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Impacts of Zinc, Selenium, and Vitamin E Supplementation on Growth Performance, Hematological and Biochemical Parameters of Blood in Broiler Chickens

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ABSTRACT

Metabolism, lipid synthesis, and reducing oxidative stress contribute to broiler chickens' growth and immunity. The current study examined how zinc, vitamin E, and selenium impact broiler growth, carcass characteristics, hematological and serum biochemical parameters, and profitability. There were 300-day-old straight-run chicks (Indian River) raised in a deep litter system until 28 days old. On day 7, the chicks were randomly divided into four groups of 75 chicks, each group replicated into 3 replications. Supplementation of zinc, selenium, and vitamin E through water was conducted from day 7 to day 28. This experiment was performed during the lifespan of chickens from 0 to 28 days of age. The treatment groups were control (drinking water with no supplementation), Zn (drinking water with 4 ml/L zinc), Se+Vit E (drinking water with 0.25 ml/L E-Sel), and Zn+Se+Vit E (drinking water with both 4 ml/L zinc and 0.25 ml/L E-Sel). The results indicated significant changes in growth and feed conversion ratio among Zn, Se, and Vit-E supplemented groups. Among the supplemented groups, the Zn+Seleium+VitaminE group exhibited higher growth performance, lower cholesterol, and lower production costs. The findings showed no significant changes in dressing characteristics and feed consumption among groups. The combined group of Zn, Se, and Vit-E had a lower abdominal fat content than other supplemented groups. Supplemented with Zn, Se, and Vit-E groups had lower cholesterol and LDL levels than the control group. Serum differential leukocyte count (eosinophils, lymphocytes, neutrophils, and monocytes) and liver and kidney function tests (ALT, AST, creatinine) showed no significant variations between the groups. Antioxidants increased profitability, with the Zn+Se+Vit E group having a higher profit per kg broiler and cost-benefit ratio. Broiler growth performance, dressing characteristics, biochemicals, and hematological indicators are associated with supplementation Zn, Se, and Vit- E. The addition of Zn (4 ml/L) and Se and Vit E solution (E-Sel) (0.25 ml/L) to drinking water could enhance broiler growth performance and reduce cholesterol and high-density lipoprotein (HDL) concentration.

Keywords: Broiler, Selenium, Vitamin E, Zinc, Performance

INTRODUCTION

Despite its limited area, Bangladesh has a rapidly expanding population and generates 9.22 million metric tons of meat per year (DLS, 2024), with the broiler sector making a significant contribution. The nation has a variety of broiler farms, ranging from small to large, although many confront suboptimal environmental circumstances detrimental to chick health. The rapid growth of broiler chickens, often associated with compromised immune systems, exacerbates their health management challenges (Oke et al., 2024). Antioxidants are chemical substances that are crucial contributors to animal survival, health, productivity, and reproductive success. Several minerals and vitamins function as antioxidants, such as zinc, selenium, and vitamin E (Surai and Fisinin, 2016).

