The Pharma Innovation Journal 2022; 11(10): 1972-1976

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(10): 1972-1976

www.thepharmajournal.com
Received: 25-08-2022
Accepted: 29-09-2022

Parmeshwar Laxman Sirsat
Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Mahendra Mohan Yadav
Zonal Agricultural Research Station, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Corresponding Author:
Mahendra Mohan Yadav
Zonal Agricultural Research Station, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Amalgamation effect of selenium and vitamin E on body weight gain and serum biochemical profile of broilers

Parmeshwar Laxman Sirsat and Mahendra Mohan Yadav

Abstract
In India, the major issue of chicken meat is high amount of polyunsaturated fatty acids (PUFA) that makes it highly susceptible to oxidative degradation. Experiential evidence on the effects of vitamin E, Se, or both on poultry performance is scarce, often inconclusive and contradictory. The feeding trial of six weeks in broiler chicks (n=160) was conducted which were subjected to 4 treatments and designated as treatment T_0, T_1, T_2 and T_3 respectively. All the broiler chicks were fed with starter ration up to 21 days and finisher ration from 22 to 42 days of age. The chicks fed with basal diet in control group (T_0), while chicks in treatment T_1 was fed with basal diet supplemented with Selenium @ 0.15 mg + Vitamin E @ 15 mg/kg of feed respectively, T_2 and T_3 were fed basal diet with Selenium @ 0.30 mg + Vitamin E @ 30 mg/kg of feed and Selenium @ 0.45 mg + Vitamin E @ 45 mg/kg of feed, respectively. All the birds were given isocaloric and isonitrogenous diets throughout the experimental period. Weekly, birds were collectively weighed upto six weeks. Serum-Biochemical viz, Albumin, Triglycerides HDL, LDL, Glucose was analysed on 42nd day by using automatic blood analyser machine. The cumulative body weight gains at 6th week were 1941.93±3.35, 2014.95±2.67, 2060.53±3.76 and 2137.95±3.05g for T_0, T_1, T_2 and T_3 groups, respectively. The average blood serum cholesterol for T_0, T_1, T_2 and T_3 were 245.33±4.80, 224.88±5.58, 211.63±3.31 and 219.98±6.02 (mg/dL), respectively. The average serum HDL (High density lipoprotein) for T_0, T_1, T_2 and T_3 were 53.47±1.94, 51.58±2.75, 58.68±2.03 and 61.07±2.39 (mg/dL), respectively. The values of low-density lipoprotein (LDL) for treatment T_0, T_1 and T_2 were 51.14±2.21, 50.25±2.01, 56.70±2.21 and 46.40±1.97 (mg/dL), respectively. The average serum triglyceride for T_0, T_1, T_2 and T_3 were 38.14±2.03, 41.42±1.90, 38.85±2.16 and 32.74±2.79 (mg/dL), respectively. The average serum albumin for T_0, T_1, T_2 and T_3 were 2.01±0.18, 1.69±0.12, 1.53±0.14 and1.45±0.12 (mg/dL), respectively.
The supplementation of selenium and Vitamin E resulted in decreased level of total cholesterol, triglycerides, glucose and LDL, whereas HDL and albumin content was increased as compared to control group. The serum performance of bird's selenium and vitamin E supplemented groups has been improved as compared to control group.

Keywords: Broilers, serum-biochemical, cholesterol, triglycerides, albumin, glucose and antibiotics

Introduction
Poultry farming is a noteworthy industry in India because of its huge potential to provide rapid cost-effective growth, particularly for the poorer sections of the population, thanks to its minimal investment requirements and short gestation period. According to India's 20th livestock census, overall poultry increased by 16.81 percent i.e., 851.81 million in 2019, including commercial poultry that increased by 4.5 percent to 534.74 million, and backyard poultry that increased by 45.78 percent to 317.07 million. The Indian Council of Medical Research (ICMR) suggested that each capital consume 180 eggs per year.
India's annual per-capita intake of poultry meat is predicted to be approximately 3.1 kg, which is low compared to the world's 17.0 kg. India's per-capita egg consumption is estimated to be around 70 eggs per year. An expanding middle class, rising employment levels, and rising earnings are all major drivers of consumption.
Selenium (Se) is a mineral that has long been recognised as a vital nutrient for immunological function, health, and productivity. Throughout the growing stage, broiler chickens should be fed a diet containing 0.15 mg of selenium per kilogramme of feed (NRC, 1994) [12]. Although natural feedstuffs can typically meet this requirement, it is usual practise to supplement broiler diets with Se. The maximum level of Se supplementation allowed is 0.3 ppm (FDA, 2004) [4]. Organic Se sources, such as Se yeast, have recently been investigated as an alternative to inorganic supplementation (Payne and Southern, 2005) [14].

