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Original Article

# Effects of Selenium-enriched Diets on the Growth Performance, Slaughter Characteristics, and Blood Biochemistry of Rhode Island Red Chicken

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## ABSTRACT

The goal of the current study was to determine how selenium-supplemented diets affected the growth performance, carcass traits, and blood biochemistry of Rhode Island Red (RIR) chickens. Organic and inorganic selenium (Se) was fed to the birds at 0.30ppm, whereas the control diet was not supplemented with selenium in either organic or inorganic form. A total of 225 day-old RIR chicks were indiscriminately distributed in three groups according to the experimental diets, in a completely randomized design. Each treatment group was repeated 5 times (replicates), and each replicate had 15 birds. Parameters of growth performance, carcass characteristics, and blood biochemistry were assessed. Birds fed an inorganic selenium-supplemented diet had higher feed intake than those fed an organic selenium-supplemented diet or the control diet, whereas birds fed an organic selenium-supplemented diet had higher body weight gains and better feed conversion ratios. Birds fed organic Se in the diet showed higher breast and thigh weight than those receiving inorganic Se, whereas dressing percentage, drumstick yield, and weights of liver, gizzard, heart, and wing were not significantly different across treatments. The organic Se group showed higher values for total protein and globulin in the blood relative to those fed inorganic Se and the control diet. Similarly, organic Se fed birds showed higher blood Se concentration than the other two groups. However, no significant differences in albumin, glucose, cholesterol, triglycerides, and uric acid were observed among the diets. These results lead to the conclusion that organic Se may be utilized in diets to improve the poor performance of RIR chicken.

## INTRODUCTION

Animal protein scarcity is one of the biggest problems in developing nations today (Shafiq, 2016). The chicken industry offers a reasonably affordable supply of meat, eggs, and other necessary nutrients. With an investment of over Rs. 750 billion, Pakistan's poultry industry is one of the most organized sectors of the country's agricultural economy, employing more than 1.5 million people (Pakistan Economic Survey, 2021-2022). Over the past ten years, this industry has grown at an amazing rate of about 7.5 percent per year (Pakistan Economic Survey, 2021-2022). One of the American poultry breeds that has adapted particularly well to the Asian climate is the Rhode Island Red (RIR) chicken (Parveen *et al.,* 2017). They are dependable birds, with a keen sense of curiosity, and are also great mothers. Moreover, they produce very high-quality meat, lay enormous, brown-tinted eggs and have a better level of tolerance to external parasites than other breeds bred in semi-intensive or extensive settings. RIR chicken, on the other hand, has a dismal track record for weight gain. Nevertheless, the performance of RIR chicken may be enhanced by nutritional interventions such as dietary Se supplementation.

Animals need Se, a vital antioxidant mineral (Surai, 2002) that has been shown to enhance immunological, antioxidative, and growth performance in broilers (Swain *et al.,* 2000; Wang & Xu, 2008; Wang *et al.,* 2011a; Liao *et al.,* 2012; Skrivan *et al.,* 2012). Glutathione peroxidase (GSH-Px), a vital component of the antioxidative protection system, is one of the proteins or enzymes that includes Se (Hoffmann & Berry, 2008; Cai *et al.,* 2012; Lee *et al.,* 2014; Dalia *et al.,* 2018). Different types of Se are available for supplemental use in poultry feed, including inorganic sodium selenite or selenite and organic Se yeast (Yuan *et al.,* 2011; Surai & Fisinin, 2014). The latter is included in amino acids and short peptides like selenomethionine, selenocysteine, and selenocysteine. Se compounds present in grains and forages share similarities with the organic form originating from yeast. Using the amino acid transport mechanism, animals and poultry have evolved naturally to absorb this form from all parts of the gastrointestinal tract. In comparison to inorganic salts, organic Se is more active, less poisonous, and accumulates at higher levels in organs like the liver, brain, and muscles (Kim & Mahan, 2001; Surai, 2002; Payne & Southern, 2005; Tiwary *et al.,* 2006; Zhang *et al.,* 2008; Attia *et al.,* 2010; Mohapatra *et al.,* 2014; Suchy *et al.,* 2014; Hassan *et al.,* 2021). Chickens' consumption of antioxidant vitamins A, C, and E is intimately related to the absorption and transport of Se. Birds have evolved to metabolize Se and take advantage of its antioxidant qualities because it is a necessary component of the majority of diets (Surai, 2006). Poultry feed, therefore, must contains organic Se to maintain the wellbeing of animals, their effective performance, and high-quality meat (Jiang *et al.,* 2009). It was, therefore, hypothesized that supplementing diets with organic Se could improve the poor growth and slaughter features of RIR chicks without negatively affecting blood chemistry. The purpose of this study was to compare the effects of various Se sources on the growth performance, carcass traits, and blood biochemistry of RIR chicken.