Zinc (Zn) is identified as essential for the production of the antioxidant superoxide dismutase enzyme that helps to break down potentially harmful oxygen molecules in cells (Long et al., 2020). Zinc is an important biological activity and is required for skeletal and improved immunological responses. The antioxidant capabilities of zinc might be attributed to its role as the catalytic core of superoxide dismutase, an essential enzyme in maintaining cellular redox balance and preventing oxidative damage that can impair immune function (Saleh et al., 2018). Zinc could be incorporated into broiler diets in the form of either organic Zn (zinc protein, zinc amino acid, or zinc picolinate) or inorganic Zn (zinc chloride, zinc sulfate, or zinc oxide). Inorganic zinc sulfate has a positive effect on broiler growth performance, serum biochemistry, and antioxidant function when compared with other zinc sources (Xie et al., 2024). $ZnSO_4$, a highly bioavailable form of zinc, is often incorporated into chicken diets to satisfy their growth-related Zn requirement (Leeson and Caston, 2008). Xie et al. (2024) demonstrated that zinc methionine and $ZnSO_4$ are equally efficacious in enhancing growth and zinc levels in day-old broiler chickens. Selenium (Se) is considered to be an essential trace mineral for both animals and humans. Selenium has the potential to enhance growth, immunity, reproductive performance, and resistance to sickness (Ghazi Harsini et al., 2012; Habibian et al., 2014). Selenium improves feed utilization by acting on the biosynthesis of amino acids, lipids, and carbohydrates (Stapleton, 2000). Selenium is a highly effective antioxidant in nature, which has a vital health-boosting effect. When selenium is paired with vitamin E, it could enhance immunity and reduce the risk of cancer (Lü and Jiang, 2005; Huang et al., 2012). Vitamin E (Vit-E) is crucial for growth and physiological and immunological function (Gao et al., 2010). Vitamin E supplementation is frequently incorporated into chicken feed as DL-α-tocopherol acetate; it has equivalent amounts of eight stereoisomers. Studies indicated that D-α-tocopherol, in contrast to synthetic alternatives, shows superior retention in blood and tissues (Cheng et al., 2017), alleviates lipopolysaccharide-induced inflammatory reactions (Kaiser et al., 2012), and improves the quality of chicken meat's quality (Gao et al., 2010; Rey et al., 2015). Vitamin E enhances the resistance of the body against free radical damage during metabolic and inflammatory processes (Sheikh et al., 2020). This function inhibits the lipid peroxidation of unsaturated fats inside the cell, therefore safeguarding the cell from the harmful effects of free radicals (Khan, 2011). Vitamin E plus selenium are important food compounds that not only have high antioxidant properties but can also affect different biological processes of the body (Alyari Gavaher et al., 2022). Selenium and vitamin E may interact synergistically to affect biological functions, including immunology and antioxidant activity (Spears and Weiss, 2008). This interaction is especially evident in neutrophil activity, lymphocyte proliferation, and cell-mediated immunity in livestock. Ribeiro et al. (2021) demonstrated similar findings regarding the impact of selenium, along with vitamin E and zinc, on the growth performance of broiler chickens. The current study is intended to assess the implications of using several micronutrients (zinc, vitamin E, and selenium) as antioxidants on broiler growth performance, dressing characteristics, and hematological and serum biochemical parameters.

MATERIALS AND METHODS

Ethical approval

All protocols and ethical use of experimental animals were approved by the Ethical Standard of Research Committee, Bangladesh Agricultural University, Mymensingh-2202 (No. BAURES/ESRC/AH/73).

Experimental layout

In this experiment, 300-day-old Indian River straight-run broiler chicks were reared. The study was conducted at a poultry farm under the Department of Poultry Science, Bangladesh Agricultural University, Mymensingh (Bangladesh). The chicks were assigned to 4 dietary treatments in 3 replications with 25 chickens per replication for 28 days, following a completely randomized design. The treatment groups were control (drinking water with no supplementation), Zn (drinking water with 4 ml/L zinc), Se+Vit-E (drinking water with 0.25 ml/L E-Sel), and Zn+Se+Vit-E (drinking water with both 4 ml/L zinc and 0.25 ml/L E-Sel).

These solutions were employed according to the manufacturer's suggestions. Inorganic zinc was used as Zesup-Vet solution, and Vitamin E and selenium solutions were provided as E-Sel® solution, which includes liquid alpha-tocopherol acetate and sodium selenite as vitamin and mineral supplements (water-soluble nutrients), both manufactured by Square Pharmaceuticals PLC, Bangladesh.

Chickens' management

The trial was performed in a semi-monitored open-sided building. The starter diet (ME 2950 Kcal and Crude protein 22%) was fed for the first 10 days, followed by the grower diet (ME 3050 Kcal and Crude protein 20%) for the broilers until they reached 4 weeks of age. This experiment was performed during the lifespan of chickens from 0 to 28 days of age. Chickens were fed twice daily, ensuring feeders were never empty and fed *ad-libitum*. Treated and non-treated water was administered twice daily. Weekly feed refusals were examined. The brooding temperature started at 34°C and decreased by 2°C weekly until the fourth week. The lighting was constant during the brooding period, followed by 23 hours of illumination and 1 hour of darkness. All chickenchickens were vaccinated against infectious bursal disease by Nobilis Gumboro 228E (I/O 1 drop at days 11 and 24) and Newcastle disease by Nobilis ND clone 30 (I/O 1 drop at days 4 and 24). Fencing and additional biosecurity measures, such as rat traps and wild chicken protector nets, secured the entire research site from rats and wild animals.

