Indian J. Anim. Nutr. 2023. 40 (1): 82-89
doi:10.5958/2231-6744.2023.00011.7

Indian Journal of Animal Nutrition

Comparative Evaluation of Selenium Yeast and Sodium Selenite Supplementation on Egg production and Egg Selenium Deposition in Layers

P. Dodamani[1], V. Malathi[2*], V. Deepthi[1], Jayanaik[2] and A.M. Jolapure[1]
[1]Department of Livestock Production Management, Veterinary College, Bangalore, KVAFSU, Karnataka, India
[2]Department of Poultry Science, Veterinary College, Bangalore, KVAFSU, Karnataka, India
*Correspondence: drmalathiprasadreddy@rediffmail.com

ABSTRACT

The effect of selenium yeast and its combination with sodium selenite on laying hens' production performance, egg quality, and selenium enrichment were evaluated in this experiment. Dual purpose Giriraja (200) were randomly divided into 4 groups having 5 replicates of 10 (9 females+1 male) birds each. The treatment groups included T1 (control diet without selenium), T2 (control diet + sodium selenite @ 0.5mg/ kg diet), T3 (control + sodium selenite @ 0.3mg/ kg diet + selenium yeast @ 0.2mg/kg diet) and T4 (control diet+ selenium yeast @ 0.5mg/kg diet). The experiment was for 8 weeks starting from 30 weeks of age. 150 g feed per bird every day and 16h light schedule was followed. Egg production performance, egg quality parameters, and egg selenium deposition were recorded. Supplementation of different sources of selenium alone and their combination did not show significant difference in production performance *viz.,* weekly hen housed egg production and feed conversion ratio per dozen eggs and also egg quality parameters. Significantly higher ($P<0.05$) egg selenium content was observed in the selenium yeast supplemented group in the fourth and eighth weeks of the trial. In the eighth week, the combination group's egg selenium content was significantly greater ($P<0.05$) than that of the sodium selenite supplemented group. In conclusion, selenium supplementation was not beneficial to production performance as selenium present in the feed raw material was sufficient to meet the requirement of layer (0.05-0.08mg/kg diet). Nevertheless, addition of selenium was useful to fortify the egg. Though combination showed significant improvement compared to inorganic but the deposition was not as efficient as organic alone. Hence, the addition of organic sources alone is a better option to produce selenium enriched eggs.

KEYWORDS: Egg production, Egg quality, Egg selenium, Laying hens, Selenium yeast

Article received: 25 February 2022; Article accepted: 24 March 2023

INTRODUCTION

Trace mineral deficiency is a global issue causing impaired health and productivity in both animals and humans. Selenium (Se) is one such essential trace element which is an inseparable part of enzymes involved in crucial biological processes, such as antioxidant activity, immune function, reproduction, and thyroid hormone metabolism (Han et al., 2017) whose dietary requirement in human varies from 55-75 mcg/day with an upper limit of 400 mcg/day (Kipp et al., 2015). Se can be supplemented in various ways in which fortification with food is an easy and efficient method. Eggs with their nutritional abundance, ease of intake, and acceptance from all aged people make them a better choice for fortification with Se (Réhault-Godbert et al., 2019). Accordingly, the addition of organic Se as selenium yeast (SY) showed a significant increase in production performance, feed conversion ratio (FCR), and egg Se deposition compared to sodium selenite (SS) in Aseel birds (Zia et al., 2016). In terms of egg quality, Se irrespective of their sources improved the quality *viz.,* yolk index (YI) and haugh unit (HU) (Arpášová et al., 2012; Radwan et al., 2015). The dose dependent increase in Se deposition was also observed with SY supplementation (Liu et al., 2020). Hence the study hypothesized a combination of the organic and inorganic sources may be as efficient as the organic source alone to improve production performance, egg quality, and

Se deposition. In this view, the experiment assessed the effect of SY alone and its combination with SS on production performance, egg quality, and egg Se content in Giriraja layers, which is dual purpose multi-coloured variety with a production capacity of 130-150 eggs per year and this variety developed by the Department of Poultry Science, Veterinary College, Bengaluru.

MATERIALS AND METHODS

Ethical statement

The Institutional Animal Ethics Committee (IAEC) approved all the procedures followed in the experiment, with IAEC No. (VCH/IAEC/2019/107).

