Direct Research Journal of Agriculture and Food Science

Direct RESEARCH JOURNALS

Vol. 13(3), Pp. 116-124, September 2025,

https://journals.directresearchpublisher.org/index.php/drjafs; https://www.ajol.info/index.php/drjafs

Research Article
ISSN: 2354-4147

Synergistic Roles of Dietary Selenium (Selenomethionine) and Vitamin E (α-tocopheryl acetate) in Enhancing Laying Performance and Egg Quality of Hens

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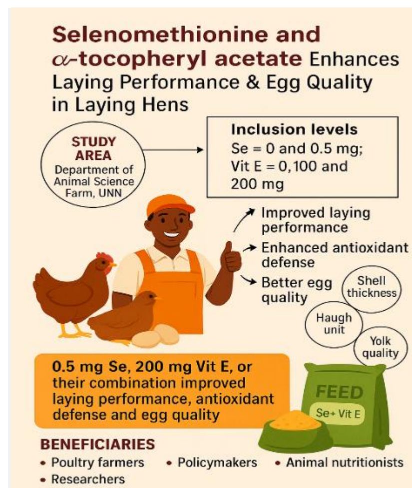
ABSTRACT: *The study explored the laying performance and egg quality of hens fed dietary selenium (Se) and vitamin E (Vit E). A total of 72 laying hens with an initial average weight of 1233.61±14.64 g were randomly assigned to six treatments, with 12 birds per treatment (replicated thrice). Hens were fed six treatments in commercial diets that were isocaloric and isonitrogenous but varied in Se and Vit E levels, namely: 0.0 mg Se + 0.0 mg Vit E, 0.5 mg Se + 0.0 mg Vit E, 0.0 mg Se + 100 mg Vit E, 0.0 mg Se + 200 mg Vit E, 0.5 mg Se + 100 mg Vit E, and 0.5 mg Se + 200 mg Vit E. The study lasted for 84 days and followed a Completely Randomized Design with a 2 × 3 factorial arrangement. Results showed that Se inclusion in hens' diets had no adverse effect on laying performance, with a significant (P<0.05) increase in feed intake and hen-day egg production when 0.5 mg was supplemented. Significant effects were observed in final body weight, weight gain, feed intake, and egg weight due to 200 mg Vit E inclusion (P<0.05). Interaction effects caused significant differences in final body weight, weight gain, and feed intake, with an improved feed conversion ratio (P<0.05). Regarding egg quality, 0.5 mg Se improved eggshell weight, eggshell thickness, and egg shape index (ESI), whereas 200 mg Vit E improved (P<0.05) yolk height, yolk index, yolk weight, egg surface area, shell percent, eggshell weight per surface area (ESWSA), and Haugh unit. Se + Vit E interactions improved ESI, Haugh unit, and ESWSA. Based on these findings, we conclude that 0.5 mg Se, 200 mg Vit E, or their combination is appropriate for optimum production and reproduction of laying hens.*

Keywords: *Antioxidant, egg traits, laying hens, production performance, selenium + vitamin E interaction*



Received 5 July 2025
Accepted 12 September 2025
Published 28 September 2025
https://doi.org/10.26765/DRJAFS14588602

Citation: Aba, C. N., Ali, L. C., Anizoba, N. W., Orjiakor, F. S., Amaefule, B. C., Nwangwu, A. C. & Machebe, N. S. (2025). Synergistic Roles of Dietary Selenium (Selenomethionine) and Vitamin E (α-tocopheryl acetate) in Enhancing Laying Performance and Egg Quality of Hens. *Direct Research Journal of Agriculture and Food Science*. Vol. 13(3), Pp. 116-124.

INTRODUCTION

Increasing chicken production is essential to meet demand, as the typical Nigerian diet is seriously deficient in animal protein. Nigeria is the leading producer of poultry eggs in Africa and the second-largest producer of chicken after South Africa (FAO, 2019; Adeyonu *et al*., 2021). Poultry plays a vital role in the economy, serving as a major enterprise for small-scale farmers who contribute significantly to national Gross Domestic Product (Ogunseitan and Ajeigbe, 2024).

Environmental stressors such as heat stress, cold stress, and high stocking density pose an increasing threat to egg quality, fertility, hatchability, and overall hen productivity (Ghanem *et al*., 2021). In Nigeria, broiler and layer chicken performance is severely impaired by intense heat stress resulting from high ambient temperatures, harmattan conditions, and elevated relative humidity that peaks at the onset of the rainy season (Bhawa *et al*., 2023). In laying hens, these harsh conditions could lead to reduced growth, lower hen-day egg production, increased immunosuppression and mortality, and reproductive failure (Ayo *et al*., 2010; Grzinic *et al*., 2023). Implementing efficient management strategies is crucial to mitigate environmental stress in poultry. Modern industrial poultry farming is inseparable from the use of various biologically active compounds. The effectiveness of different minerals and vitamins in chicken diets has been well established in scientific studies and is widely recognized by poultry breeders (Razanova *et al*., 2024; Zurak *et al*., 2025).