Data collection and record-keeping

After the first day of the experiment, chicks were weighed from each replication once a week up to the end of the experiment. The initial body weight was subtracted from the end body weight to get the average body weight increase for each replicate group under the four treatments. Weights were recorded in the morning before feeding. Every week's feed consumption for the chickens in each replication of all treatment groups was determined by subtracting the quantity of excess feed from the total amount provided. One broiler with equivalent body weight was pulled out from each pen after the study in order to record the parameters and quality of the meat yield. They were killed following the Halal technique (Riaz et al., 2021), which involves cutting the neck and holding the chicken until the bleeding is completely stopped. Skin, feathers, viscera, giblets, legs, and heads were removed from the carcass. Meat yield data, including weights of live, dressed, liver, gizzard, abdominal fat, spleen, thighs, drumsticks, and breast, were recorded by replicating and converted into percentages of live weight before statistical analysis.

Hematological and serum biochemical parameters

To collect 4 or 5 ml of blood from each replication, a series of sterile blood collection tubes having the anticoagulant EDTA at a ratio of 1:10 was utilized. After slaughtering, blood samples were taken from the jugular vein of the broiler chicken. After two hours, the separated blood serum was extracted to an Eppendorf tube and centrifuged for ten minutes at 4000 rpm. The serum was separated using a Microfuge 20R centrifuge (Beckman Coulter Inc., USA). The serum was then put into a different Eppendorf tube and preserved at -20°C until it was time to be assessed. Serum cholesterol, triglycerides (TG), low-density lipoprotein (LDL), high-density lipoprotein (HDL), liver enzyme aspartate aminotransferase (AST), and alanine aminotransferase (ALT) were estimated using a commercial kit (Monlab S.L., Spain) with a standard method using the double-beam UV-visible spectrophotometer LAMBDA 365 (Perkin Elmer, Inc., USA). The creatinine test is based on a modified picrate reaction and uses a cromatest solution (Linear Chemicals S.L.U, Spain). For differential lymphocyte count, a blood smear was prepared with Wright's stain, and then methanol fixing was done. In terms of the total number of leucocytes, the percentage of differential leucocyte count (DLC) was represented.

Cost-benefit analysis

The cost-benefit ratio indicates the investment's net benefits and capital cost over time. The profitability index measures the present value of benefits per dollar invested. For the cost-benefit analyses (in US dollars) of the experiment, different parameters were computed, as described by Alabi and Aruna (2005), where Total Revenue (TR) referred to the total income generated from chicken sales, and Net Profit (NP) was determined by subtracting the total cost of production from total revenue. The Cost-Benefit Ratio (CBR) was determined using the TR ÷ TCP method, indicating the experiment's financial feasibility.

Statistical analysis

SAS (2009) general linear models performed a fully randomized variance analysis of broiler chickens' body weight, body weight gain, feed intake, feed conversion ratio (FCR), dressing parameters, and hematological and serum biochemical parameters. Duncan's Multiple Range Test was carried out to assess mean value variation. The significance and higher significant levels were chosen at $p < 0.05$ and $p < 0.01$, respectively.

RESULTS

Growth performances of broiler chicken

Table 1 presents higher significant variances in the body weight at 28th days of age in the supplemented groups ($p < 0.01$). Higher significant variations were noticed in the body weight gain during 15-28 days and a total 0-28 days of age among the treated groups ($p < 0.01$). In supplemented groups, the Zn + Se + Vit-E group represented the highest body weight and weight gain, followed by the Se + Vit-E and control groups. No significant feed consumption changes were seen in treated and non-treated throughout the periods of 0-14 days, 15-28 days, and total 0-28 days of age ($p > 0.05$). Figure 1 indicates a significant variation ($p < 0.01$) of FCR in growing (15-28 days) and total period (0-28 days) among the treated groups. The group supplemented with Zn + Se + Vit-E had an improved FCR value than other treated groups for the period of 0-28 days and 15-28 days of age.

