL/LDL cholesterol ratio[34]. Selenium deficiency seems to result in increased total cholesterol and LDL levels and a significant decrease in HDL levels in rat and it has been proposed that this may be related to an increased HMG CoA reductase activity [37].

Falkowska et al. [38] showed that supplementation of a diet with selenium and vitamin E significantly increased HDL fraction in blood of cows from 0.440 to 0.552 mmol/l. The present findings was not in agreement with Brzoska and Brzoska[39] who observed that increase in the level of dietary selenium reduced the cholesterol content of blood plasma of cows from 228.6 to 183.9 mg/dl, with simultaneous decrease in HDL and LDL fractions. The reason for the contradiction among the results might be due to the result of the difference in the species used, age of

animals, duration and the amount of vitamin E and selenium supplemented to the diet. Unfortunately, there is a scarcity in information in the literature with respect to the lipid parameters of layer chickens.

In conclusion, this study suggests that combination of vitamin E at a level of 200mg and selenium at 0.4mg/kg diet are good for improving growth rate of layer chickens. Thus, supplementation of vitamin E and selenium at levels above those recommended as nutritional requirements enhances the performance of layer birds. The present study also stresses that vitamin E and selenium may have a role in lipoprotein metabolism, which may or may not be related to their antioxidant action. The effect of vitamin E and selenium on lipoprotein metabolism is either through their antioxidant activity or by some other mechanism is not clear at present, and requires further carefully planned investigation.

REFERENCES

1. Linge P, The use of probiotic and yeast derivatives in India. World Poult, 21: 12-15, (2005).
2. Surai PF, Selenium in poultry nutrition. 1. Antioxidant properties, deficiency and toxicity. World's Poult. Sci. J, 58: 333-345, (2002).
3. McDowell LR, Reevaluation of the metabolic essentiality of the vitamins. Asian- Australian J. Anim. Sci, 13: 115-125, (2000).
4. Surai PF and Dvorska EJ, Dietary organic selenium and eggs: From improvements in egg quality to production of functional food. Proceedings of IX European Symposium on the quality of eggs and egg products, Sep 9-12, Kusadasi, Turkey (2001).
5. Packer L, Protective role of vitamin E in biological system., Am. J. Clin. Nutr, 53: 1050-1055, (1991).
6. Brigelius-Flohe R, Tissue specific functions of individual glutathione peroxidases. Biol. Med, 27: 951-965, (1999).
7. Wolfram S, Absorption and metabolism of selenium: difference between inorganic and organic sources. In: Biotechnology in the Feed industry. Proceedings of the 15th Annual Symposium, Edited by T.P. Lyons, and K.A. Jacques, Nottingham University Press, Nottingham, UK, 1999, pp. 547-566.
8. Edens FW, Practical applications for selenomethionine: broiler breeder reproduction. In: Biotechnology in the Feed Industry. Proceedings of the 18th Alltech's Annual Symposium, Edited by T.P. Lyons, and K.A. Jacques, Nottingham University Press, Nottingham, UK, 29-42, (2002).
9. Jain SK, McVie R, Jaramillo JJ, Palmer M, Smith T, Meachum ZD andLittle RL, The effect of modest vitamin E supplementation on lipid peroxidation products and other cardiovascular risk factors in diabetic patients. Lipids, 31: 87-90, (1996).
10. Kacmaz M, Ozturk HS, Cete S, Kavutcu M and Durak I, The effects of smoking on antioxidant defence system and membrane free fatty acid content of erythrocytes and plasma lipid parameters: protective role of antioxidant vitamins. Nutr. Res, 17: 931-940, (1997).
11. Miller ER, Appel LJ, Levander OA and Levine DM, The effect of antioxidant vitamin supplementation on traditional cardiovascular risk factors. J. Cardiovasc Risk, 4: 19-24, (1997).
12. Brown KM, Morrice PC and Duthie GG, Vitamin E supplementation suppresses indices of lipid peroxidation and platelet counts in blood of smokers and nonsmokers but plasma lipoprotein concentrations remain unchanged. Am. J. Clin. Nutr, 60: 383-387, (1994).
13. Mahmoud KZ and Edens FW, Influence of selenium sources on age-related and mild heat stress-related changes of blood and liver glutathion redox cycle in broiler chickens (*Gallus domesticus*). Comparative Bioch. Physiol. Part B, 136: 921-934, (2003).
14. Vinson JA, Stella JM and Flanagan TJ, Selenium Yeast is an effective *in vitro* and *in vivo* antioxidant and hypolipemic agent is

normal hamsters. Nutr. Res, 18: 735-742, (1998).