Trace minerals are indispensable in poultry diets because of their roles in growth, development, and biochemical processes. Selenium (Se) is a vital trace element, functioning as a component of glutathione peroxidase (GSH-Px), an antioxidant enzyme that neutralizes reactive oxygen species (ROS) generated under stress (Ogbuewu and Mbajiorgu, 2023). Since natural antioxidant levels in tissues decline after hatching, selenium supplementation enhances GSH-Px activity and improves chick viability (Araujo and Lara, 2023). GSH-Px detoxifies peroxides such as hydrogen peroxide and lipid hydroperoxides (Lapenna *et al*., 2019). The Se requirement differs among species: 0.2 ppm for turkeys, quail, and ducks, and 0.06 ppm for laying hens (Habibian *et al*., 2015). Organic Se sources, such as Se-enriched yeast, have higher bioavailability than inorganic forms, leading to greater egg Se content (Zhang *et al*., 2017) and improved feed conversion ratios in laying hens (Zhou *et al*., 2025). In organic form, Se is efficiently incorporated into proteins, reducing environmental excretion while enhancing deposition in tissues and eggs (Surai and Kochish, 2019). Se also accumulates in reproductive organs, particularly the testes in mammals (Alharthi *et al*., 2020). Low dietary Se is linked to higher risks of chronic diseases, making supplementation valuable for improving the nutritional quality of eggs for human consumption (Genchi *et al*., 2023). Beyond enhancing egg production and weight, Se levels are positively associated with bone mineral density and reduced bone turnover (Gjorgovska *et al*., 2012; Ziaei *et al*., 2013). Vitamin E (Vit E) is another essential nutrient in poultry diets. As a lipid-soluble antioxidant that birds cannot synthesize, it must be supplied through the diet (Idamokoro *et al*., 2020). Supplementation has been shown to enhance egg production under both normal and heat-stressed conditions (Amevor *et al*., 2021; Oke *et al*., 2025). Vit E improves immune function, protects cell membranes from oxidative damage, and stimulates the synthesis and release of vitellogenin, which is vital for yolk development, particularly during heat stress (Sadiq *et al*., 2023). At the membrane-water interface, it efficiently scavenges free radicals and enhances the antioxidant activity of Se (Surai *et al*., 2019; Araujo and Lara, 2023). In combination, Vit E and Se provide stronger cellular protection than either nutrient alone, thereby supporting reproduction, productivity, and overall health.

Excessive ROS can inhibit osteoblast differentiation and are associated with osteoporosis (Agidigbi and Kim, 2019). Because Se and Vit E act interdependently in antioxidant defense, adequate dietary provision of both is essential for optimal performance, bone health, and reproductive outcomes in poultry. This study aimed to evaluate the effects of varying dietary levels of Se (selenomethionine) and Vit E (α-tocopheryl acetate) on laying performance and egg quality of hens.

MATERIALS AND METHODS

Ethical concern

In strict accordance with the guidelines for the care of animal specimen, as recommended by the Animal Experimentation Ethics Committee, University of Nigeria, Nsukka (Research Ethics Committee Recommendations, 2013), the hens in this study were treated humanely to ensure improved welfare and proper care.

Study area

The study was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka in Enugu State, South Eastern Nigeria (Figure 1). Nsukka is located where the minimum and highest temperatures are 21 and 29.7 °C, respectively. The area experience annual rainfall ranging from 986-2098 mm. The area is situated at an altitude of 456 m above sea level with a humid tropical climate (Ihinegbu *et al*., 2019).

Experimental hens and management

This study lasted for a period of 84 days (3 months). A total of 72 sixteen-weeks old laying hens sourced from Agritech