In considering the entire time frame, the Zn + Se + Vit-E group revealed lower FCR in comparison to the other groups.

Dressing parameters

Table 2 shows that no substantial variations were noticed in dressing parameters (dressing %, spleen, liver, abdomen fat, gizzard weight), breast meats, thigh meats and bone, and drumstick meats and bone among the groups ($p > 0.05$). The Zn and Zn + Se + Vit-E treated groups reported a numerically low level of abdominal fat ($p > 0.05$).

Hematological and serum biochemical parameters

Table 3 illustrates that significant variations were found in LDL and cholesterol levels across the dietary groups ($p < 0.05$). The groups supplied with antioxidants showed low concentrations of LDL and cholesterol, while both Zn and Zn + Se + Vit-E groups had relatively similarly low values to the Se + Vit-E supplemented group. However, no significant differences were seen in the levels of creatinine, TG, HDL, ALT, and AST in the treated groups ($p > 0.05$). According to the results, Zn, Se, and Vit-E had no influence on liver and kidney function. The serum differential leukocyte count (DLC) results are listed in Table 4, which suggested no significant variations ($p > 0.05$) among the supplemented groups. All treated groups had a numerical increase in eosinophil and lymphocyte concentrations compared to the control.

Cost-benefit analysis of broiler chicken

Figure 2 shows that the control group possessed the higher production cost per kilogram of chicken, while the Zn + Se + Vit-E group was the lowest. The research estimated the profit per kilogram of chicken to be \$0.33 for the control, \$0.34 for the Zn, \$0.34 for the Se + Vit-E, and \$0.35 for the Zn + Se + Vit-E group. As a result, the cost-benefit ratio was greater for the antioxidant-fed chickens compared to the control. Nevertheless, there was no economic variation in the Zn and Se + Vit-E groups.

Table 1. Effects of zinc, selenium, and Vit-E on body weight, body weight gain, and feed intake of broiler chickens

Parameters	Control	Zn	Se+Vit-E	Zn+Se+Vit-E	P Value	LS
Body weight (g/chicken)						
14 days	510.08±2.57	506.72±7.44	507.81±3.47	507.64±5.25	0.964	NS
28 days	1577.53^{c}±2.13	1649.96^{b}±9.51	1636.21^{b}±0.15	1672.00^{a}±7.75	0.0001	**
Body weight gain (g/chicken)						
Period (0-14) days	467.50±2.57	464.27±7.44	466.21±3.47	465.06±5.25	0.970	NS
Period (15-28) days	1067.45^{c}±1.53	1143^{ab}±15.50	1128.40^{b}±3.36	1164.94^{a}±6.57	0.0003	**
Total Period (0-28) days	1543.95^{c}±2.13	1607.5^{b}±9.51	1594.6^{b}±0.15	1630.00^{a}±7.75	0.0001	**
Feed intake (g/chicken)						
Period (0-14) days	561.69±1.42	546.71±6.77	560.12±1.63	557.13±4.58	0.125	NS
Period (15-28) days	1810.55±20.75	1828.40±10.15	1833.96±5.28	1806.31±8.96	0.395	NS
Total Period (0-28) days	2372.25±19.39	2375.11±9.39	2394.08±4.36	2363.44±4.42	0.333	NS

^{abc} means different superscript letters in the same row show significant differences; Data presented as mean ± standard error; **: $p < 0.01$; LS: Level of Significance; NS: Non-significant