15. Oriani G, Salvatori G, Maiorano, G Belisario MA, Pastinese A, Manchisi A and Pizzuti G, Vitamin E nutrition status and serum lipid pattern in normal rabbits. J. Anim. Sci, 75: 402–408, (1997).
16. B.I.S. Nutrient requirement for poultry, Bureau of Indian Standards, I.S. 13574, (1992).
17. Snedecor GW and Cochran WG, Statistical methods, 8th ed., Iowa State University Press/Ames, Iowa-50010, (1989).
18. Arvind KL, Gowdh CV, Manjunath BP, Rajendera AY and Ganpule SP, Influence of dietary level of selenium and vitamin E on growth, immunity and carcass traits in broiler chickens. Indian J. Poult. Sci, 36: 58-62, (2001).
19. Sahin N, Sahin K and Onderci M, Vitamin E and selenium supplementation to alleviate cold-stress associated deterioration in egg quality and egg yolk mineral concentrations of Japanese quails. Biol. Trace Elem. Res, 96: 179-189, (2003).
20. Sahin K, Sahin N, Onderci M, Gursu MF and Issi, M Vitamin C and E can alleviate negative effects of heat stress in Japanese quails. J. Food Agric. Environ,1: 244-249, (2003).
21. Kucuk O, Sahin N, K. Sahin, M.F. Gursu F. Gulsu and M. Issi, Egg production, egg quality and lipid peroxidation status in laying hens maintained at a low ambient temperature(6°C) and fed a vitamin C and vitamin E supplemented diet,.Veterinarni Medicina, 48: 33-40, (2003).
22. Swain BK, Johri TS and Majumdar S, Effect of supplementation of vitamin E, selenium and their different combinations on the performance and immune response of broilers. Br. Poult. Sci, 41: 287-292, (2000).
23. Siam SS, Mansour KM, El-Anwer EMM and El-Warith AA, Laying hens performance, hatchability, immune response and some blood constituents as affected by vitamin E and selenium supplementation under hot conditions. Egyptian Poult. Sci. J, 24: 483-496, (2004).
24. Nageshwara AR, Ramasubbba Reddy V and Ramakota Reddy M, Effect of E-Care-Se-Herbal on the performance and immune response in broilers. Indian J. Poult. Sci, 38: 115-120, (2003).
25. Surai PF, Effect of selenium and vitamin E content of the maternal diet on the antioxidant system of the yolk and the developing chick. Br. Poult. Sci, 41: 235-243, (2000).
26. Bhat GA and Ganai TAS, Effect of feeding vitamin E on the performance of broilers under temperate agro-climatic conditions. Indian J. Poult. Sci, 34: 83-85, (1999).
27. Asli MM, Hosseini SA, Lotfollahian H and Shariatmadari F, Effects of probiotics, yeast, vitamin E and vitamin C supplements on performance and immune response of laying hen during high environmental temperature. Int. J. Poult. Sci, 6: 895-900, (2007).
28. Swain BK and Johri TS, Effect of supplementation of combinations of different levels of selenium and vitamin E on relative weights of some organs and serum enzyme level in broilers. Indian J. poult. Sci, 35: 66-69, (2000).
29. Naylor AJ, Choct M and Jacques KA, Effects of selenium source and level on performance and meat quality in male broilers. Poult. Sci, 79: 117,(2000).
30. Winklhofer-Roob BM, Rock E, Ribalta J, Shmerling DH and Roob JM, Effects of vitamin E and carotenoid status on oxidative stress in health and disease. Evidence obtained from human intervention studies. Mol. Aspects Med, 24:391-402, (2003).
31. IizukaY, Sakurai E and Tanaka Y, Effect of selenium on serum, hepatic and lipoproteins lipids concentration in rats fed on a high-cholesterol diet. Yakugaku Zasshi, 121: 93-96, (2001).
32. Kang BP, Bansal MP and Mehta U, Hyperlipidemia and type I 5'-monodeiodinase activity: regulation by selenium

supplementation in rabbits. Biol. Trace Elem. Res, 7: 231-239, (2000).

33. Sahin N, Sahin K, Onderci MC, Karatepe M, Smith MO and Kucuk O, Effects of dietary lycopene and vitamin E on egg production, antioxidant status and cholesterol levels in Japanese quail. Asian-Australian J. Anim. Sci, 19: 224–230, (2006).

34. Ozturk HS, Akbay R, Kacmaz M, Elgun S and Yeldan M, The effects of antioxidant vitamins supplementation on serum lipid parameters in chicken. T. Klin J. Med. Res, 18: 95-97, (2000).

35. Gabryszuk M, Czauderna M, Baranowski A, Strzałkowska N, Jozwik A, Krzyzewski J, The effect of diet supplementation with Se, Zn and vitamin E on cholesterol, CLA and fatty acid contents of meat and liver of lambs. Anim. Sci. Papers and Reports, 25: 25-33, (2007).

36. Prasad K and Kalra J, Oxygen free radicals and hypercholesterolemic atherosclerosis – Effect of vitamin E. Am. Heart J, 125: 958–973, (1993).

37. Qu X, Huang K, Deng L and Xu H, Selenium deficiency-induced alternations in the vascular system of the rat. Biol. Trace Elem. Res, 75: 119-128, (2000).

38. Falkowska A, Minakowski D and Tywonczuk J, The effect of supplementing rations with selenium and vitamin E on biochemical parameters in blood and performance of cows in the early stage of lactation. J. Anim. Feed Sci, 9: 271-282, (2000).

39. Brzoska F and Brzoska B, Effect of dietary selenium on milk yield of cows and chemical composition of milk and blood. Annal. Anim. Sci, 4: 57-67, (2004).