Experimental design

A total of 180 (female) + 20 (male) Giriraja laying hens of 30 weeks of age with uniform body weight were wing banded and housed in an experimental house containing 20 experimental pens. The birds were distributed into 4 treatment groups having five replicates with 10 (9 females + 1 male) birds in each pen, following a completely randomized design. The corn-soybean meal based basal diet (control diet, T1) was formulated according to National Research Council (NRC, 1994) specifications. The ingredient and nutrient composition of the basal diet is given in Table 1. To the basal diet, SS, SS + SY, and SY were added at the dose rate of 0.5, 0.3 + 0.2, and 0.5 mg Se/kg diet to form experimental groups T2, T3, and T4, respectively. Both SY and SS were procured from the open market and SY was assessed for Se content by Inductively Coupled Plasma – Optical Emission Spectrophotometer (ICP-OES). The trial was conducted in a conventional open-sided poultry house on a deep litter system to suit Indian commercial poultry farming practices. Standard managemental practices and a 16-hour light schedule were followed. Throughout the experiment, controlled feeding of 150 g/day was given in the morning along with *ad lib* access to water. Eggs were collected every two hours, marked pen-wise, and shifted to the cold store in the hatchery. The feeding trial was for a period of 8 weeks.

Parameters studied

Production performance of hens was assessed in terms of hen-housed egg production (HHEP) and FCR per dozen eggs were calculated using the following formula-

$$\text{HHEP (\%)} = \frac{\text{Total number of eggs laid during the period}}{\text{Total number of birds housed at the beginning}} \times 100$$

$$\text{FCR} = \frac{\text{Feed consumption per bird per week(Kgs)}}{\text{number of eggs produced per week}} \times 12$$

At the end of 4^{th} and 8^{th} weeks, three eggs from each replicate and fifteen eggs from each treatment were collected and subjected to quality analysis on the same day. Shell thickness (ST) was measured using a screw gauge with a precision of 0.01 mm. Albumen index (AI) and yolk index (YI) were measured using slide calipers with 0.05mm precision and tripod AMES micrometre with a precision of 0.01mm, respectively, and calculated using the formulae (Romanoff and Romanoff 1949). Haugh unit (HU) was calculated using the formula (Haugh, 1937).

AI = h/ (0.5 x (D+d))

Where, h - the height of thick albumen at the boundary with the yolk; D and d - long and short diameters of albumen, respectively.

YI= h/D

Where, h - yolk height and D - yolk diameter.

HU=100 x log (h+7.57- 1.7 x $EW^{0.37}$)

Where, h - the height of thick albumen at the boundary with the yolk; EW is the egg weight.

Egg Se deposition was analysed at the end of 4^{th} and 8^{th} week of the experiment where two fresh eggs from each replicate (ten eggs from each treatment) were collected for the estimation of Se content. The egg yolk sample was digested in 10 ml nitric acid (65%). Then the solution was cooled and filtered in Whatman filter paper No. 42. The volume of the solution was made to 20ml with ultrapure water. The concentration of Se was estimated using ICP–OES (Perkin Elmer Optima 8000) using Argon gas as fuel and nitrogen gas for purging. Wavelength used for estimation was 196 nm.

All the data pertaining to various parameters were analysed statistically by one-way analysis of variance using Software Package for Social Sciences (SPSS) software. Differences between the means were tested using Tukey's test at $P < 0.05$.

Table 1. Percent ingredient and nutrient composition of basal experimental diet

Ingredients	Percentage (%)	Nutrient composition	
Yellow maize	51.00	ME (kcal/kg)[1]	2618
Soybean meal (46% CP)	25.00	Crude Protein (%)[2]	16.3
Deoiled Rice bran	14.11	Crude Fiber (%)[2]	4.22
Oyster shell grit	6.20	Crude Fat (%)[2]	2.25
Mineral Mixture*	2.89	Calcium (%)[2]	3.52
Vitamin Premix**	0.06	Phosphorus (%)[2]	0.61
DL-Methionine	0.10	Lysine (%)[1]	1.01
Common Salt	0.4	Methionine (%)[1]	0.39
Liver tonic	0.09		
Toxin binder	0.09		
Antibiotic	0.06		
Total	100.0		