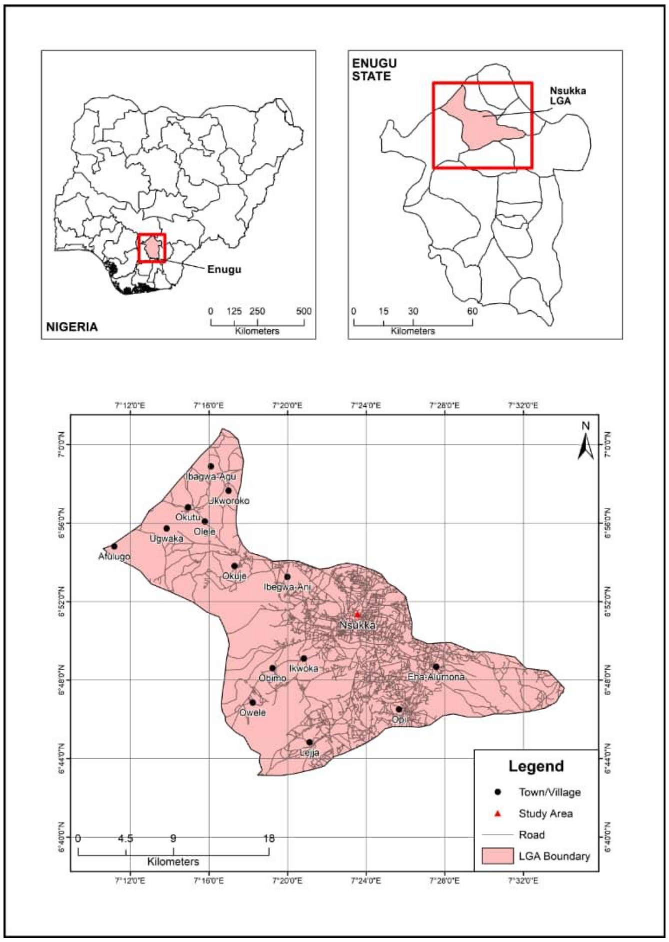


Figure 1: Map of the study area.

Company in Ibadan, Oyo state, Nigeria were used in the study. The hens were housed in the laying pens situated at the Poultry Unit and allocation of test ingredients began when they were 17 weeks old so as to get them acclimatized to the environment. Their initial weight were taken and randomly distributed in deep litter pens in separate cells with a floor measurement of 4 × 7 m^2. The pens were cleaned, disinfected and spread with wood shavings before placing the hens. Feed and water were supplied *ad-libitum* with similar management conditions being provided to the hens. The light cycle during this study was 11 hours of light and 13 hours of darkness.

Experimental ration and treatments

The experimental ration used in this study was a commercial layers mash (Hybrid Feed Nigeria Limited). The crude protein level was 16.80%, with a metabolizable energy of 2700 kcal/kg, in line with the recommended requirements for laying hens. The nutrient composition of the commercial diet, as stipulated by the manufacturer, is presented in (Table 1). The 72 laying hens were randomly assigned to six treatments with 12 hens per treatment. Each treatment were divided into three replicate groups with four hens each. Selenomethionine and α-tocopheryl acetate were sourced from an online vendor; Jumia Nigeria Limited (Jumia Nigeria, 2024). Se (0.0 and 0.5 mg/kg) and Vit E (0.0, 100 and 200 mg/kg) were supplemented in the diets per kg of feed as follows; Treatment 1 (T_1): 0.0 mg Se + 0.0 mg Vit E, Treatment 2 (T_2): 0.5 mg Se + 0.0 mg Vit E, Treatment 3 (T_3): 0.0 mg Se + 100 mg Vit E, Treatment 4 (T_4): 0.0 mg Se + 200 mg Vit E, Treatment 5 (T_5): 0.5 mg Se + 100 mg Vit E and Treatment 6 (T_6): 0.5 mg Se + 200 mg Vit E.

Data on laying performance and egg quality

The initial and final body weights were recorded at the beginning and end of the trial. Body weight gain was calculated as the difference between the final and initial weights. Feed intake was measured by recording the feed offered and subtracting the leftovers (Torki *et al*., 2020). According to Ade *et al*. (2024), feed conversion efficiency was evaluated by relating the quantity of feed consumed to the egg mass produced. Egg weight was measured using an electronic sensitive scale (Mettler-Toledo® PB 3002) with 0.01 g sensitivity. Hen-day egg production was determined as the number of eggs laid relative to the number of live birds present each day (Isaac and Obike, 2020).

For egg quality study, 54 eggs (nine eggs per treatment and three eggs per replicate) were randomly selected from all treatments at the end of the feeding trial. Albumen and yolk weights were measured with a sensitive scale following the modified methods of Isaac and Obike (2020). Albumen and yolk heights were determined by using egg quality slide rule, as described by Mohammed and Dei (2013). According to the formula applied by Anizoba *et al*. (2024), albumen index = albumen height / albumen width; and yolk index = yolk height / yolk width. However, with the use of a pair of calipers, the widths of the albumen and yolk were measured as the maximum cross-sectional diameters and recorded with a centimeter-calibrated ruler. Egg surface area was calculated by applying Carter (1975) formula: $3.9782W^{0.7056}$, where W = egg weight. Shell percentage was calculated using the formula: [shell weight / egg weight] × 100. Eggshell thickness in mm was determined using a micrometer screw gauge with a sensitivity of 0.01 mm. The average of three readings taken at the blunt, equator, and sharp ends of the egg on a wet basis was used for this measurement. Egg shape index was expressed using the formula: [egg width / egg length] × 100 (Isaac and Obike, 2020; Anizoba *et al*., 2024).

