Effects of selenium supplementation on the growth performance, slaughter characteristics, and blood biochemistry of naked neck chicken

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ABSTRACT This study examined how selenium-supplemented diets affected the performance of naked neck chickens. The birds were fed both organic and inorganic selenium at 0.30 ppm, while the control diet did not include any additional selenium. A total of 225 one-day-old naked neck chicks were randomly divided into 3 experimental groups, each of which was replicated 5 times (replicates) and contained 15 birds. This was done using a completely randomized design. The data was collected after growth, meat quality, and blood profile parameters were assessed. The findings showed that the birds fed inorganic selenium in the diet displayed increased ($P < 0.05$) feed intake followed by those administered organic selenium and the control diet. On the other hand, birds fed organic selenium in the diet showed enhanced body weight gain and better feed conversion ratio ($P < 0.05$). Similarly, organic selenium supplementation increased ($P < 0.05$) breast and thigh weight compared to inorganic selenium, but no other metrics, such as dressing percentage, drumstick weight, liver weight, gizzard weight, heart weight, or wing weight, significantly differed between treatments ($P > 0.05$). When compared to birds fed inorganic Se and control diet, the birds fed organic Se had greater ($P < 0.05$) blood levels of total protein and globulin. Additionally, it was discovered that organic Se-fed birds had greater ($P < 0.05$) blood Se concentrations than control and inorganic Se-fed birds. However, no differences between treatments were found in albumin, glucose, cholesterol, triglycerides, or uric acid ($P > 0.05$). In conclusion, adding Se-enriched yeast, as an organic selenium source, to diets may enhance the poor growth and slaughter characteristics of naked neck chicks without negatively affecting blood chemistry.

Key words: selenium, growth, slaughter traits, blood chemistry

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INTRODUCTION

Indigenous chicken breeds have recently gained more attention from the general public due to growing customer desire for healthier meat (Jayasena et al., 2013). In comparison to broilers, the meat of native chicken breeds contains more protein, less fat, and special tastes

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(Jayasena et al., 2013). Native chicken breeds are recognized as a better source for the production of meat (Ibrahim et al., 2019) with a high nutritional content (Jung et al., 2015). The most significant rural chicken breeds in Pakistan are the naked neck, Fayoumi, Desi, and Aseel, which are raised as backyard chickens (Sadef et al., 2015). Among all of them, naked neck is gaining popularity because of its ability to endure and produce better in hot weather conditions, making it suitable for home poultry production, especially in tropical climates (Patra et al., 2002). The breed of chicken with a naked neck chick has done exceptionally well in the humid Asian environment. The naked neck chicken breed is a hardy in nature that produces very high-quality meat in extensive or semi-intensive systems. The primary barrier to the propagation of the naked neck chicken is, however, its poor growth performance. The poor performance of naked neck chicken may be improved by nutritional adjustments, such as adding selenium (**Se**) to the diet.

Selenium has been demonstrated to be one of the essential nutrients that birds require for optimum growth and reproduction (Khan et al., 2017, 2018). It performs a range of activities connected to chicken rearing and production. Additionally, glutathione peroxidase, an antioxidant enzyme, collaborates with Se to control hydrogen peroxide levels (Ahmadi et al., 2018). Selenium is also thought to play a key role in the antioxidant defense system, raising the level of antioxidants in chicks and maybe enhancing their growth performance (Ibrahim et al., 2019). Similar to this, supplementing feed with Se has been found to enhance broilers' immune systems' ability to fight off disease (Ibrahim et al., 2019; Shojadoost et al., 2019). Selenium deficiency has been connected to metabolic problems and slowed growth in the literature (Zheng et al., 2019). The most often utilized sources of selenium in the field of animal nutrition are inorganic sodium selenite and organic selenium yeast (Surai and Fisinin, 2014). Organic Se supplements, such as Se yeast, have been shown to be more effective in improving the growth performance of broilers than inorganic Se supplements, such as sodium selenite (Jiang et al., 2009) because Se yeast is more readily available to boost the GSH-Px activity and Se deposition in muscle of broilers (Ahmad et al., 2012). Keeping in view that it was hypothesized that adding organic selenium to diets may help improve the poor growth and slaughter features of naked neck chicks. The aim of this study was to compare the effects of different Se sources on the growth performance, carcass traits, and blood biochemistry of naked neck chicken.