* Mineral Premix: Each 100g contains, Magnesium Oxide-1.48 g, Ferrous Sulphate- 6.0 g, Copper Sulphate- 0.05 g, Manganese Sulphate-0.04 g, Potassium Iodide-0.001g, Zinc Sulphate-1.0 g, Potassium Chloride- 17.09 g.
** Vitamin premix: Each 100gm contains Vitamin AD3 (Vitamin A-10,00,000 IU/g, Vitamin D-200000 IU/g)- 0.165 g, Vitamin K3- 0.103 g, Vitamin E -2.4 g, Thaimine Mononitrate- 0.206 g, Riboflavin- 0.513 g, Pyridoxine hydrochloride- 0.309 g, Cayanocoblamine- 0.00031 g, Folic Acid -0.103 g, Niacin- 4.124 g, Ca-D-Pantothenate- 1.031 g, Biotin - 1.5 g, Maltodextrine- 89.545 g
[1]Calculated values; [2]Analysed values

RESULTS AND DISCUSSION

Production performance

Egg production and FCR are important indicators of production performance in laying hens and markers of the profitability of poultry farms. These are affected by various conditions such as breed, quality and quantity of feed, stress, deficiency of minerals etc. In our study, there was no significant difference in HHEP and FCR (Tables 2 and 3) observed between the Se supplemented groups and the control group. However, egg production in the 5th week and FCR in 5, 6, and 7th weeks showed a significant difference but it was not consistent throughout the experiment. Similar results were reported by Jing et al. (2015) who showed the non-significant effect of different sources of Se (SS, SY, and selenomethionine) on production performance in laying hens. Liu et al. (2020) used different sources of Se at different levels (SS and SY @ 0.3 and 0.5 mg Se/kg diet each) and found no significant improvement in production performance and FCR. Contrarily, many authors reported improvement in performance and FCR with the addition of Se to the diet (Attia et al., 2010; Zia et al., 2016). Egg production and FCR are not associated with a single factor and are associated with several other factors such as animal species, the environment in which birds are kept, the concentration of Se, other minerals in feed ingredients, and the physiological status of birds. As there was no external environmental stress given to birds throughout the trial, birds were not under production stress and feed ingredients that are used in the basal diet also contain traces of Se that could have met the requirement of birds for production.

Table 2. Effect of additional Selenium yeast and/or Sodium Selenite on egg production

Description	Egg Production (%)							
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
T1	56.5 ± 5.25	62.2 ± 5.30	66.3 ± 2.63	68.8 ± 1.19	60.9 ± 4.10[b]	59.3 ± 2.64	56.5 ± 4.13	56.8 ± 5.10
T2	56.5 ± 5.16	68.8 ± 5.89	69.5 ± 5.03	77.1 ± 3.81	79.6 ± 3.31[a]	73.9 ± 4.00	70.4 ± 3.57	63.1 ± 4.30
T3	62.2 ± 2.53	73.9 ± 3.35	73.6 ± 2.39	75.5 ± 1.85	70.4 ± 4.10[ab]	70.4 ± 4.28	69.5 ± 4.39	66.3 ± 2.94
T4	58.1 ± 2.91	61.2 ± 3.53	71.7 ± 4.12	67.9 ± 2.32	70.4 ± 3.57[ab]	69.8 ± 3.82	69.8 ± 3.72	62.5 ± 4.48

Data are presented as mean ± standard error (SE).
Means in the same column with no common superscript differ significantly ($P \leq 0.05$)

Egg quality in poultry does not vary much but gets affected by factors such as infection, stress, and deficiencies. Results of the present study showed no significant improvement in additional supplementation when compared to the control group in any of the egg quality parameters *viz*., egg weight, AI, YI, ST, and HU at the end of the 4th week and 8th week of the experiment (Table 4 and 5). Similar findings were observed by Mohiti-Asli et al. (2008), who showed that egg quality of layers in additional supplemention with different Se sources (basal diet + 0.4 mg Se/kg diet as SS and SY) was not significantly different from the control group (basal diet with 0.2 mg Se/kg diet Se). Similarly, Lu et al. (2019) observed no significant difference in any of the egg quality traits among dietary groups which were fed with 0.3, 1.5, and 3.0 mg Se/kg diet of Se as SY for 12 weeks. Contrary to our findings, Se supplementation showed a significant increase in egg weight (Payne et al., 2005), HU score (Arpášová et al., 2012), YI (Radwan et al., 2015), and ST (Kralik et al., 2016). However, in this trial, the Se requirement of the laying hens (0.05 – 0.08mg/kg) might have been met through Se content in the raw materials of the basal diet. Hence further additional supplementation of Se in the experimental diet did not show any significant influence on egg quality parameters, which may be the possible reason for the findings of the present study.