## MATERIALS AND METHODS

### Ethics

The aforementioned study was carried out in accordance with the recommendations of the Cholistan University of Veterinary and Animal Sciences, Bahawalpur, Ethical Review Committee. An ethics certificate was obtained from the Office of Research Innovation and Commercialization, CUVAS, Bahawalpur, prior to the start of the trial (Letter No: ORIC-190, Dated: 29-08-22).

### Experiment site, birds, and housing

During the course of 42 days, the current study was carried out at the PRO-MAX Protein Farm in Punjab, Pakistan. 225 day-old RIR chicks were indiscriminately distributed into three groups based on three diets, namely organic (Se-enriched yeast), inorganic (sodium selenite), and control diet, under a completely randomized design (CRD). Each group was repeated 5 times (replicates/pens), with 15 birds in each pen. The experimental birds were placed in an open-sided house, which was built to be well-ventilated. A basal diet (Table 1 and 2) based on corn-soybean meal, containing the same amount of protein and energy, was offered to the birds. It was formulated keeping in view the dietary needs of the birds (NRC, 1994), containing 20-22% of crude protein and 2,800-3200 metabolizable energy (kcal/kg), respectively. Before the start of the trial, the

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

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

[1]MCP=monocalcium phosphate.

[2]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.

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

| Ingredients (%) | Quantity |
|---|---|
| Maize | 67.00 |
| Soybean meal | 22.00 |
| Poultry-by-product meal | 4.000 |
| Rapeseed meal | 2.900 |
| Corn gluten 60% | 1.700 |
| Limestone | 0.800 |
| Lysine HCL | 0.333 |
| DL-Methionine | 0.224 |
| Salt | 0.220 |
| MCP[1] | 0.200 |
| Rice polish | 0.200 |
| Soda | 0.100 |
| Threonine | 0.090 |
| Vitamin premix[2] | 0.055 |
| Mineral premix[2] | 0.055 |
| Betaine HCL | 0.050 |
| Enramycin | 0.030 |
| Coxiril** | 0.010 |
| Phytase | 0.010 |
| Nutrient | |
| ME (kcal/kg) | 3150 |
| CP (%) | 20.000 |
| Moisture (%) | 10.500 |
| Crude fat (%) | 4.500 |
| Ash (%) | 4.000 |
| Crude fiber (%) | 4.000 |

[1]MCP=monocalcium phosphate.

[2]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.

basal diet was examined to determine the amount of Se it contained. Each pen (1 × 1 m$^2$) contained a nipple drinker and two round feeders to provide water and feed *ad-libitum* to the birds. The chicks were brooded at 34 ± 1.1°C temperature with relative humidity set at 62 ± 3%, during the first week. Temperature was gradually decreased to 24°C with RH 65%. Natural day light was provided to birds throughout the study period. The chicks were vaccinated against infectious bronchitis, Newcastle disease, avian influenza H9, and infectious bursal disease according to the instructions given by the company. A deep litter system was prepared before trial, whereon rice husk was spread as bedding material.

### Data collection

#### *Growth performance and carcass characteristics*

The performance parameters of feed intake (FI), body weight gains (BWG), and feed conversion ratio (FCR) were assessed, and the data were then recorded on a weekly basis. The weight gain and FCR were computed using feed intake and body weight. The deceased birds were removed twice daily, and FCR was modified accordingly. Three broilers with average weights per pen were chosen to collect data on carcass characteristics at the end of the trial. These birds were starved for four hours before being slaughtered in accordance with Halal guidelines, and the carcasses were then defeathered and eviscerated. Breast, thigh, drumstick, wing, liver, gizzard, and heart were dissected and separately weighed in order to gather data on carcass characteristics. The ratio of dressed weight to live weight (excluding skin, shanks, and head) was multiplied by 100 to determine the dressing percentage. Similarly, thigh, drumstick, breast, liver, wing, heart, and gizzard weight were calculated as the ratio between individual weight of each organ and live weight multiplied by 100.