MATERIALS AND METHODS

Experimental Birds and Husbandry

The trial was carried out for a total of 42 d in accordance with the experimental protocols and standards authorized by the Cholistan University of Veterinary and Animal Sciences (**CUVAS**), Bahawalpur, Pakistan. In that regard, a total of 225 naked neck chicks were split into 3 experimental groups (organic, inorganic, and control) in accordance with a completely randomized design (**CRD**) that was reproduced 5 times, with 15 birds included in each replicate. An open sided house with well-ventilation was used for the execution of the trial. An iso-nitrogenous and iso-caloric corn-soybean meal basal diet (included the same amount of protein and calories) was used throughout the trial. The basal diet (Table 1 and 2) was designed specifically for birds after taking into account their specific dietary needs (NRC, 1994). The birds were fed both organic and inorganic selenium at 0.30 ppm, while the control diet did not include any additional selenium. A nipple drinker and 2 round feeders were placed in each pen (1×1 m^2) to provide feed and water to the birds adlibitum. During the first week of brooding, temperature of the chicks was maintained at 34 ± 1.1°C with relative humidity (**RH**) at 62 ± 3%. Temperature was subsequently reduced to 24°C with RH 65% and maintained thereon. Natural day light was provided to birds throughout the study period. Vaccination of the birds was done against infectious bronchitis, Newcastle disease, avian influenza H9, and infectious bursal disease following the company recommendation. For the deployment of the birds, deep litter system with 15 floor pens as replicates and rice husk as bedding material was created.

Table 1. Composition of the basal diet for the starter phase.

Ingredients (%)	Quantity
MCP	0.300
Lysine HCL	0.310
DL-methionine	0.263
Threonine	0.100
Salt	0.220
Soda	0.100
Betaine HCL	0.075
Phytase	0.010
Coxiril[2]	0.010
Enramycin	0.030
Vitamin premix[1]	0.055
Mineral premix[1]	0.055
Trial product	0.000
Rice polish	10.272
Limestone	1.000
Maize	52.200
Soybean meal	29.000
Canola meal	3.000
Poultry-by-product meal	3.000
Nutrient	
Moisture (%)	10.500
CP (%)	22.000
Ash (%)	5.000
Crude fat (%)	4.000
Crude fiber (%)	3.000
ME (kcal/kg)	2900
Selenium, ppm	0.04

Abbreviation: MCP, moncalcium phosphate.

[1]Provided per kg of diet: vitamin A, 11,000 IU; vitamin D_3, 2,560 IU; vitamin E, 44 IU; vitamin K, 4.2 mg; riboflavin, 8.5 mg; niacin, 48.5 mg; thiamine, 3.5 mg; d-pantothenic, 27 mg; choline, 150 mg; vitamin B_{12}, 33 μg; copper, 8 mg; zinc, 75 mg; manganese, 55 mg; iodine, 0.35 mg.

[2]A drug, containing 0.5 % diclazuril, used for the control of coccidiosis.

Table 2. Composition of the basal diet for the finisher phase.

Ingredients (%)	Quantity
MCP	0.200
Lysine HCL	0.333
DL-Methionine	0.224
Threonine	0.090
Salt	0.220
Soda	0.100
Betaine HCL	0.050
Phytase	0.010
Coxiril[**]	0.010
Enramycin	0.030
Vitamin premix[1]	0.055
Mineral premix[1]	0.055
Trial product	0.000
Rice polish	0.200
Limestone	0.800
Maize	67.00
Soybean meal	22.00
Rapeseed meal	2.900
Poultry-by-product meal	4.000
Corn gluten 60%	1.700
Nutrient	
Moisture (%)	10.500
CP (%)	20.000
Ash (%)	4.000
Crude fat (%)	4.500
Crude fiber (%)	4.000
ME (kcal/kg)	3150

Abbreviation: MCP, moncalcium phosphate.

[1]Provided per kg of diet: vitamin A, 11,000 IU; vitamin D_3, 2,560 IU; vitamin E, 44 IU; vitamin K, 4.2 mg; riboflavin, 8.5 mg; niacin, 48.5 mg; thiamine, 3.5 mg; d-pantothenic, 27 mg; choline, 150 mg; vitamin B_{12}, 33 μg; copper, 8 mg; zinc, 75 mg; manganese, 55 mg; iodine, 0.35 mg.

[**]A drug, containing 0.5 % diclazuril, used for the control of coccidiosis.