Table 3. Effect of additional Selenium yeast and/or Sodium Selenite on FCR

Description	Feed conversion ratio (FCR)							
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
T1	3.29 ± 0.27	2.98 ± 0.27	2.73 ± 0.11	2.62 ± 0.04	3.00 ± 0.18^{a}	3.06 ± 0.14^{a}	3.25 ± 0.21^{a}	3.27 ± 0.28
T2	3.28 ± 0.28	2.70 ± 0.25	2.65 ± 0.19	2.36 ± 0.13	2.27 ± 0.09^{b}	2.46 ± 0.15^{b}	2.58 ± 0.13^{b}	2.91 ± 0.21
T3	2.91 ± 0.11	2.45 ± 0.11	2.45 ± 0.08	2.39 ± 0.06	2.59 ± 0.15^{ab}	2.59 ± 0.16^{ab}	2.63 ± 0.16^{ab}	2.74 ± 0.13
T4	3.13 ± 0.17	2.97 ± 0.15	2.54 ± 0.14	2.66 ± 0.09	2.58 ± 0.13^{ab}	2.61 ± 0.14^{ab}	2.61 ± 0.14^{ab}	2.95 ± 0.25

Data are presented as mean ± SE
Means in the same column with no common superscript differ significantly ($P \leq 0.05$)

Table 4. Effect of additional Selenium yeast and/or Sodium Selenite on egg quality parameters at the end of fourth week

Description	Egg Quality parameters (fourth week)					
	Egg weight (g)	Albumen index	Yolk index	Haugh unit score	Shell thickness (mm)	Shape index
T1	59.9 ± 1.12	0.03 ± 0.00	0.43 ± 0.01	85.5 ± 1.71	0.33 ± 0.01	77.7 ± 0.72
T2	61.2 ± 0.70	0.03 ± 0.00	0.42 ± 0.01	85.9 ± 0.98	0.35 ± 0.00	76.6 ± 1.06
T3	62.1 ± 0.93	0.03 ± 0.00	0.43 ± 0.00	89.2 ± 1.53	0.36 ± 0.01	76.3 ± 0.73
T4	62.2 ± 0.86	0.03 ± 0.00	0.43 ± 0.01	84.8 ± 2.19	0.33 ± 0.01	76.5 ± 0.90

Each value represents the mean of 15 eggs ± SE

Table 5. Effect of additional Selenium yeast and/or Sodium Selenite on egg quality parameters at the end of eighth week

Description	Egg Quality parameters (eighth week)					
	Egg weight (g)	Albumen index	Yolk index	Haugh unit score	Shell thickness (mm)	Shape index
T1	60.5 ± 1.00	0.03 ± 0.00	0.43 ± 0.01	85.4 ± 3.07	0.32 ± 0.01	73.9 ± 1.06
T2	60.9 ± 0.93	0.03 ± 0.00	0.43 ± 0.01	85.2 ± 2.65	0.35 ± 0.01	75.5 ± 0.71
T3	60.7 ± 0.81	0.02 ± 0.00	0.43 ± 0.01	83.1 ± 1.77	0.35 ± 0.01	74.7 ± 1.26
T4	63.6 ± 1.19	0.03 ± 0.00	0.43 ± 0.00	85.6 ± 2.44	0.35 ± 0.01	76.0 ± 0.79

Each value represents the mean of 15 eggs ± SE

Table 6. Effect of additional Selenium Yeast and/or Sodium Selenite on egg Se deposition