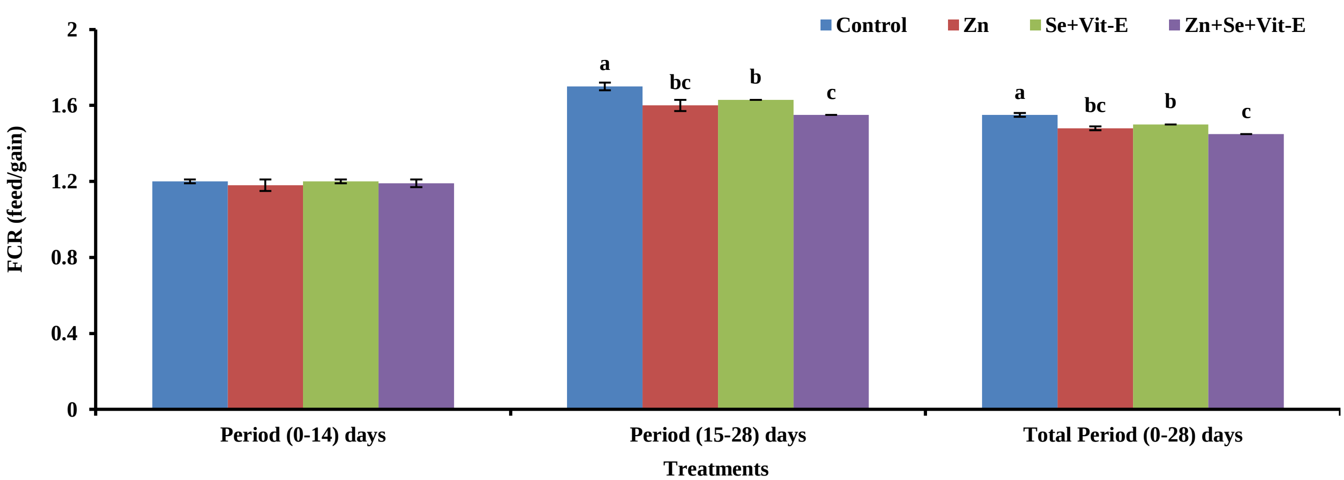

Figure 1. Effects of zinc, selenium, and Vit-E on feed conversion ratio (feed/gain) of broiler chickens. Values are expressed as means ± SD. Bars within a time class not sharing a common letter are significantly different ($p < 0.05$).

Table 2. Effects of zinc, selenium, and Vit-E on dressing parameters of broiler chickens (relation percentage to body weight)

Parameters	Control	Zn	Se+Vit-E	Zn+Se+Vit-E	P Value	LS
Dressing yield	73.06±1.76	70.64±1.45	72.40±0.10	72.31±0.99	0.583	NS
Spleen	0.18±0.03	0.21±0.05	0.19±0.00	0.14±0.03	0.623	NS
Liver	2.84±0.16	2.94±0.07	2.76±0.22	3.29±0.39	0.465	NS
Abdominal fat	0.98±0.06	0.88±0.08	1.08±0.24	0.84±0.04	0.603	NS
Gizzard	1.20±0.05	1.43±0.26	1.35±0.01	1.41±0.16	0.727	NS
Breast meat	11.81±0.26	10.83±0.34	10.71±0.81	10.19±0.22	0.191	NS
Thigh meat	5.06±0.58	5.14±0.34	5.36±0.28	4.99±0.33	0.925	NS
Drumstick meat	3.58±0.28	3.88±0.23	3.29±0.08	3.69±0.23	0.352	NS
Thigh bone	0.87±0.17	0.98±0.08	0.72±0.05	0.98±0.06	0.300	NS
Drumstick bone	1.24±0.08	1.40±0.18	0.99±0.07	1.03±0.32	0.440	NS

Data presented as mean ± standard error; LS: Level of Significance; NS: Non-significant

Table 3. Effects of zinc, selenium, and Vit-E on blood biochemical parameters of broiler chickens (mg/dl)

Parameters	Control	Zn	Se+Vit-E	Zn+Se+Vit-E	P Value	LS
Cholesterol	174.62^{a}±3.67	148.39^{c}±3.36	164.51^{ab}±3.69	152.69^{bc}±6.86	0.014	**
TG	88.33±7.26	91.87±8.34	77.25±9.11	92.60±0.91	0.450	**NS**
HDL	43.70±1.45	37.69±0.69	41.64±1.11	39.11±2.23	0.081	**NS**
LDL	113.25^{a}±3.17	92.33^{b}±4.41	107.22^{ab}±4.88	95.05^{b}±5.30	0.032	*
ALT	27.48±4.43	32.27±3.41	27.59±5.76	27.17±6.67	0.882	**NS**
AST	214.37±3.18	225.32±4.63	229.77±6.86	214.80±1.66	0.101	**NS**
Creatinine	0.61±0.06	0.96±0.15	1.02±0.18	0.95±0.15	0.245	**NS**