Due to its high amount of polyunsaturated fatty acids (PUFA), poultry flesh is very susceptible to oxidative degradation (Nanari *et al*. 2004) [11]. The rate of lipid oxidation affects the shelf life of meat and meat products. Vitamin-E is a biological antioxidant that is preferentially maintained in cellular membranes and serves as the first line of defence against oxidative damage. Selenium and Vitamin E together have been proven to have an important function in the formation and maintenance of defence systems (Marsh *et al*. 1986) [9]. Vitamin E is best known for its antioxidant properties that help to prevent cellular free radical damage. Vitamin E may also influence the formation and maintenance of immunological competence through a variety of mechanisms, including direct action on immune cells and indirect changes in metabolic and endocrine characteristics, which influence immune function (Gershwin *et al*. 1985) [5].

For decades, selenium has been recognised as an essential trace mineral required by all creatures (Sevescova *et al*. 2006) [16]. Berzelius, a Swedish scientist, was the first to discover and name selenium (Se) in 1818. El-Sheikh *et al*. 2006 [3] discovered that selenium is nutritionally necessary in chicks. However, there is considerable concern that the selenium minimum requirement is insufficient to prevent output losses caused by selenium insufficiency, thus research into alternate selenium sources and supplementation levels is ongoing. Ismail *et al*. (2014) [7] observed that increasing vitamin E levels had no effects on, total cholesterol and high-density lipoprotein cholesterol (HDL). However, LDL levels were lower when feed supplemented with vitamin E. Naik *et al.* (2014) [10] observed that protein, globulin and HDL cholesterol concentration increased significantly (p<0.01) whereas, total cholesterol decreased in organic selenium and vitamin-E supplemented treatments. Recep *et al.* (2016) [15] observed that heat stress statistically resulted in an increase in cholesterol, LDL and total protein. Glucose level also statistically decreased with increase in heat stress, while they increased with applied vitamin E. Olla *et al.* (2021) [13] observed increase in total cholesterol and HDL when compared with the control group. Moreover, HDL significantly (p≤0.05) increased in the group that received both supplements. On the other side, serum triglyceride and LDL not affected. As a result, the goal of our study is to see whether selenium and vitamin E supplementation to a basal diet affects growth performance in 0 to 42-day-old Vencobb Broilers.

Material and Methods

Present study was carried out at Poultry Unit, Veterinary Polyclinic and A.I. Centre, Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra State. Minimum and maximum ambient temperature range from 12 °C to 15 °C in winter and 33 °C to 38 °C in summer with annual rainfall of 455 mm. The experiment was conducted in July - August during the year 2021-22. The experimental chicks were all raised in a deep litter system with rice husk as a litter material in a well-ventilated house under the same management and environmental conditions. For the first three weeks of life, proper brooding of chicks was accomplished by giving adequate heat and light using electric lamps in each group.

Selection of Experimental Chicks

For the present study 160 chicks of day old age, commercial broiler chicks of Vencob strain were procured from M/s. Venkateshwara Hatcheries Pvt. Limited, Pune, Maharashtra. On arrival, chicks were weighed and distributed randomly in to 4 groups viz. T_0, T_1, T_2 and T_3 with 40 chicks in each treatment as replicates, on equal weight basis.

Treatment Details

The dietary treatments are as follows,

T_0 Basal Diet (Control)

T_1 Basal diet supplemented with Selenium @ 0.15 mg + Vitamin E @ 15 mg/kg of feed.

T_2 Basal diet supplemented with Selenium @ 0.30 mg + Vitamin E @ 30 mg/kg of feed.

T_3 Basal diet supplemented with Selenium @ 0.45 mg + Vitamin E @ 45 mg/kg of feed.

Proximate Composition of Experimental Broiler Ration

It was observed that experimental broiler rations contained adequate nutrients for growth as per BIS (1992). The proximate composition of experimental Pre-starter, starter ration and finisher ration is given in Table 1. The crude protein and calculated metabolizable energy (ME) of the diet was 20.01 percent and 3006.44 Kcal/kg respectively.