As proposed by Kul and Seker (2004), egg specific gravity (ESG) was calculated using the formula: ESG = EW / [0.968EW – 0.4759ESW]; where EW is egg weight and ESW is eggshell weight. According to Abdallah *et al*. (1993), eggshell weight per surface area (ESWSA) was calculated as: ESWSA = {ESW / [3.9782 × ($EW^{0.7056}$)]} ×

Table 1: The nutrient composition of the commercial ration.

Diet Composition	Layers mash
Crude protein	16.80 %
Fat	3.60 %
Crude fiber	4.20 %
Calcium	4.20 %
Available phosphorus	0.50 %
Lysine (min)	0.65 %
Methionine (min)	0.45 %
Metabolizable Energy (min)	2700 kcal/kg

*As labelled by the manufacturer.

Table 2: Production performance of layers fed selenium and vitamin E supplements.

Parameters	IBW (g)	FBW (g)	TWG (g)	ADWG (g)	TFI (g)	ADFI (g)	FCR
Selenium effect							
0 mg Se	1233.89±10.13	1538.78±33.67	304.89±29.64	4.36±0.42	6783.06±306.61^{b}	96.90±4.38^{b}	3.25±0.32
0.5 mg Se	1233.33±8.16	1576.89±41.36	343.56±41.22	4.91±0.59	7580.74±210.56^{a}	108.30±3.01^{a}	3.17±0.33
P. value	0.94 ^{NS}	0.21 ^{NS}	0.18 ^{NS}	0.18 ^{NS}	0.00**	0.00**	0.72 ^{NS}
Vitamin E effect							
0 mg Vit E	1234.17±8.41	1535.33±50.47^{c}	301.17±53.24^{c}	4.30±0.76^{c}	6795.28±395.92^{b}	97.08±5.66^{b}	3.05±0.55^{b}
100 mg Vit E	1233.33±10.54	1558.67±46.10^{b}	325.33±40.55^{b}	4.65±0.58^{b}	7211.53±306.60^{ab}	103.02±4.38^{ab}	3.15±0.31^{b}
200 mg Vit E	1233.33±14.98	1579.50±46.67^{a}	346.17±41.59^{a}	4.95±0.59^{a}	7538.89±348.08^{a}	107.70±4.97^{a}	3.42±0.33^{a}
P. value	0.99 ^{NS}	0.04*	0.05**	0.05**	0.01**	0.01**	0.05**
Interaction effect							
0 mg Se + 0 mg Vit E	1235.00±14.43	1501.67±46.04^{c}	266.67±44.19^{c}	3.81±0.63^{c}	6091.67±475.83^{c}	87.02±6.80^{c}	3.04±0.84^{bc}
0.5 mg Se + 0 mg Vit E	1233.33±12.02	1569.00±97.37^{b}	335.67±105.03^{b}	4.80±1.50^{b}	7498.89±249.54^{ab}	107.13±3.56^{ab}	3.05±0.88^{bc}
0 mg Se + 100 mg Vit E	1233.33±14.53	1545.67±28.90^{bc}	312.33±41.22^{bc}	4.46±0.59^{bc}	6868.06±518.97^{b}	98.12±7.41^{b}	3.79±0.23^{ab}
0 mg Se + 200 mg Vit E	1233.33±28.48	1569.00±97.37^{b}	335.67±75.22^{b}	4.80±1.07^{b}	7389.45±453.72^{ab}	105.56±6.48^{ab}	2.92±0.49^{c}
0.5 mg Se + 100 mg Vit E	1233.33±18.56	1571.67±98.08^{b}	338.33±79.70^{b}	4.83±1.14^{b}	7555.00±287.59^{ab}	107.93±4.11^{ab}	2.52±0.11^{c}
0.5 mg Se + 200 mg Vit E	1233.33±17.64	1590.00±36.06^{a}	356.67±53.64^{a}	5.10±0.77^{a}	7688.33±614.49^{a}	109.83±8.78^{a}	3.93±0.19^{a}
P. value	0.99 ^{NS}	0.05*	0.05*	0.05*	0.05*	0.05*	0.00**

^{abc}: Means on the same column with different superscripts are significantly different (P<0.05). IBW: Initial body weight, FBW: Final body weight, TWG: Total weight gain, ADWG: Average daily weight gain, TFI: Total feed intake, ADFI: Average daily feed intake, FCR: Feed conversion ratio.

1000. As reported by Haugh (1937), Haugh unit (HU) was calculated using the formula: HU = 100 log ($H - 1.7W^{0.37} + 7.57$); where H is the height of albumen and W is weight of egg.