Data Collection

Growth Performance and Slaughter Traits Measurements for growth were recorded on weekly intervals. The weight and feed intake of birds per pen were measured to calculate body weight gain (**BWG**), feed intake (**FI**), and feed conversion ratio (**FCR**). The weighed feed was offered and then refusal feed was weighed on daily basis for each group. For measurement of FI, feed refused was subtracted from total feed offered. Birds were weighed at day 0 and BWG was measured on every fortnight for which the initial weights recorded were subtracted from the final weights and FCR was calculated dividing total feed consumed by average gain. Daily dead birds were picked up and removed, and FCR was adjusted in accordance. Fifteen birds per treatment (3 birds/ replicate) were chosen in order to collect data on carcass characteristics. The chosen birds were denied feed for a period of 4 h, after which they were slaughtered using the Halal method, and their carcasses were defeathered and eviscerated. Breast, thigh, drumstick, wing, liver, heart, and gizzard were dissected out and weighed separately. Dressing percentage was determined by multiplying the ratio of dressed weight to live weight (without skin, shanks, or head) by 100. Similar calculations were used to determine the percentages of the breast, thigh, drumstick, wing, liver, heart, and gizzard.

Blood Biochemistry Data were collected for blood profile (albumin, total protein, glucose, globulin, uric acid, triglycerides, and cholesterol) at the time of slaughter for which blood samples were collected from all the experimental birds chosen for slaughtering. From each bird, 3ml blood sample was collected. Syringe (5 mL, disposable) containing no anticoagulant was used for the collection of blood samples. Blood was drawn from the wing vein and placed in blood vacutainers for transport. Centrifugation of blood was done at 3,000 × g for 10 min and serum was separated and poured in Eppendorf tubes (1.5 mL). Serum was preserved at a very low temperature of −20°C to prevent the initiation of biochemical process. Later on serum was thawed at temperature of 4°C and analyzed spectrophotometrically to collect data for above-said parameters (Rehman et al., 2017).

Statistical Analysis

In this study, each pen served as an experimental unit, and data were gathered in accordance. The SAS GLM process (SAS Institute Inc., 2002−03) and the ANOVA approach were used to analyze the data. The Duncan's multiple range test was used to compare means at 5% probability level.

RESULTS

Growth Performance

There were significant differences between treatments for any performance metrics measured throughout the study's duration. The birds fed inorganic selenium in the diet showed increased feed intake followed by those fed organic selenium and the control diet. On the other hand, birds that were fed organic selenium in the diet displayed improved body weight gain and a superior feed conversion ratio (Table 3).

Carcass Characteristics

Data on slaughter traits indicated that organic selenium supplementation increased breast and thigh weight compared to inorganic selenium, but no other metrics, such as dressing percentage, drumstick weight, liver weight, gizzard weight, heart weight, or wing weight, significantly differed between treatments (Table 4).

Table 3. Effect of selenium-supplemented diets on the growth performance of growing naked neck chicks.[1]

	Parameters		
Treatments	FI	BWG	FCR
Organic Se	1.175[b]	383.86[a]	3.06[c]
Inorganic Se	1.195[a]	348.50[b]	3.42[b]
Control	1.035[c]	290.08[ab]	3.56[a]
P-value	0.02	0.05	0.03

Abbreviations: BWG, body weight gain; FCR, feed conversion ratio; FI, feed intake.

[a-c]The treatment means in a column without any shared superscripts differ significantly ($P < 0.05$).

[1]Data represent the means of 5 replicates (n = 5), each with 15 birds.

Table 4. Effect of selenium-supplemented diets on the slaughter characteristics of growing naked neck chicks.[1]

Parameters	Treatments			
	Organic Se	Inorganic Se	Control	P value
CY	63.6	62.3	62.5	0.050
BY	23.8[a]	21.6[b]	22.6[ab]	0.004
TY	22.2[a]	20.1[b]	21.5[ab]	0.0188
DW	15.9	15.7	16.1	0.0018
LW	3.1	3.4	3.2	0.0013
GW	3.0	3.2	2.99	0.0004
HW	0.7	0.8	0.8	0.005
WW	8.3	7.9	8.0	0.0172

Abbreviations: BY, breast yield; CY, carcass yield; DW, drumstick weight; GW, gizzard weight; HW, heart weight; LW, liver weight; TY, thigh yield; WW, wing weight.