Observations Recorded

Body Weight

At the end of each week, total numbers of birds were collectively weighed replicate wise and data were recorded. However, in next week same birds were weighed to obtain the body weight gain. Likewise the data were recorded to calculate gain in weight in each replicate.

Methods of Analysis

Total serum cholesterol (TC), triglycerides (TG), low density lipoprotein (LDL) and high density lipoprotein (HDL), albumin and glucose which were determined in serum using was analysed on 42nd day by using M/s. Miura Blood Analyser machine.

Statistical Analysis

The data were analyzed using General Linear Model procedure of statistical package for social sciences (SPSS) 20th version and comparison of means tested using Duncan's multiple range test (1955) and significance was considered at (p<0.05).

Result and Discussion

Growth performance

The performance parameters like cumulative body weight gain and weekly body weight gain are narrated here as under.

Cumulative body weight

The cumulative body weight gains at 6th week were 1941.93±3.35, 2014.95±2.67, 2060.53±3.76 and 2137.95±3.05g for T_0, T_1, T_2 and T_3 groups, respectively. Significantly (p<0.05) higher body weight gains were recorded for the group T_3 (2137.95 g). However, no treatments were at par with each other. The results indicated that the combination of selenium @ 0.45 mg/kg and vitamin E @ 45 mg/kg on the diet of broilers had highest cumulative body weight gain because this combination act as natural antioxidant due to that combination of Vitamin E and Selenium act against harmful free radicles produced by their

body as a consequence bird becomes resistant to various diseases and heat stress this mechanism improves their overall performance. Similar finding was also reported by Attia *et al*. (2001) [1] that supplementation of vitamin-E significantly increased body weight at six weeks of age (p<0.05) and that of body weight gain.

Body weight gain

The data of the gain in body weight of experimental broiler birds under different experimental treatments observed during the six weeks period were assigned to CRD. Table 3 depicts the average weekly body weight gain in g of the broiler birds. The weekly live body weight gain of chicks indicated no significant difference among various treatment groups during the first two weeks of the experiment. There is significant (p<0.05) difference among the treatments from third weeks onwards. In the fifth week, significantly (p<0.05%) higher body weight gain in the T_3 (Selenium @ 0.45mg/kg and vitamin E @ 45mg/kg) group was recorded. However, no treatments were at par to each other. During sixth week significantly higher body weight gain was observed in treatment T_3 (603.43) followed by T_2 (566.03), T_1 (541.18) and T_0 (520.18) g, respectively. The results indicated that the combination of selenium @ 0.45 mg/kg and vitamin E @ 45 mg/kg on the diet of broilers had highest cumulative body weight gain because this combination act as natural antioxidant due to that combination of Vitamin E and Selenium act against harmful free radicals produced by their body as a consequence bird becomes resistant to various diseases and heat stress this mechanism improves their overall performance.

Similar finding was also reported by Attia *et al*. (2001) [1] that supplementation of vitamin-E significantly increased body weight at six weeks of age (p<0.05) and that of body weight gain. Comparable findings of greater body weight gain fed with higher level of vitamin E than those fed with lower one was observed by Siegel *et al*. (2001) [17].

Weekly body weight gain

The weekly live body weight gain of chicks indicated no significant difference among various treatment groups during the first two weeks of the experiment. There is significant (p<0.05) difference among the treatments from third weeks onwards. In the fifth week, significantly (p<0.05%) higher body weight gain in the T3 (Selenium @ 0.45mg/kg and vitamin E @ 45mg/kg) group was recorded. However, no treatments were at par to each other. During sixth week significantly higher body weight gain was observed in treatment T3 (603.43) followed by T2 (566.03), T1 (541.18) and T0 (520.18) g, respectively. Chitra *et al*. (2014) [2] found that inclusion of Vitamin E and selenium in diet stimulated favorable microbial balance in gut and consequently improved feed efficiency and growth performance in Japanese quail broilers. The improvement in the body weight of the birds after the supplementation might be due to the beneficial effect of selenium and vitamin E on the gut flora as reported by Wang and Zhou (2011) [18]. In the same way, Guo *et al*. (2001) [6] noted that vitamin-E supplementation has improved the growth and body weight gain. Lin *et al*. (2005) [8] found that cockerels receiving supplements of more than 40 mg/kg Vitamin E had higher body weight gain.

Serum Biochemical Profile

Present study was conducted to investigate the effects of selenium and vitamin E on broilers performance and Serum-biochemical changes. Table 5 represents the data on Serum parameters (%) due to different dietary treatments of selenium and vitamin E supplementation during experimental period.