^{abc} means having not similar superscripts in the same row differed significantly; Data presented as mean ± standard error; *: p < 0.05; **: p < 0.01; LS: Level of Significance; NS: Non-significant

Table 4. Effects of zinc, selenium, and Vit-E on hematological (%) parameters of broiler chickens

Parameters	Control	Zinc	Se+Vit-E	Zn+Se+Vit-E	P Value	LS
Neutrophils	31.33±1.45	28.67±2.19	30.33±0.67	31.00±1.73	0.665	NS
Eosinophils	1.33±0.88	1.67±0.67	1.67±0.88	2.00±0.58	0.941	NS
Lymphocytes	64.67±0.88	68.67±1.86	66.00±1.00	65.00±1.52	0.236	NS
Monocytes	2.67±0.33	1.00±0.58	2.00±0.57	2.00±0.58	0.244	NS

Data presented as mean ± standard error; LS: Level of Significance; NS: Non-significant

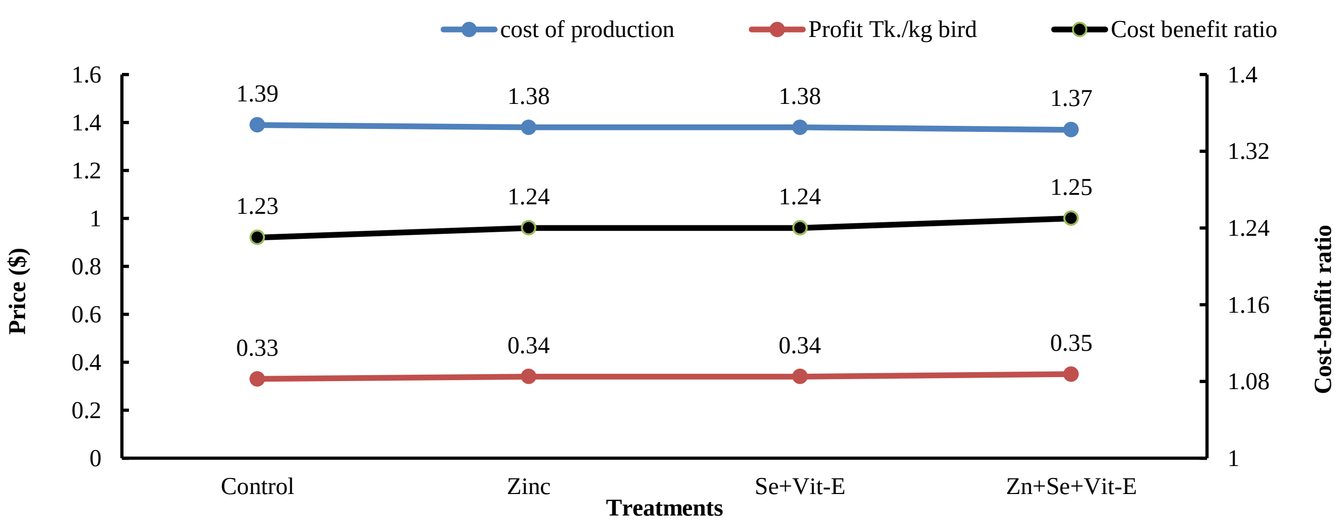

Figure 2. Effects of zinc, selenium, and Vit-E on the cost-benefit ratio of broiler chickens. 1 USD = 119.67 BDT