Statistical analysis

Hens were distributed in a Completely Randomized Experimental Design with a 2 × 3 factorial arrangement with the model shown below:

$$Y_{ijk} = \mu + T_i + R_j + (TR)_{ij} + \varepsilon_{ijk}$$

Where: Y_{ijk} is overall observations, μ is overall mean, T_i is effect of Se (i^{th} = 0 and 0.5 mg), R_j is effect of Vit E (j^{th} = 0, 100 and 150 mg), $(TR)_{ij}$ is effect of interaction between Se and Vit E, and ε_{ijk} is experimental error. Data analysis was done using IBM SPSS version 20. Mean separation was done using Duncan post-hoc test across the treatments and results were presented as mean ± SEM (standard error of mean). At 5% level, significant differences were recorded.

RESULTS AND DISCUSSION

Effects of different levels of dietary selenium and vitamin E on laying performance of hens

Table 2 presents the production performance of hens fed Se and Vit E supplemented feed. The results on laying performance showed that Se supplementation significantly (P<0.05) influenced feed intake, average daily feed intake, egg weight, and hen-day egg production (HDEP) (Figure 2), while initial body weight, final body weight, weight gain, and feed conversion ratio (FCR) were not significantly affected (P>0.05). Hens fed 0.5 mg Se consumed more feed compared to the control. Interestingly, egg weight was higher in the control group than in the 0.5 mg Se group. However, HDEP was greatest in hens fed 0.5 mg Se relative to the control.

Vit E supplementation showed significant effects (P<0.05) on final body weight (FBW), total weight gain (TWG), average daily weight gain (ADWG), feed intake (FI), average daily feed intake (ADFI), FCR, and egg weight (Figure 3). Non-significant (P>0.05) differences were recorded in initial body weight (IBW) and HDEP. Hens fed 200 mg Vit E recorded the highest FBW compared to the control. A similar pattern was observed in TWG and ADWG. Feed intake and ADFI were also highest in the 200 mg Vit E group compared to the control. For FCR, the control and 100 mg Vit E groups showed similarity, while in egg weight, the control and 100 mg Vit E recorded higher means compared to hens fed 200 mg Vit E.

The interaction between Se and Vit E resulted in

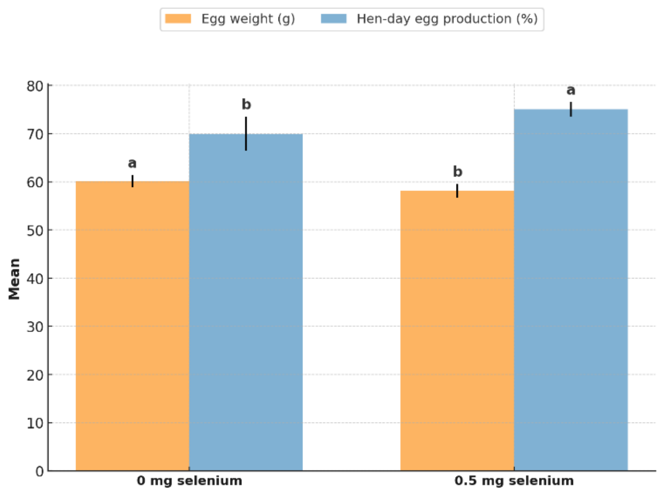


Figure 2: Effect of selenium on egg weight and hen-day egg production.

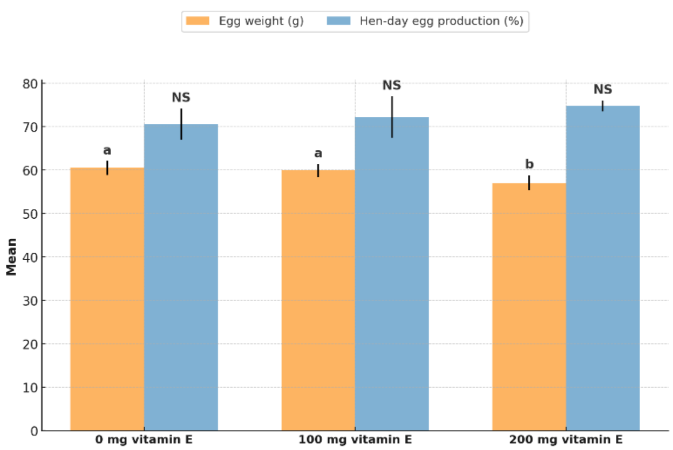


Figure 3: Effect of vitamin E on egg weight and hen-day egg production.

significant differences (P<0.05) in FBW, TWG, ADWG, FI, ADFI, and FCR, but not in IBW, egg weight, or HDEP (Table 2). The Figure for interaction effect on egg weight and HDEP was not presented since there was not significant effect (P>0.05). Birds supplemented with 0.5 mg Se + 200 mg Vit E recorded the highest values for FBW, TWG, ADWG, FI, and ADFI compared to the control group (0 mg Se + 0 mg Vit E), which had the lowest values. For FCR, the best responses were observed in 0 mg Se + 200 mg Vit E and 0.5 mg Se + 100 mg Vit E (Figure 3).