The serum parameters data indicated significant difference in the serum traits (%) among treatment groups. The serum-biochemical constituents like glucose, cholesterol, triglyceride, high density lipoprotein (HDL), low density lipoprotein (LDL) was estimated at the end of experiment and the results are presented in Table. 2 corresponding analysis carried out in CRD.

The average blood serum cholesterol at the end of experimental period for T_0, T_1, T_2 and T_3 were 245.33±4.80, 224.88±5.58, 211.63±3.31 and 219.98±6.02 (mg/dL), respectively. The statistical difference in control group was significantly (p<0.05) higher as compared to other treatment group. However, treatment T_1, T_2 and T_3 were at par to each other. In general, the broilers fed selenium and vitamin E in the treatment group had positive effect on reducing serum cholesterol level then control group.

The significant (p<0.05) differences were observed between treatment groups for high density lipoprotein (HDL) cholesterol levels. The average serum HDL (High density lipoprotein) at the end of experimental period for T_0, T_1, T_2 and T_3 were 53.47±1.94, 51.58±2.75, 58.68±2.03 and 61.07±2.39 (mg/dL), respectively. There was significant (p<0.05) improvement in HDL cholesterol levels in all supplemented groups, while the highest level of HDL cholesterol was observed in the group T_3 (61.07 mg/dl). From above data, it is observed that the feeding of selenium and vitamin E had beneficial effect on serum HDL (High density lipoprotein).

Significant (p<0.05) differences were observed between treatment groups for low density lipoprotein (LDL) cholesterol levels. The values of low-density lipoprotein (LDL) for treatment T_0, T_1 and T_2 were 51.14±2.21, 50.25±2.01, 56.70±2.21 and 46.40±1.97 (mg/dL), respectively. There was significant (p<0.05) decrease in LDL cholesterol levels in all supplemented groups, while the lowest level of LDL cholesterol was observed in the group T3 (46.40 mg/dl). The trend showed that the used selenium and vitamin E in the diet of broiler chicken it reduces the bad cholesterol. Similar observations were also been recorded by Ismail *et al*. (2014) [7] who observed that increasing vitamin E levels had no effects on total cholesterol and high-density lipoprotein cholesterol (HDL). However, LDL levels were lower at 300 mg kg-1 vitamin E supplementation but plasma Total Protein and albumin levels were higher at 300 mg kg-1 vitamin E supplementation.

The average serum triglyceride at the end of experimental period for T_0, T_1, T_2 and T_3 were 38.14±2.03, 41.42±1.90, 38.85±2.16 and 32.74±2.79 (mg/dL), respectively. The difference was statistically non-significant among the entire treatment group. The dietary addition of selenium and vitamin E resulted in lower triglycerides concentration in the serum of broiler chicken compared to control group.

The average blood serum glucose values range from 193.68 to 204.83. Statistically non-significant difference was reported in glucose (mg/dL). These results showed that the serum glucose was unaffected by the dietary treatments of Selenium and Vitamin E.

The average serum albumin at the end of experimental period for T_0, T_1, T_2 and T_3 were 2.01±0.18, 1.69±0.12, 1.53±0.14 and1.45±0.12 (mg/dL), respectively. The dietary addition of selenium and vitamin E in the diet of broilers significantly (p<0.05) increases the albumin in the treatment group as compared to control group. However, treatment T_0, T_1, and T_1, T_2 and T_3 were at par to each other. However, Olla *et al.* (2021) [13] recorded that vitamin E supplementation (Vit. E) and/or selenium (Se and Vit. E + Se) significantly ($p \leq 0.05$) increase total cholesterol and HDL when compared with the control group. Moreover, HDL significantly ($p \leq 0.05$) increased in the group that received both supplements (Vit. E + Se). On the other side, serum triglyceride and LDL not affected.

Table 1: Proximate chemical composition of experimental broiler ration (% DM basis)

Particulars ⇨ / Ingredients (%) ⇩	Starter (0-3 week)	Finisher (3-6 week)
Yellow maize	62.17	70.31
Soybean meal	34.2	26.40
Vegetable oil	0.30	00
Dicalcium phosphate	1.40	1.40
Limestone	1.20	1.20
Salt	0.30	0.30
DL-methionine	0.15	0.12
B-complex	0.02	0.02
Choline chloride	0.06	0.05
Trace mineral premix1	0.10	0.10
Vitamin premix2	0.10	0.10
Total	100.00	100.00
Nutrient composition (%)		
Dry matter	94.71	94.32
Crude protein	23.02	20.01
Ether extract	04.80	04.30
Crude fiber	04.60	03.78
Total ash	07.20	06.85
ME, Kcal / Kg	2951.20	3006.44

Table 2: Effect of supplementation of Selenium and Vitamin E on cumulative body weight changes of broilers.