[a,b]The treatment means in a column without any shared superscripts differ significantly ($P < 0.05$).

[1]Data represent the means of 5 replicates (n = 5), each with 15 birds.

Blood Biochemistry

When compared to birds fed inorganic Se and control diet, the birds fed organic Se had greater blood levels of total protein and globulin. Similarly, organic Se-fed birds had greater blood Se concentrations followed by inorganic Se and control birds. However, no differences ($P > 0.05$) between treatments were found in albumin, glucose, cholesterol, triglycerides, or uric acid (Table 5).

DISCUSSION

Se Effect on Growth Performance

Poultry industry requires efficient growth to maintain profitability in poultry business. The current study was carried out during a hot, humid season. According to El-Deep et al. (2014), broiler chickens' growth performance is greatly reduced by high ambient temperatures, but supplementing with antioxidants including probiotics, vitamins, and trace elements has shown to be effective in reducing the negative impacts of this challenge (Eid et al., 2003; Lin et al., 2006; Eid et al., 2008; Sahin et al., 2009). Studies have shown that dietary organic Se modulates the antioxidant system more effectively than inorganic sources under stress (Sahin et al., 2008; Surai, 2016) and removes free radicals from metabolic activity (Papazyan et al., 2006; Sluis, 2007; Hanafy et al., 2009; Attia et al., 2010). Thus, the current research demonstrated that dietary supplementation with organic Se could alleviate the adverse effects of heat stress since it raised BWG and FI and lowered FCR. Furthermore, improved BWG, FI, and lower FCR due to the organic form of Se suggested that the body used it more effectively. These results support other researchers' assertions that the performance of the birds fed organic Se was superior (Saleh and Ebeid, 2019; Gul et al., 2021). However, it was also discovered that supplementing broilers with Se had no effect on their ability to grow (Chen et al., 2014; Li et al., 2018; Bakhshalinejad et al., 2019).

Table 5. Effect of selenium-supplemented diets on the blood biochemistry of growing naked neck chicks.[1]

Parameters	Treatments			
	Organic Se	Inorganic Se	Control	P value
TP (g/dL)	3.5	3.7	3.6	0.060
AB (g/dL)	1.7	1.6	1.6	0.1445
GB (g/dL)	1.5	1.4	1.6	0.057
GL (mg/dL)	137.1	138. 9	136. 4	0.2494
CH (m/dL)	159.5	158.9	158.6	0.620
TR (mg/dL)	90.3	89.5	88.8	0.329
UA (g/dL)	3.7	3.9	3.7	0.832
Se (μg/L)	58.19[a]	52.14[b]	43.25[c]	0.002

Abbreviations: AB, albumin; CH, cholesterol; GB, globulin; GL, glucose; TP, total protein; TR, triglycerides; UA, uric acid.

[a-b]The treatment means in a row without any shared superscripts differ significantly ($P < 0.05$).

[1]Data represent the means of 5 replicates (n = 5), each with 15 birds.

Se Effect on Slaughter Traits

The rise in the proportion of breast and thigh tissue in the treatment group was likely due to higher absorption and enhanced development brought on by the organic Se-enhanced metabolism of thyroid hormones that controlled animal growth (Arthur, 1991; Jianhua et al., 2000). The higher breast muscle and thigh muscle weights brought on by organic Se supplementation are consistent with Saleh and Ebeid's (2019) observation that these muscle weights rose when organic Se was used as a dietary supplement. On the other hand, Wang et al. (2021) found no changes ($P > 0.05$) between broilers fed the Se-supplemented diets and those fed the control diet in the percentages of breast and thigh muscles. According to our findings, the carcass weights and percentages of the drumstick, liver, gizzard, heart, and wing were unaffected by Se supplementation. Similar results were obtained by other researchers, who found no influence of Se supplementation on carcass weight (Chen et al., 2013; Wang et al., 2021) or carcass parts output (Chen et al., 2014; Li et al. 2018; Bakhshalinejad et al., 2019). In contrast, organic forms of Se increased eviscerated weight in 1 study (Choct et al., 2004).

Se Effect on Blood Biochemistry

Biochemical markers can be used to determine the animals' physiological and overall health (Kamal et al., 2007) and are positively correlated with their dietary state (Adejumo, 2004). Selenium deficiency is linked to increased reactive oxygen species production and high levels of oxidative stress on blood metabolites (Zheng et al., 2019). An enzyme called glutathione peroxidase is crucial in preventing oxidative stress and free radical damage to blood metabolites. Due to the presence of selenium in this enzyme, selenium indirectly contributes to the reduction of oxidative damage to blood metabolites.