The ranges of means in laying performance parameters obtained in this study aligned with earlier findings by Khawaja *et al*. (2012), Atsbeha and Hailu (2021), and Melkamu (2022), although slight variations were noted in FI, ADFI, and HDEP, which may be attributed to differences in hen age and environmental conditions. Similarly, Susmita *et al*. (2020) reported improved feed intake and FCR with Se and Vit E supplementation which is consistent with the present findings. In contrast, Ziaei *et al*. (2013) found no significant effect on feed intake, while Moradi Kor *et al*. (2012) observed reduced FCR under heat stress when Se and Vit E were supplemented. Other studies (Ibrahim *et al*., 2011; Zia *et al*., 2016) demonstrated selenium's positive effect on body weight and gain, which contrasts with the non-significant effects reported in this study.

Animal research is making progress in the creation and use of Se and Vit E in animal agriculture. The age and environmental conditions of the hens may have a role in some of the variations between earlier reports and the current study. Se and Vit E are two trace nutrients with remarkable impact on biological processes like production, reproduction, and antioxidant defense (Xiao *et al*., 2021; Fatima *et al*., 2025). Se has a significant impact on animal tissues' protein content, which is linked to immunological function, health, and productivity (Wang and Xu, 2008). According to Qiu *et al*. (2021), increasing dietary Se had a favorable impact on egg mass and production, which is consistent with this study. Additionally, Rizk *et al*. (2017) reported that supplementing hen diets with 0.3 mg/kg nano-selenium, alongside other Se sources, significantly improved productive and reproductive performance. Nevertheless, Se plays a crucial role in metabolism by functioning at the active site of glutathione peroxidase, an enzyme that protects cells from lipid peroxides and free radical damage. Glutathione peroxidase eliminates peroxides before they can damage liposomal membranes (Scheideler *et al*., 2010). On the other hand, Se deficiency increases animals' susceptibility to various diseases (Pecoraro *et al*., 2022). Susmita *et al*. (2020) emphasized Se as a vital trace element for growth and efficiency in poultry, particularly laying hens. Similarly, Attia *et al*. (2010) reported that supplementing Gimmizah breeding chickens with organic and inorganic Se enhanced both reproductive and productive performance.

All cells benefit from the intracellular antioxidant properties of the fat-soluble Vit E. By capturing reactive oxygen radicals in biological membranes, it prevents free radical-induced oxidative damage (Susmita *et al*., 2020). Fu *et al*. (2022) similarly reported effects of Vit E supplementation on egg characteristics in laying geese. However, other studies, including those by Urso *et al*. (2015) and Yang *et al*. (2020), reported that dietary Vit E did not influence laying performance. The improvement observed in the present study may be attributed to reduced malondialdehyde levels in the liver and ovaries, along with increased antioxidant enzyme activity induced by Vit E (Fu *et al*., 2022). It can be inferred that a favorable impact on chicken yield indicators may be seen even in the situation of a deficiency of both Se and Vit E due to the relationship between the two nutrients, which spares the requirement for Se.

The relationship between Vit E levels and the requirement for Se indicates how Vit E affects the need for Se. In other words, a lack of Se raises the requirement for Vit E (De Almeida *et al*., 2012).

Table 3: Egg qualities of layers fed selenium and vitamin E supplements.