Weeks		Treatments			SE (+)	CD @5%
	T_0	T_1	T_2	T_3		
1	150.9±0.42	151.48±0.5	151.78±0.49	150.28±0.6	0.51	NS
2	342.6±0.39	336.65±0.28	343.3±7.46	341.28±1.62	3.83	NS
3	$630.68±1.85^a$	$640.33±2.87^b$	$661.98±1.58^c$	$691.45±2.86^d$	2.36	6.60
4	$951.35±2.23^a$	$974.23±2.3^b$	$996.55±2.59^c$	$1028.4±2.17^d$	2.33	6.50
5	$1421.75±3.1^a$	$1473.78±3.2^b$	$1494.5±3.25^c$	$1534.53±3.23^d$	3.20	8.95
6	$1941.93±3.35^a$	$2014.95±2.67^b$	$2060.53±3.7^c$	$2137.95±3.05^d$	3.23	9.03

Table 3: Effect of supplementation of Selenium and Vitamin E on weekly body weight changes of broilers.

Weeks		Treatments			SE (+)	CD @5%
	T_0	T_1	T_2	T_3		
1	107.38±0.57	108.05±0.64	108.28±0.62	107±0.72	0.64	NS
2	191.7±0.54	185.18±0.65	191.53±7.46	191±1.69	3.85	NS
3	$288.08±2^a$	$303.68±2.91^b$	$318.68±7.82^c$	$350.18±3.67^d$	4.66	13.03
4	$320.68±1.56^a$	$333.9±3.65^b$	$334.58±1.21^b$	$336.95±3.46^b$	2.70	7.54
5	$470.4±5.28^a$	$499.55±5.47^b$	$497.95±5.8^b$	$506.13±3.14^b$	5.03	14.05
6	$520.18±6.41^a$	$541.18±4.77^b$	$566.03±6.95^c$	$603.43±6.22^d$	6.14	17.15

Table 4: Effect of supplementation of Selenium and Vitamin E on feed conversion ratio of broilers.

Weeks		Treatments			SE(+)	CD @5%
	T_0	T_1	T_2	T_3		
1	1.63±0.01	1.62±0.02	1.62±0.02	1.64±0.03	0.02	NS
2	1.89±0.02	1.98±0.02	1.74±0.14	1.94±0.03	0.07	NS
3	$2.2±0.02^d$	$2.06±0.02^c$	$1.94±0.03^b$	$1.76±0.04^a$	0.03	0.08
4	$2.51±0.03^c$	$2.4±0.03^{ab}$	$2.38±0.03^a$	$2.36±0.04^a$	0.03	0.09
5	$1.73±0.04^b$	$1.58±0.03^a$	$1.59±0.03^a$	$1.55±0.03^a$	0.04	0.10
6	$1.75±0.06^b$	$1.65±0.02^b$	$1.58±0.05^a$	$1.47±0.04^a$	0.04	0.12
Overall	$1.95±0.01^c$	$1.88±0.01^b$	$1.81±0.03^a$	$1.79±0.01^a$	0.02	0.05

Table 5: Effect of different levels of selenium and vitamin E on serum constituents of broiler chicks

Treatments	Serum Parameters					
	Cholesterol (mg/dL)	HDL (mg/dL)	LDL (mg/dL)	Triglyceride (mg/dL)	Total glucose (mg/dL)	Albumin (g/dL)
T_0	245.33±48^{b}	53.47±1.94^{a}	51.14±2.21^{ab}	38.14±2.03	192.64±4.08	2.01±0.18^{b}
T_1	219.88±3.92^{a}	51.58±2.75^{a}	50.25±2 .0^{ab}	41.42±1.90	196.95±5.19	1.69±0.12 ^{ab}
T_2	208.81±7.23^{a}	58.68±2.03^{ab}	56.70±2.2^{b}	38.85±2.16	193.68±4.51	1.53±0.14 ^{a}
T_3	206.13±3.34^{a}	61.07±2.39^{b}	46.40±1.97 ^{a}	32.74±2.79	204.83±7.2	1.45±0.12 ^{a}
Mean±SE	220.03±4.82	56.20±2.29	51.12±2.10	37.78±2.24	197.02±5.24	1.67±0.14
CD @ 5%	14.89	6.77	6.19	NS	NS	0.41

Conclusion

The conclusions can be drawn from this project that the supplementation of selenium and vitamin E results in decreased levels of total cholesterol, low density lipoprotein, albumin and triglycerides whereas high density lipoprotein and glucose content was increased as compared to control. It was concluded that supplementation of selenium and vitamin E in the feed is beneficial for overall improvement in broiler performance.