DISCUSSION

Growth performances of broiler chickens

Human health widely uses zinc, selenium, and vitamin E as medicinal products. The addition of Zn, Se + Vit-E, and Zn + Se+Vit-E to drinking water positively impacted the growth performances of broiler chickens. Zn (80 mg/L) added to drinking water significantly enhanced growth performance (Mohammed et al., 2023). The results of the present study aligned with the findings of Khalifa et al. (2021), who discovered that nutritional supplementation of chickens with Vit-E (100 mg/kg) and Se (0.3 mg/kg) significantly enhanced growth compared to the control. However, Tayeb and Qader (2012) indicated that supplementation of Vit-E and Se (0.45 mg Se +150 mg Vit-E/kg feed) failed to cause significant changes in the growth performance of broiler chicken. Zinc increases glucose utilization and insulin metabolism, which affects weight growth. The Se and Vit-E influence the growth hormone receptor (GHR) and insulin-like growth factor 1 (IGF1), which promote growth performance in broiler chickens (Khalifa et al., 2021). This study revealed no significant variations in feed intake across the dietary groups. The present study corresponded with Tayeb and Qader (2012) and Albuquerque et al. (2017), who demonstrated that no significant changes were in feed consumption across all treatments (Vit-E and Se) and controls. Zhang et al. (2018) stated that Zn did not influence feed intake. This study contradicted the findings of Vit-E and Se by Laganá et al. (2007) and Zn and Vit-E by Hosseini-Mansoub et al. (2010), where supplemented broiler chickens consumed decreased feed intake. Additionally, El-Sebai (2000) stated that supplementation with Se and Vit-E significantly improved feed intake. The current study demonstrated that supplementation of Zn, Se, and Vit-E exhibited improved feed efficiency compared to the control group. The combination of Zn, Se, and Vit-E achieved the maximum feed conversion ratio, followed by the groups receiving Zn, Se + Vit-E, compared to the control group. Hosseini-Mansoub et al. (2010) reported the optimal feed conversion ratio when broilers supplemented with zinc and Vit-E (100 and 50 mg/kg) relative to the control. Ao et al. (2009) discovered that $ZnSO_4$ (31 mg/kg) supplementation affected FCR. The present study agreed with the findings of Laganá et al. (2007), who showed that supplemented chickens with Zn who found that adding Zn (50, 75, and 100 mg/kg) caused a significant improvement in serum cholesterol in broiler breeders; this increase may be attributed to the role of steroid hormones, though the mechanism was not entirely clear. Similarly, Aljumaily and Aljumaily (2021) provided chickens with Se and Vitamin E (0.25 mg and 300 mg/kg), (40 ppm/kg), and Se (0.3 ppm/kg) had a much-improved feed conversion ratio. Ghazi Harsini et al. (2012) reported that adding Vit-E (1 mg/kg) and Se (0.5 mg/kg) enhanced the feed efficiency of chickens in turning feed into meat. Zinc, a cofactor in over 240 enzymes, metabolizes foods including carbohydrates and proteins, boosting growth and reproduction (Chand et al., 2014). The Zn supplementation improved enzyme activity and efficiency of feed by increasing the digestibility of nutrients in broiler chickens (Kucuk et al., 2003). Selenium and Vit-E reduce oxidative stress that impairs growth and feed efficiency. Tayeb and Qader (2012) observed no major changes in the feed conversion ratio among all treatments (Vit-E, 100mg/kg and Se 0.3mg/kg) and controls, while Zhang et al. (2018) mentioned that Zn did not influence feed efficiency.

Dressing parameters

The present study did not observe any significant changes in dressing characteristics among the supplemented groups. Lu et al. (2014) found no significant variations in chicken breast meat, liver, and heart weight in Vit-E-supplemented groups. Perić et al. (2009) found no noteworthy impacts in broiler dressing parameters for the selenium-supplemented group, while Aljumaily and Aljumaily (2021) noticed Se and Vit-E had no consequence on dressing parameters in broiler chickens. Attia et al. (2016) and Yusof et al. (2023) observed no impacts of Zn (0.05 mg/kg and 40 mg/kg consecutively) on dressing percentage in broiler chickens. Moreover, the chickens fed Zn (20 mg/kg) demonstrated a decrease in abdominal fat (Kucuk et al., 2003). In addition, Vit-E had an important role in fat reduction in broiler chickens (Zhang et al., 2021).