The reasons why birds fed organic Se had higher levels of total protein and globulin than birds fed inorganic Se and a control diet were not immediately clear. No differences ($P > 0.05$) between treatments were found in albumin, glucose, cholesterol, triglycerides, or uric acid. This agrees with previous findings that selenium had no significant effects on serum biochemical parameters of broilers (Hosseini Mansoub et al., 2010; Kanchana and Jeyanthi, 2010; Rashidi et al. 2010; Habibian et al., 2014; Khalifa et al., 2021) or laying hens (Lin et al., 2020). On the other hand, feeding broilers with Se was found to significantly affect the plasma concentrations of total cholesterol and triglycerides (Saleh and Ebeid, 2019). In the current investigation, the blood Se concentrations of the organically fed birds were higher than those of the control and inorganically fed birds. It is consistent with other observations that the blood Se concentration of the birds fed organic Se was higher (Gul et al., 2021).

CONCLUSIONS

The results of the present study suggest that dietary supplementation with Se-enriched yeast, as an organic selenium source, at 0.30 ppm may improve the poor growth and slaughter characteristics of naked neck chicks without negatively affecting blood chemistry.

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DISCLOSURES

No conflict of interests was reported by the authors regarding the publication of this research article.

REFERENCES

Adejumo, D. O. 2004. Performance, organ development and hematological indices of rats fed sole diets of graded levels of cassava flour and soybean flour (soygari) as substitutes for energy and protein concentrates. Trop. J. Anim. Sci. 7:57–63.

Ahmad, H., J. Tian, J. Wang, M. A. Khan, Y. Wang, L. Zhang, and T. Wang. 2012. Effects of dietary sodium selenite and selenium yeast on antioxidant enzyme activities and oxidative stability of chicken breast meat. J. Agric. Food Chem. 60:7111–7120.

Ahmadi, M., A. Ahmadian, and A. R. Seidavi. 2018. Effect of different levels of nano-selenium on performance, blood parameters, immunity and carcass characteristics of broiler chickens. Poult. Sci. J. 6:99–108.

Arthur, J. R. 1991. The role of selenium in thyroid hormone metabolism. Can. J. Physiol. Pharmacol. 69:1648–1652.

Attia, Y. A., A. A. Abdalah, H. S. Zeweil, F. Bovera, A. A. Tag El-Din, and M. A. Araft. 2010. Effect of inorganic or organic selenium supplementation on productive performance, egg quality and some physiological traits of dual-purpose breeding hens. Czech. J. Anim. Sci. 55:505–519.

Bakhshalinejad, R., A. Hassanabadi, and R. A. Swick. 2019. Dietary sources and levels of selenium supplements affect growth performance, carcass yield, meat quality and tissue selenium deposition in broilers. Anim. Nutr. 5:256–263.

Chen, G., J. Wu, and C. Li. 2014. Effect of different selenium sources on production performance and biochemical parameters of broilers. J. Anim. Physiol. Anim. Nutr. 98:747–754.

Chen, G. S., J. F. Wu, and C. Li. 2013. The effect of different selenium levels on production performance and biochemical parameters of broilers. Ital. J. Anim. Sci. 12:486–491.

Choct, M., A. J. Naylor, and N. Reinke. 2004. Selenium supplementation affects broiler growth performance, meat yield and feather coverage. Br. Poult. Sci. 45:677–683.

Eid, Y., T. Ebeid, M. Moawad, and M. El-Habbak. 2008. Reduction of dexamethasone-induced oxidative stress and lipid peroxidation in laying hens by dietary vitamin E supplementation. Emir. J. Food Agric. 20:28–40.

Eid, Y. Z., A. Ohtsuka, and K. Hayashi. 2003. Tea polyphenols reduce glucocorticoid-induced growth inhibition and oxidative stress in broiler chickens. Br. Poult. Sci. 44:350–356.

El-Deep, M. H., D. Ijiri, Y. Z. Eid, H. Yamanaka, and A. Ohtsuka. 2014. Effects of dietary supplementation with Aspergillus awamori on growth performance and antioxidative status of broiler chickens exposed to high ambient temperature. J. Poult. Sci. 51:281–288.