References

1. Attia AA, Abou-Zeid AE, Mohamed FF, Yakout HM. Enhancement of broiler performance and immune response by α-tocopherol supplemented in diets. Pakistan. Journal of Biological Sciences. 2001;4:1029-1035.
2. Chitra SC, Edwin, Moorthy M. Effect of dietary supplementation of vitamin E and selenium on Japanese quail broilers Indian Journal of Veterinary and Animal Science Research. 2014;43(3):195-205.
3. El-Sheikh TM, Ahmed S, Nagwa N. An attempt to alleviate heat stress of broiler chicks through stocking density, dietary organic selenium (sel-plex) and vitamin e-selemium. Egyptian Poultry Science. 2006;26:1587-1611.
4. FDA (US Food and Drug Administration). Code of Federal Regulations. Title 21 CFR Part c2004. p. 573.920.
5. Gershwin M, Beach R, Hurley L. The potent impact of nutritional factors on immune response. In Nutrition and Immunity. Academic Press, New York, NY; c1985; p. 1-7.
6. Guo Y, Tang Q, Yuan J, Jiang Z. Effects of supplementation with vitamin E on the performance and the tissue peroxidation of broiler chicks and the stability of thigh meat against oxidative deterioration. Animal Feed Science and Technology. 2001;89:165-173.
7. Ismail FS, El-Gogary MR, El-Nadi MI. Influence of vitamin E supplementation and stocking density on performance, thyroid status, some blood parameters, immunity and antioxidant status in broiler chickens. Asian Journal of Animal and Veterinary Advances. 2014;9:702-712.
8. Lin YF, Chang SJ, Yang JR, Lee YP, Hsu AL. Effects of supplemental vitamin E during the mature period on the reproduction performance of Taiwan native chicken cockerels. British Poultry Science. 2005;46:366-73.
9. Marsh JA, Combs GF, Whitacre ME, Dieter RR. Effect of selenium and vitamin E dietary deficiencies on chick lymphoid organ development. Proceedings of Society for Experimental Biology and Medicine. 1986;182:425-436.
10. Naik SK, Tiwari SP, Sahu T. Effect of organic selenium and vitamin-E on biochemical profile of broiler chickens. Indian Veterinary Journal. 2014;91:54-55.
11. Nanari MC, Hewavitharana AK, Beca C, de Jong S. Effect of dietary tocopherols and tocotrienols on the antioxidant status and lipid stability of chicken. Meat Science. 2004;68:155-162.
12. NRC. Nutrient Requirements of Poultry. 9th rev. ed. National Academy Press, Washington, DC; c1994.
13. Olla A, Rasha AA, Wakeel SA, Hemeda MM, Abdel D, Ghadeer M, *et al*. Impact of vitamin E and/or selenium dietary supplementation on growth parameters and expression levels of the growth-related genes in broilers. BMC Veterinary Research; c 2021. p. 17:251.
14. Payne RL, Southern LL. Comparison of inorganic and organic selenium sources for broilers. Poultry Science. 2005;84:898-902.
15. Recep Gumus, Halit Imik. Effects of vitamin E (α-Tocopherol acetate) on serum lipid profile, Ca and P levels of broilers exposed to heat stress. Scholar Journal of Agriculture Veterinary Science. 2016;3(2):105-110.
16. Sevescova S, Skrivan M, Dlouha G, Kouck M. The effect of selenium source on the performance and meat quality of broiler chickens. Czech Journal of Animal Science. 2006;51:449-457.
17. Siegel PB, Price SE, Meldrum E, Picard M, Geraert PA. Performance of pureline broiler breeders fed two levels of vitamin E. Poultry Science. 2001;80:1258-1262.
18. Wang Y, Zhou X. Influence of dietary nano elemental selenium on growth performance, tissue selenium distribution meat quality and glutathione e peroxidase activity in guangxi yellow chicken. Poultry Science. 2011;90(3):680-688.