Hematological and serum biochemical parameters

The study indicated that the supplemented groups had significantly lower cholesterol and LDL levels than the control group. This study aligned with the findings of Kucuk et al. (2003), Aksu and Ozsoy (2010), and Moustafa et al. (2021) in broiler chickens and Babazadeh et al. (2022) in rats. Mangayarkarasi et al. (2015) found that Zn, Vit-E, and Se (80 mg, 0.25 mg, and 50 mg/kg) administration reduced serum cholesterol and LDL concentrations in broiler chickens. However, the present study contradicted the study of Al-Daraji and Amen (2011), who found that adding Zn (50, 75, and 100 mg/kg) caused a significant improvement in serum cholesterol in broiler breeders and this increase may be attributed to the role of steroid hormones but mechanism was not quietly clearly, as well as Aljumaily and Aljumaily (2021), who gave chickens Se and Vit-E (0.25 mg and 300 mg/kg). Antioxidant supplements (Se and Vit-E) did not affect TG or HDL. According to Habibian et al. (2014), there were no significant changes in HDL and cholesterol, however, LDL concentrations were higher when chickens' diets supplemented Se and Vit-E. A diet supplemented with Se, Zn, and Vit-E may reduce malondialdehyde production in the liver by increasing glutathione peroxidase enzyme, reducing oxidative damage, and lowering serum cholesterol and LDL levels (Yanardag et al., 2007). The results demonstrated no significant changes in AST, ALT, and creatinine among the supplemented groups. Yusof et al. (2023) found no effect of dietary Zn (40 mg/kg on basal diet) on AST and ALT activity. According to Arslan et al. (2001), Vit-E and Se had no impacts on plasma AST or ALT levels. Conversely, Gul et al. (2022) observed that Vit-E and Se elevated AST, ALT, and creatinine levels in comparison to the control group. The Vit-E and Se decrease oxidative damage to muscle tissues, hence reducing muscle degradation and the consequent synthesis of creatinine (Ryan et al., 2010). Mashkoor et al. (2013) and Aljumaily and Aljumaily (2021) reported that supplementing broiler diets with Se and Vit-E increased lymphocytes. It also supported the findings of Sridhar et al. (2015), who found that supplementing with Zn raised the concentration of lymphocytes. This study deviated from the conclusions of Da Silva et al. (2009), who claimed that Vit-E did not impact broiler hematological parameters and had no noticeable impact on lymphocyte depletion analysis. The present study confirmed the findings of Chand et al. (2014), who reported that although heterophils and eosinophils did not alter, lymphocytes in the treated groups significantly increased. Selenium, a vital component of the antioxidant enzyme glutathione peroxidase (GPx), plays a crucial role in maintaining cellular redox balance and thereby protecting lymphocytes. In response to intestinal infections, Zn stimulates the generation of circulating lymphocytes and antibodies (Lamberti et al., 2013). However, Vit-E and Se treatment had no significant effects on any hematological parameters, according to a study by Tras et al. (2000).

Cost-benefit analysis of broiler

The present study has shown that supplementing with Zn, Se, and Vit-E was the most cost-effective way to improve productivity. The antioxidant-supplemented groups were able to increase their total profit due to increased body weight gain by increasing nutrient metabolism and reducing oxidative stress. Salami et al. (2015) indicated that a combination of dietary antioxidants (Vit-E, Vit-C, Se) might offer significant financial benefits in chickens. Jayanthi et al. (2018) and Abou–Ashour et al. (2022) reported that selenium supplementation increased body weight and reduced production cost in chickens.

CONCLUSION

Diets supplemented with antioxidants, including Zn (4 ml/L), Se, and Vit-E solution (0.25 ml/L), exhibited improved growth and feed efficiency in broilers, leading to greater profit relative to the other treatment groups. Moreover, antioxidant treatments led to a significant decrease in cholesterol and LDL concentrations. Future studies should be conducted to estimate better dosages of these micronutrients in broiler chicken production.

DECLARATIONS

Acknowledgments

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Authors’ contributions

Jakir Hossain contributed to the research, data collection, data analysis, and manuscript preparation. Md. Elias Hossain and Musabbir Ahammed supervised and revised the manuscript. The final version of the article was reviewed and approved by all the authors, who also looked over the information submitted in this publication.

Availability of data and materials

This article incorporates all research data, with additional material attainable upon reasonable request from the corresponding author.

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Ethical considerations

The manuscript underwent scrutiny for ethical issues, including plagiarism, permission to publish, misconduct, data fabrication and falsification, double publishing, and redundancy by all authors.

Competing interests

All authors have declared that they have no conflicts of interest.

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