Gul, F., B. Ahmad, S. Afzal, A. Ullah, S. Khan, K. Aman, M. T. Khan, F. Hadi, K. Kiran, M. Zahra, and T. Maqbool. 2021. Comparative analysis of various sources of selenium on the growth performance and antioxidant status in broilers under heat stress. Braz. J. Biol. 83:e251004.

Habibian, M., S. Ghazi, M. Moeini, and A. Abdolmohammadi. 2014. Effects of dietary selenium and vitamin E on immune response and biological blood parameters of broilers reared under thermoneutral or heat stress conditions. Int. J. Biometeorol. 58:741–752.

Hanafy, M. M., A. M. H. El-Sheik, and E. A. Abdalla. 2009. The effect of organic selenium supplementation on productive and physiological performance in a local strain of chicken.1-The effect of organic selenium (Sel-PlexTM) on productive, reproductive and physiological traits of Bandarah local strain. Egypt. Poult. Sci. 29:1061–1084.

Hosseini-Mansoub, N., S. Chekani-Azar, A. A. Tehrani, A. Lotfi, and M. Manesh. 2010. Influence of dietary vitamin E and zinc on performance, oxidative stability and some blood measures of broiler chickens reared under heat stress (35°C). J. Agrobiol. 27:103–110.

Ibrahim, D., G. Goshu, W. Esatu, and A. Cahaner. 2019. Dual-purpose production of genetically different chicken crossbreeds in Ethiopia. 2. Egg and meat production of the final-crossbreed females and males. Poult. Sci. 98:3405–3417.

Ibrahim, D., A. T. Kishawy, S. I. Khater, A. Hamed Arisha, H. A. Mohammed, A. S. Abdelaziz, G. I. Abd El-Rahman, and M. T. Elabbasy. 2019. Effect of dietary modulation of selenium form and level on performance, tissue retention, quality of frozen stored meat and gene expression of antioxidant status in Ross broiler chickens. Animals. 9:342.

Jayasena, D. D., S. Jung, H. J. Kim, Y. S. Bae, H. I. Yong, J. H. Lee, J. G. Kim, and C. Jo. 2013. Comparison of quality traits of meat from Korean native chickens and broilers used in two different traditional Korean cuisines. Asian-Australas. J. Anim. Sci. 26:1038–1046.

Jiang, Z. Y., Y. C. Lin, G. L. Zhou, L. H. Luo, S. Q. Jiang, and F. Chen. 2009. Effects of dietary selenomethionine supplementation on growth performance, meat quality and antioxidant property in yellow broilers. J. Agric. Food Chem. 57:9769–9772.

Jianhua, H., A. Ohtsuka, and K. Hayashi. 2000. Selenium influences growth via thyroid hormone status in broiler chickens. Br. J. Nutr. 84:727–732.

Jung, S., Y. S. Bae, H. I. Yong, H. J. Lee, D. W. Seo, H. B. Park, J. H. Lee, and C. Jo. 2015. Proximate composition, and L-carnitine and betaine contents in meat from Korean indigenous chicken. Asian-Australas. J. Anim. Sci. 28:1760–1766.

Kamal, M. S., A. Khane, F. Rizvi, and M. Siddique. 2007. Sadeeq-Ur-Rehman. 2007. Effect of cypermethrin on haematological parameters in rabbit. Pak. Vet. J. 27:171–175.

Kanchana, G., and G. P. Jeyanthi. 2010. The effect of supplementation of diet with vitamin-E and selenium and their combinations on the performance and lipid profiles of layer chickens. Int. J. Pharm. Bio. Sci. 1:1–11.

Khalifa, O. A., R. A. Al Wakeel, S. A. Hemeda, M. M. Abdel-Daim, G. M. Albadrani, A. El Askary, S. E. Fadl, and F. Elgendey. 2021. The impact of vitamin E and/or selenium dietary supplementation on growth parameters and expression levels of the growth-related genes in broilers. BMC Vet. Res. 17:251.

Khan, M. T., A. Mahmud, K. Javed, I. Zahoor, S. Mehmood, J. Hussain, and M. S. Rehman. 2018. Organic and inorganic selenium in Aseel chicken diets: effect on production performance. J. Appl. Poult. Res. 27:292–298.

Khan, M. T., A. Mahmud, I. Zahoor, and K. Javed. 2017. Organic and inorganic selenium in Aseel chicken diets: effect on hatching traits. Poult. Sci. 96:1466–1472.