Parameters	ALBH (mm)	ALB I (%)	ALB W (g)	YolkH (mm)	Yolk I (%)	Yolk W (g)	ESA (cm^2)	S %	ESWSA (mg/cm^2)	ESG	HU (%)	ESW (g)	EST (mm)	ESI (%)
Selenium effect														
0 mg Se	8.52±0.32^{a}	7.17±0.39^{a}	37.52±1.00^{a}	1.49±0.04	39.73±0.83	14.09±0.40	73.25±1.65	10.21±0.41	68.12±2.67	1.09±0.00	90.94±2.24	5.32±0.15^{a}	0.39±0.01^{a}	75.71±0.80^{b}
0.5 mg Se	7.09±0.45^{b}	5.71±0.39^{b}	34.12±0.71^{b}	1.53±0.06	40.99±1.61	14.38±0.33	74.68±1.44	10.60±0.35	69.88±1.78	1.09±0.00	91.03±2.45	4.86±0.11^{b}	0.35±0.01^{b}	78.17±0.55^{a}
P. value	0.00**	0.00**	0.00**	0.28 ^{NS}	0.18 ^{NS}	0.28 ^{NS}	0.20 ^{NS}	0.09 ^{NS}	0.18 ^{NS}	0.11 ^{NS}	0.95 ^{NS}	0.00**	0.00**	0.00**
Vitamin E effect														
0 mg Vit E	8.22±0.44	6.84±0.52^{a}	37.07±1.60^{a}	1.42±0.04^{b}	38.48±0.85^{b}	13.88±0.45^{b}	71.58±2.00^{b}	9.47±0.48^{b}	63.13±2.86^{b}	1.08±0.00	86.49±3.39^{b}	5.28±0.10^{a}	0.37±0.02	76.94±1.38
100 mg Vit E	7.84±0.62	6.55±0.71^{ab}	36.10±1.21^{a}	1.54±0.04^{a}	40.48±1.47^{a}	14.02±0.48^{b}	74.66±1.53^{a}	10.62±0.23^{ab}	70.73±1.08^{a}	1.09±0.00	91.97±1.95^{a}	5.16±0.23^{b}	0.37±0.00	76.95±0.80
200 mg Vit E	7.36±0.63	5.93±0.44^{b}	34.30±0.73^{b}	1.56±0.08^{a}	42.12±1.97^{a}	14.80±0.35^{a}	75.65±1.92^{a}	11.14±0.38^{a}	73.13±2.23^{a}	1.10±0.00	94.50±2.11^{a}	4.83±0.18^{c}	0.37±0.01	76.92±0.78
P. value	0.08 ^{NS}	0.02*	0.00**	0.00**	0.01**	0.01**	0.01**	0.00**	0.00**	0.00^{NS}	0.00**	0.00**	0.55 ^{NS}	1.00 ^{NS}
Interaction effect														
0 mg Se + 0 mg Vit E	9.00±0.19	7.73±0.61^{a}	39.67±1.60^{a}	1.37±0.06	37.57±0.87	13.87±0.86	69.12±2.96	9.02±0.81	60.17±4.79^{c}	1.08±0.00	86.09±4.61^{d}	5.46±0.15	0.41±0.02^{a}	74.19±1.28^{c}
0.5 mg Se + 0 mg Vit E	7.44±0.59	5.94±0.44^{b}	34.47±1.88^{b}	1.47±0.04	39.39±1.42	13.90±0.51	74.04±2.26	9.91±0.54	66.10±3.03^{b}	1.09±0.00	86.89±6.01^{cd}	5.11±0.01	0.32±0.02^{c}	79.69±0.55^{b}
0 mg Se + 100 mg Vit E	8.56±0.44	7.83±0.40^{a}	37.97±1.44^{a}	1.55±0.02	40.53±0.81	14.07±0.99	75.16±2.05	10.78±0.38	72.08±1.42^{a}	1.09±0.00	94.73±2.00^{ab}	5.37±0.45	0.38±0.01^{b}	76.42±1.64^{b}
0 mg Se + 200 mg Vit E	8.00±0.88	5.94±0.44^{b}	34.93±1.31^{b}	1.55±0.05	41.08±1.84	14.33±0.34	75.46±2.59	10.84±0.42	72.10±3.65^{a}	1.09±0.00	92.00±3.93^{abc}	5.13±0.14	0.37±0.00^{b}	76.51±1.24^{b}
0.5mg Se+100mg Vit E	7.11±1.10	5.27±0.84^{b}	34.23±1.32^{b}	1.53±0.10	40.42±3.20	13.97±0.38	74.16±2.69	10.45±0.29	69.37±1.42^{ab}	1.09±0.00	89.21±2.72^{bcd}	4.96±0.11	0.36±0.00^{b}	77.48±0.48^{b}
0.5mg Se+200mg Vit E	6.71±0.89	5.91±0.87^{b}	33.67±0.74^{b}	1.58±0.17	43.17±3.86	15.27±0.53	75.83±3.41	11.45±0.67	74.16±3.25^{a}	1.09±0.00	96.99±0.71^{a}	4.52±0.22	0.36±0.01^{b}	77.33±1.17^{a}
P. value	0.94 ^{NS}	0.00**	0.03*	0.41 ^{NS}	0.59 ^{NS}	0.23 ^{NS}	0.08 ^{NS}	0.07 ^{NS}	0.03*	0.08 ^{NS}	0.03*	0.47 ^{NS}	0.00**	0.00**

^{abcd}: Means on the same column with different superscripts are significantly different (P<0.05), ALB H: Albumen height, ALB I: Albumen index, ALB W: Albumen weight, Yolk H: Yolk height, Yolk I: Yolk index, Yolk W: Yolk weight, ESA:

Effects of different levels of dietary selenium and vitamin E on egg quality of hens

Results on egg qualities of hens fed selenium and vitamin E supplemented feed is presented in Table 3. Se supplementation produced significant (P<0.05) effects on albumen height, albumen index, albumen weight, eggshell weight (ESW), eggshell thickness (EST), and egg shape index (ESI). Hens in the control group recorded higher albumen trait values than those supplemented with 0.5 mg Se, except for ESI. These findings suggest that Se did not consistently improve albumen and shell traits, consistent with earlier reports showing limited influence of Se on egg quality (Pavlovic *et al*., 2010; Invernizzi *et al*., 2013), although contradictory results have also been documented (Skrivan *et al*., 2006; Hanafy *et al*., 2009). Lu *et al*. (2019) reported no significant differences in either the external or internal characteristics of fresh eggs from chickens fed varying levels of Se. Such discrepancies may reflect differences in genetic background, selenium source, environmental conditions, or laboratory methods.