Description	Egg Se content (µg/100g)	
	Week 4*	Week 8*
T1	27.1 ± 0.96[c]	37.5 ± 2.08[c]
T2	33.9 ± 4.43[bc] (24.85 %)	40.2 ± 1.57[c] (7.2%)
T3	44.6 ± 3.38[b] (64.64 %)	54.6 ± 2.42[b] (45.6%)
T4	70.7 ± 3.78[a] (160.49 %)	76.1 ± 4.55[a] (102.9%)

Each value represents the mean of 10 eggs ± SE
Mean in the same column with no common superscript differ significantly ($P \leq 0.05$)
*Values in parenthesis indicate percent increase in Se deposition compared to the T1 group

Selenium can be supplemented either in its organic or inorganic forms. When an inorganic source such as SS is supplemented, it gets absorbed and gets converted to hydrogen selenide in the liver, which is further used in the metabolism of Se. Hydrogen selenide is methylated and used for further utilisation in the production of selenoproteins and incorporation into tissue proteins or excreted. Organic Se sources such as SY and selenomethionine (SM) follow different paths and are either directly utilised as a source of methionine or stored in organs where high protein synthesis occurs. SS can also be utilised to get incorporated into tissue proteins but cannot be stored like that of an organic source (Arnaut et al., 2021). Results of our study showed that Egg Se content at the end of the 4th week of the trial (Table 6) was significantly ($P<0.05$) higher when supplemented with organic Se alone and its combination with inorganic Se compared to the control diet group. No significant difference was observed between inorganic Se supplementation alone and the control group; similarly, there was no significant difference between the combination of Se sources and inorganic Se supplemented groups. At the end of the 8th week, egg Se content was significantly higher in the organic Se supplemented and combination group compared to the control and inorganic Se source groups. However, there was no significant difference between inorganic Se and the control group. Similar findings were also reported earlier, wherein, they used the low (0.3mg/kg) and high (0.5 mg/kg) levels of organic and inorganic Se sources and found significantly higher deposition of Se in eggs with organic Se supplementation in a dose-dependent manner compared to the inorganic source (Liu et al., 2020). We also showed 160 percent more deposition of Se in the SY alone group in comparison to the control. Higher Se deposition with SY was also reported by Invernizzi et al. (2013) who showed deposition of about 50% more Se in SY supplemented eggs than in SS. Also, the combination of SY and SS showed significant improvement in Se deposition compared to SS and control at the end of 8th week but was not as efficient as SY alone. A similar result was reported by Han et al. (2017) who reported significant improvement in Se deposition in combination after the 42nd day of supplementation but was less efficient compared to SY alone. This higher deposition of Se with supplementation of organic source might be because of the fact that the bioavailability of organic Se is more compared to the inorganic source. Also, the absorbed Se in the body is utilised directly as methionine/cysteine rather than as Se for incorporation into tissue protein. Whereas, inorganic Se appears to be under homeostatic regulation, hence less available for tissue incorporation (Chantiratikul et al., 2008).

CONCLUSION

In conclusion, the results of our study indicate that additional supplementation of different sources of Se and their combination had no significant effect on egg production, FCR, and egg quality parameters. Though the combination of organic and inorganic showed a significant increase in Se deposition, the efficient and highest Se deposition was achieved through the organic source.

ACKNOWLEDGMENTS

The authors thank the Department of Poultry Science, Veterinary College, Bangalore, Karnataka Veterinary, Animal and Fisheries Sciences University for providing all necessary facilities for the conduct of experiment and all analysis.

REFERENCES

Arnaut, P.R., da Silva Viana, G., da Fonseca, L., Alves, W.J., Muniz, J.C.L., Pettigrew, J.E., e Silva, F.F., Rostagno, H.S. and Hannas, M.I. 2021. Selenium source and level on performance, selenium retention and biochemical responses of young broiler chicks. BMC Veterinary Research. 17: 1-13.

Arpášová, H., Hašèík, P., Kaèániová, M., Gálik, B., Golian, J. and Mellen, M. 2012. The effect of various forms and doses of selenium supplementation of the hens diet on selected qualitative parameters and freshness of table eggs. Scientific Papers: Animal Science and Biotechnologies. 45(1): 11-16.

Attia, Y.A., Abdalah, A.A., Zeweil, H.S., Bovera, F., El-Din, A.T. and Araft, M.A. 2010. Effect of inorganic or organic selenium supplementation on productive performance, egg quality and some physiological traits of dual-purpose breeding hens. Czech Journal of Animal Science. 55(11): 505-519.