Li, J. L., L. Zhang, Z. Y. Yang, Z. Y. Zhang, Y. Jiang, F. Gao, and G. H. Zhou. 2018. Effects of different selenium sources on growth performance, antioxidant capacity and meat quality of local Chinese Subei chickens. Biol. Trace Elem. Res. 181:340–346.

Lin, H., H. C. Jiao, J. Buyse, and E. Decuyperre. 2006. Strategies for preventing heat stress in poultry. Worlds Poult. Sci. J. 62:71–86.

Lin, X., T. Yang, H. Li, Y. Ji, Y. Zhao, and J. He. 2020. Interactions between different selenium compounds and essential trace elements involved in the antioxidant system of laying hens. Biol. Trace Elem. Res. 193:252–260.

National Research Council. 1994. Nutrient Requirements of Poultry. 9th rev. ed. National Academy Press, Washington, DC.

Papazyan, T. T., S. A. Denev, and P. F. Surai. 2006. Selenium in poultry nutrition: lessons from research and wild nature. Krmiva 48:275–283.

Patra, B. N., R. K. S. Bais, R. B. Prasad, and B. P. Singh. 2002. Performance of naked neck versus normally feathered coloured broilers for growth, carcass traits and blood biochemical parameters in tropical climate. Asian-Australas. J. Anim. Sci. 15:1776–1783.

Rashidi, A. A., Y. G. Ivari, A. Khatibjoo, and R. Vakili. 2010. Effects of dietary fat, vitamin E and zinc on immune response and blood parameters of broiler reared under heat stress. Res. J. Poult. Sci. 3:32–38.

Rehman, M. S., A. Mahmud, S. Mehmood, T. N. Pasha, J. Hussain, and M. T. Khan. 2017. Blood biochemistry and immune response in Aseel chicken under free range, semi-intensive, and confinement rearing systems. Poult. Sci. 96:226–233.

Sadef, S., M. S. Khan, and M. S. Rehman. 2015. Indigenous chicken production in Punjab: a detailed survey through participatory rural appraisals. J. Anim. Plant Sci. 25:1273–1282.

Sahin, K., N. Sahin, O. Kucuk, A. Hayirili, and A. S. Prasad. 2009. Role of dietary zinc in heat stressed poultry: a review. Poult. Sci. 88:2176–2183.

Sahin, N., M. Onderci, K. Sahin, and O. Kucuk. 2008. Supplementation with organic or inorganic selenium in heat-distressed quail. Biol. Trace. Elem. Res. 122:229–237.

Saleh, A. A., and T. A. Ebeid. 2019. Feeding sodium selenite and nano-selenium stimulates growth and oxidation resistance in broilers. S. Afr. J. Anim. Sci. 49:176–183.

SAS Institute Inc. 2002-03. SAS/STAT User's Guide: Statistics. Version 9.1. SAS Inst. Inc., Cary, NC.

Shojadoost, B., R. R. Kulkarni, A. Yitbarek, A. Laursen, K. Taha-Abdelaziz, T. N. Alkie, N. Barjesteh, W. M. Quinteiro-Filho, T. K. Smith, and S. Sharif. 2019. Dietary selenium supplementation enhances antiviral immunity in chickens challenged with low pathogenic avian influenza virus subtype H9N2. Vet. Immunol. Immunopathol. 207:62–68.

Sluis, W. V. D. 2007. Selenium yeast benefits in poultry production. Worlds Poult. Sci. 8:15.

Surai, P. F. 2016. Antioxidant systems in poultry biology: Superoxide dismutase. Anim. Nutr. 1:8.

Surai, P. F., and V. I. Fisinin. 2014. Selenium in poultry breeder nutrition: an update. Anim. Feed Sci. Technol. 191:1–15.

Wang, C. L., G. Z. Xing, L. S. Wang, S. F. LI, L. Y. Zhang, L. U. Lin, X. G. Luo, and X. D. Liao. 2021. Effects of selenium source and level on growth performance, antioxidative ability and meat quality of broilers. J. Integr. Agric. 20:227–235.

Zheng, S., J. Zhao, H. Xing, and S. Xu. 2019. Oxidative stress, inflammation, and glycometabolism disorder-induced erythrocyte hemolysis in selenium- deficient exudative diathesis broilers. J. Cell Physiol. 234:16328–16337.