Vit E supplementation significantly (P<0.05) affected albumen index, albumen weight, yolk traits, egg surface area, shell percentage, ESWSA, HU, and ESW. Non-significant effects (P>0.05) were recorded for albumen height, specific gravity, EST, and ESI. Hens receiving 100 mg and 200 mg Vit E showed higher yolk height, yolk index, yolk weight, and related parameters compared with the control, with the greatest yolk weight observed in the 200 mg group. Improvements in shell quality and HU with Vit E supplementation are consistent with earlier studies (Amevor *et al*., 2021; Linghu *et al*., 2021), although other reports found no significant effects (Zaghari *et al*., 2013; Yang *et al*., 2020). Such discrepancies may reflect differences in strain, age, feeding duration, or Vit E dosage. The Haugh unit, a key indicator of egg quality, reflects egg protein content through albumen measurement (Kop-Bozbay *et al*., 2021). Vit E has been shown to increase egg protein content, and in this study, its supplementation significantly enhanced egg production and quality. These effects are likely linked to its role in stimulating hepatic release of estrogen and yolk precursor vitellogenin, as well as its function as an anti-stressor (Ciftci *et al*., 2005; Amevor *et al*., 2021).

Interaction effects between Se and Vit E supplementation significantly improved albumen index, albumen weight, ESWSA, HU, EST, and ESI. The combination of 0.5 mg Se and 200 mg Vit E produced higher ESWSA and HU values than the control. These findings align with reports of synergistic effects of Se and Vit E on egg quality (Abd El-Hack *et al*., 2017). This synergy is attributed to their combined roles in protecting tissues from oxidative damage, promoting yolk precursor protein release, and maintaining metabolic balance. Nevertheless, some studies have reported no such interactions (Galobart *et al*., 2001). These elements are necessary for the system's metabolism and the actions of thyroid hormones that may favorably impact egg quality (Zhu *et al*., 2025). The physiological basis of these responses is linked to the metabolic pathways of Se and Vit E. Dietary Se, either organic or inorganic, undergoes incorporation into proteins or conversion to selenide for selenoprotein synthesis (Bodnar *et al*., 2016). Vit E metabolism, on the other hand, is closely tied to cholesterol and lipoprotein pathways, facilitated by α-tocopherol transfer protein, which regulates uptake, trafficking, and tissue distribution (Zingg, 2015; Galli *et al*., 2022). The synergistic action of these nutrients ensures protection against oxidative damage, supports reproductive physiology, and improves internal and external egg quality parameters. Based on our findings, Se supplementation alone did not consistently enhance egg quality traits, while Vit E, particularly at 200 mg, significantly improved yolk and shell characteristics, as well as the Haugh unit. The combination of Se and Vit E demonstrated synergistic benefits, particularly for ESWSA and HU, suggesting that co-supplementation may be more effective in improving overall egg quality than individual supplementation.

Conclusion

The result of this study showed that Se supplementation had no adverse effect on laying performance but significantly ($P<0.05$) increased FI and HDEP at 0.5 mg inclusion. Vit E supplementation at 200 mg significantly improved FBW, TWG, ADWG, FI, ADFI and FCR. Interaction effect indicated that combining 0.5 mg Se with either 100 mg or 200 mg vitamin E enhanced FBW, TWG, ADWG, and FCR. For egg quality, 0.5 mg Se significantly improved ESI, while 200 mg Vit E improved yolk height, yolk index, yolk weight, ESA, shell percent, ESWSA, and Haugh unit. Interaction effects showed that 0 mg selenium + 100 mg vitamin E enhanced albumen index, albumen weight, and ESWSA, whereas 0.5 mg Se + 200 mg Vit E improved Haugh unit and ESI. The output of this study will benefit poultry farmers seeking to improve hens' laying performance and egg quality, as well as researchers exploring nutrient interactions in laying hens. In addition, policy makers and the poultry industry can use the findings to refine production standards, while consumers will indirectly benefit from nutritionally improved eggs.

Acknowledgements

The authors wish to acknowledge the Department of Animal Science, University of Nigeria, Nsukka, for providing the facilities used in executing this research. Appreciation is also extended to Umeugokwe Paulinus Ikenna for providing the map of the study area.

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