#### *Blood biochemistry*

At the moment of slaughter, measurements of blood indices like albumin, total protein, glucose, globulin, cholesterol, uric acid, and triglycerides were taken. For this, samples of 3 ml of blood from three birds per replicate were taken from the wing vein. An anticoagulant was used inside a single-use syringe measuring 5 ml. Blood vacutainers were used in order to transfer the blood. Serum was extracted from the blood by centrifuging it at 3,000 g for 10 minutes. Serum was stored in 1.5-mL Eppendorf tubes at -20°C for later examination. Blood parameters were determined by spectrophotometric analysis of the serum (Rehman *et al.,* 2017). Prior to analysis, frozen serum was thawed at 4°C.

### Statistical analysis

Analysis of variance (ANOVA) technique with GLM procedure of SAS was applied to analyze data recorded, and means were compared through Duncan's multiple range test by taking each pen as experimental unit.

## RESULTS

### Growth performance

The results indicated significant differences in growth performance parameters among the diets. The birds fed inorganic selenium showed increased feed intake, followed by those fed organic Se and the control diet. On the other hand, birds fed organic Se exhibited higher body weight gain compared with those fed inorganic Se. Similarly, birds fed organic Se showed improved feed conversion ratio, followed by those fed inorganic Se and the control group (Table 3).

**Table 3 –** Effect of selenium-supplemented diets on the growth performance of growing Rhode Island Red chicks[1].

| Parameters[2] | Treatments | | | |
|---|---|---|---|---|
| | Organic Se | Inorganic Se | Control | *p*-value |
| FI (kg) | 1.235[a] | 1.280[ab] | 1.175[b] | 0.03 |
| BWG (g) | 333.66[a] | 318.60[b] | 280.40[c] | 0.05 |
| FCR | 3.70[c] | 4.01[b] | 4.19[a] | 0.02 |

[a-c]Different letters on treatment means within a row show significant differences ($p<0.05$).

[1]Data are means of 5 replicates (n=5) with 15 birds per replicate.

[2]FI: feed intake, BWG: body weight gain, FCR: feed conversion ratio.

### Slaughter characteristics

Our results showed that organic Se supplementation increased breast and thigh weights when compared to inorganic Se, but no other metrics, such as dressing percentage, drumstick weight, liver weight, gizzard weight, heart weight, or wing weight, significantly varied between treatments (Table 4).

**Table 4 –** Effect of selenium-supplemented diets on the slaughter traits of growing Rhode Island Red chicks[1].

| Parameters[2] | Treatments | | | |
|---|---|---|---|---|
| | Organic Se | Inorganic Se | Control | *p*-value |
| CY (%) | 62.9 | 61.5 | 61.2 | 0.06 |
| BY (%) | 22.9[a] | 20.7[b] | 21.5[ab] | 0.005 |
| TY (%) | 21.2[a] | 20.2[b] | 20.9[ab] | 0.02 |
| DW (%) | 16.4 | 15.1 | 15.3 | 0.0025 |
| LW (%) | 3.4 | 3.7 | 3.5 | 0.063 |
| GW (%) | 3.2 | 3.5 | 3.3 | 0.055 |
| HW (%) | 0.7 | 0.6 | 0.7 | 0.05 |
| WW (%) | 8.5 | 8.1 | 7.9 | 0.0172 |

[a-b]Different letters on treatment means within a row show significant differences ($p<0.05$).

[1]Data are means of 5 replicates (n=5) with 15 birds per replicate.

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

### Blood biochemistry

When compared to birds fed inorganic Se and the control diet, birds fed organic Se had greater blood levels of total protein and globulin. Additionally, it was discovered that organic Se-fed birds had greater blood Se concentrations than control and inorganic Se-fed birds. However, no differences ($p>0.05$) between treatments were found for albumin, glucose, cholesterol, triglycerides, or uric acid levels (Table 5).