Chantiratikul, A., Chinrasri, O. and Chantiratikul, P. 2008. Effect of sodium selenite and zinc-L-selenomethionine on performance and selenium concentrations in eggs of laying hens. Asian-Australasian Journal of Animal

Sciences. 21(7): 1048-1052.

Han, X.J., Qin, P., Li, W.X., Ma, Q.G., Ji, C., Zhang, J.Y. and Zhao, L.H. 2017. Effect of sodium selenite and selenium yeast on performance, egg quality, antioxidant capacity, and selenium deposition of laying hens. Poultry Science. 96(11): 3973-3980.

Haugh, R.R., 1937. The Haugh unit for measuring egg quality. United States Egg Poultry Magazine. 43: 552-555.

Invernizzi, G., Agazzi, A., Ferroni, M., Rebucci, R., Fanelli, A., Baldi, A., Dell'Orto, V. and Savoini, G. 2013. Effects of inclusion of selenium-enriched yeast in the diet of laying hens on performance, eggshell quality, and selenium tissue deposition. Italian Journal of Animal Science. 12(1): 1-8.

Jing, C.L., Dong, X.F., Wang, Z.M., Liu, S. and Tong, J.M. 2015. Comparative study of DL-selenomethionine vs sodium selenite and seleno-yeast on antioxidant activity and selenium status in laying hens. Poultry Science. 94(5): 965-975.

Kipp, A.P., Strohm, D., Brigelius-Flohé, R., Schomburg, L., Bechthold, A.E., Leschik-Bonnet, E., Heseker, H. and German Nutrition Society (DGE). 2015. Revised reference values for selenium intake. Journal of Trace Elements in Medicine and Biology. 32: 195-199.

Kralik, Z., Grceviæ, M., Radišiæ, Ž., Kralik, I., Lonèariæ, Z. and Škrtiæ, Z. 2016. Effect of selenium-fortified wheat in feed for laying hens on table eggs quality. Bulgarian Journal of Agricultural Science. 22(2): 297-302.

Lu, J., Qu, L., Shen, M.M., Wang, X.G., Guo, J., Hu, Y.P., Dou, T.C. and Wang, K.H. 2019. Effects of high-dose selenium-enriched yeast on laying performance, egg quality, clinical blood parameters, organ development, and selenium deposition in laying hens. Poultry Science. 98(6): 2522-2530.

Liu, H., Yu, Q., Tang, X., Fang, C., Chen, S. and Fang, R. 2020. Effect of selenium on performance, egg quality, egg selenium content and serum antioxidant capacity in laying hens. Pakistan Journal of Zoology. 52(2): 635.

Mohiti-Asli, M., Shariatmadari, F., Lotfollahian, H. and Mazuji, M.T. 2008. Effects of supplementing layer hen diets with selenium and vitamin E on egg quality, lipid oxidation and fatty acid composition during storage. Canadian Journal of Animal Science. 88(3): 475-483.

NRC. 1994. National Research Council. Nutrient Requirements for Poultry. 8th Revised Ed. National Academy Press, Washington, DC, USA.

Payne, R.L., Lavergne, T.K. and Southern, L.L. 2005. Effect of inorganic versus organic selenium on hen production and egg selenium concentration. Poultry Science. 84(2): 232-237.

Radwan, N.L., Eldin, T.S., El-Zaiat, A.A. and Mostafa, M.A. 2015. Effect of dietary nano-selenium supplementation on selenium content and oxidative stability in table eggs and productive performance of laying hens. International Journal of Poultry Science. 14(3): 161.

Réhault-Godbert, S., Guyot, N. and Nys, Y. 2019. The golden egg: nutritional value, bioactivities, and emerging benefits for human health. Nutrients. 11(3): 684.

Romanoff, A.L. and Romanoff, A.J. 1949. The avian egg. University of Michigan. J. Wiley and sons Publications, New Jersey, USA.

Zia, M.W., Khalique, A., Naveed, S. and Hussain, J. 2016. Impact of selenium supplementation on productive performance and egg selenium status in native Aseel chicken. Italian Journal of Animal Science. 15(4): 649-657.