## DISCUSSION

### Se effect on growth performance

The poultry industry requires efficient growth to maintain business profitability. The weather was hot and humid when this study was conducted. According to the reports (Siegel, 1995; Melesse *et al.,* 2011; El-Deep *et al.,* 2014; Surai, 2016), high ambient temperature reduces the feed intake, live weight gain, feed efficiency, and immune response of broiler chicken. Moreover, hyperthermia may promote the formation of reactive oxygen species (ROS) (Mujahid *et al.,* 2005). Excessive ROS levels disturb the balance between oxidation and antioxidant defense systems, resulting in lipid peroxidation (Shimizu *et al.,* 2006) and oxidative damage to immune responses (Surai & Fisinin, 2016b), absorption of nutrients (Surai and Fisinin, 2015), and feed conversion efficiency (Belhdj *et al.,* 2015; Vasantha *et al.,* 2016). Therefore, a balance between ROS production and the antioxidant system must be established to maintain immune function, health, and productivity (Surai, 2002). Natural antioxidants including probiotics, vitamins, and trace elements play vital roles in protecting cells from ROS by reducing free radicals and preventing the peroxidation of lipids (Eid *et al.,* 2003; Lin *et al.,* 2006; Eid *et al.,* 2008; Sahin *et al.,* 2009). According to earlier reports, in comparison to its inorganic form, Se in the organic form is more potent (Sahin *et al.,* 2008; Surai, 2016) and eliminates free radicals from metabolic activity more effectively (Papazyan *et al.,* 2006; Sluis, 2007; Hanafy *et al.,* 2009; Attia *et al.,* 2010). Hence, it is possible to assume that including organic Se in the diet of RIR chicks improved growth performance by reducing the negative effects of high ambient temperature and promoting better nutrient utilization.

These results are consistent with reports of other authors (Zhou & Wang, 2011; Markovic *et al.,* 2018; Saleh & Ebeid, 2019; Gul *et al.,* 2021). Contrarily, Se supplementation in broilers has also been observed to not have any effect on growth performance (Payne & Southern, 2005; Ryu *et al.,* 2005; Peric *et al.,* 2009; Cai *et al.,* 2012; Chen *et al.,* 2013; Briens *et al.,* 2014; Chen *et al.,* 2014; Oliveira *et al.,* 2014; Boostani *et al.,* 2015; Chadio *et al.,* 2015; Liu *et al.,* 2015; Bakhshalinejad *et al.,* 2018; Li *et al.,* 2018; Bakhshalinejad *et al.,* 2019). Furthermore, it has also been demonstrated that broilers' growth performance could be improved through the supplementation of Se using either sodium selenite or Se yeast (Mansoub *et al.,* 2010; Wang *et al.,* 2021).

### Se effect on slaughter traits

Our results showed that organic Se supplementation increased breast and thigh weights when compared to inorganic Se. The treatment group's increased proportion of breast and thigh tissue was probably caused by the higher absorption and improved development brought on by the organic Se enhancing the metabolism of thyroid hormones that regulated animal growth (Arthur, 1991; Jianhua *et al.,* 2000). These findings are in line with what other writers have reported (Saleh & Ebeid, 2019). On the other hand, broilers given Se-supplemented diets and those fed the control diet showed no differences ($p$>0.05) in the percentages of breast and thigh muscles. Our results showed that Se supplementation had no effect on carcass weights and the percentages of drumstick, liver, gizzard, heart, and wings. Similar outcomes were obtained by other researchers, who discovered no connection between Se supplementation and carcass weights (Choct & Naylor, 2004; Payne & Southern, 2005; Sevcikova *et al.,* 2006; Heindl *et al.,* 2010; Chen *et al.,* 2013; Wang *et al.,* 2021) or carcass parts outputs (Downs *et al.,* 2000; Choct & Naylor, 2004; Payne & Southern, 2005; Sevcıkova *et al.,* 2006; Heindl *et al.,* 2010; Cai *et al.,* 2012; Chen *et al.,* 2013; Hada *et al.,* 2013; Chen *et al.,* 2014; Oliveira *et al.,* 2014; Baltic *et al.,* 2016; Bakhshalinejad *et al.,* 2018; Jamnongtoi *et al.,* 2018; *Li et al.,* 2018; Bakhshalinejad *et al.,* 2019). In contrast, organic forms of Se increased eviscerated weight in one study (Choct *et al.,* 2004).

### Se effect on blood biochemistry

Animals' physiological and general health can be assessed using biochemical indicators (Qiu *et al.,* 2021), which are positively connected with their dietary state (Adejumo, 2004). High levels of oxidative stress on blood metabolites and increased generation of reactive oxygen species are associated with Se deficiency (Zheng *et al.,* 2019). In order to avoid oxidative stress and free radical damage to blood metabolites, an enzyme known as glutathione peroxidase is essential. Selenium indirectly helps to reduce oxidative damage to blood metabolites since selenium is present in this enzyme.

In the current investigation, the levels of total protein and globulin in the blood of the birds fed organic Se were higher than those of the control diet and birds fed inorganic Se. The causes for this were not immediately apparent. Furthermore, it was shown that birds fed organic Se had higher blood Se concentrations than control and inorganic Se-fed birds. Albumin, glucose, cholesterol, triglycerides, and uric acid levels did not differ ($p$>0.05) between treatments (Table 5). This supports earlier findings that Se had no significant effects on broiler (Hosseini Mansoub *et al.,* 2010; Rashidi *et al.,* 2010; Kanchana & Jeyanthi, 2010; Habibian *et al.,* 2014; Khalifa *et al.,* 2021) or layer (Lin *et al.,* 2020) serum biochemical markers. On the other hand, it was discovered that feeding broilers Se had a substantial impact on the plasma levels of total cholesterol and triglycerides (Saleh & Ebeid, 2019). In the current study, the organically fed birds had greater blood Se concentrations than the control and inorganically fed birds. The fact that the birds given organic Se had greater blood selenium concentrations is consistent with other previous results (Gul *et al.,* 2021).

**Table 5 –** Effect of selenium-supplemented diets on the blood profile of growing Rhode Island Red chicks[1].

| Parameters[2] | Treatments | | | |
|---|---|---|---|---|
| | Organic Se | Inorganic Se | Control | P-value |
| TP (g/dL) | 3.4 | 3.3 | 3.5 | 0.05 |
| AB (g/dL) | 1.8 | 1.7 | 1.7 | 0.15 |
| GB (g/dL) | 1.5 | 1.5 | 1.7 | 0.05 |
| GL (mg/dL) | 138.3 | 140.7 | 137.2 | 0.35 |
| CH (m/dL) | 160.2 | 158.7 | 157.5 | 0.70 |
| TR (mg/dL) | 91.7 | 90.4 | 89.6 | 0.52 |
| UA (g/dL) | 3.8 | 3.9 | 3.6 | 0.72 |
| Se (µg/L) | 57.35[a] | 50.20[b] | 41.15[c] | 0.002 |

[a-b]Different letters on treatment means within a row indicate significant differences ($p$<0.05).

[1]Data are means of 5 replicates (n=5) with 15 birds per replicate.

[2]TP: total protein, AB: albumin, GB: globulin, GL: glucose, CH: cholesterol, TR: triglycerides, UA: uric acid.

## CONCLUSIONS

Nutritional supplementation with Se enriched yeast, an organic source of selenium, may help improve the growth and slaughter features of Rhode Island Red chicks without having a detrimental impact on blood biochemistry.

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## DISCLOSURE OF POTENTIAL CONFLICT OF INTEREST

All authors of the present study declare that there is no financial or any other conflict of interest.

## AUTHOR CONTRIBUTIONS

Conceptualization, M.T.K. and M.A.; methodology, M.T.K., T.A. and M.A.; software, F.R., M.A.G., M.Q. and G.F.; validation, M.R., S.L. and F.A.; formal analysis, M.T.K., Z.M.I., F.W. and I.H.R.; investigation, M.T.K., S.A. and M.A.; data curation, S.A., M.A., T.A. and M.A.; writing—original draft preparation, M.T.K., S.A., S.N., H.A.B., G.A., Z.F. and E.B.; writing—review and editing, U.Y. and Q.N.; supervision, M.T.K. and M.A. All authors have read and agreed to the published version of the manuscript.

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