Asian-Aust. J. Anim. Sci.
Vol. 21, No. 7 : 1048 - 1052
July 2008

www.ajas.info

Effect of Sodium Selenite and Zinc-L-selenomethionine on Performance and Selenium Concentrations in Eggs of Laying Hens

Anut Chantiratikul*, Orawan Chinrasri and Piyanete Chantiratikul[1]
Faculty of Veterinary Medicine and Animal Science, Mahasarakham University
Muang, Maha Sarakham, 44000, Thailand

ABSTRACT : The objective of this study was to determine the effect of sodium selenite and zinc-L-selenomethionine on performance and egg Se concentration in laying hens. Two hundred and twenty-four CP Browns aged 71 weeks were divided according to a 2×3 factorial in a completely randomized design. One more group without additional Se supplementation was used as a negative control. Each treatment consisted of four replicates and each replicate contained eight laying hens. The dietary treatments were T1: basal diet; T2, T3 and T4: basal diets plus 0.3, 1.0 and 3.0 mg Se from sodium selenite/kg, respectively; T5, T6 and T7: basal diets plus 0.3, 1.0 and 3.0 mg Se from zinc-L-selenomethionine/kg, respectively. The findings revealed that feed conversion rate/kg eggs, egg production, egg weight, Haugh units and eggshell thickness were not affected by source and level of Se ($p>0.05$). Increasing level of dietary Se significantly increased ($p<0.05$ the Se content of eggs. Zinc-L-selenomethionine markedly increased $p<0.05$ egg Se concentration as compared with sodium selenite. The results indicated that Se source did not influence performance of laying hens. However, zinc-L-selenomethionine increased $p<0.05$ egg Se concentration more than sodium selenite. (**Key Words :** Sodium Selenite, Zinc-L-selenomethionine, Performance, Egg Se Concentration, Laying Hens)

INTRODUCTION

Selenium (Se) is an essential trace element in animal nutrition (Kim and Mahan, 2003). It is a vital part of numerous selenoproteins, most of which are involved in the antioxidant systems of the body (Arthur, 1997; Lyons et al., 2007). The required amounts of Se necessary for animals range from 0.15 to 0.3 mg/kg depending on the animal species and the levels of vitamin E in the diet (Girling et al., 1984). Selenium requirement for laying hens ranges from 0.05 to 0.08 mg/kg for the maintenance of optimal health and egg production (NRC, 1994; Choct et al., 2004). Furthermore, Se allowance higher than 0.1 mg/kg is necessary to improve immunity (Song et al., 2006). Recently, many scientific studies revealed that organic Se from Se-enriched yeast had higher availability in laying hens than inorganic Se from sodium selenite, resulting in higher egg Se content (Payne et al., 2005; Utterback et al., 2005; Skrivan et al., 2006; Pan et al., 2007). Most of previous studies supplemented Se in the experimental diets of laying hens ranged from 0 to 1 mg/kg. However, Payne et al. (2005) used Se from sodium selenite or Se-enriched yeast up to 3.0 mg/kg in the diets. They found no negative effect of high level of Se on egg production. Presently, there is insufficient available information of the utilization of other forms of organic Se compound such as zinc-L-selenomethionine in laying hens. Zinc-L-selenomethionine is designed to be highly soluble, protected from microflora degradation, and increase bioavailability of selenium (Ward, 2003). The recent studies found that zinc-L-selenomethionine was more effective at improving short-term Se status in horses (Richardson et al., 2006) and at increasing muscle Se concentration in broilers (George et al., 2004) than sodium selenite. Hence, the purpose of this trial was to determine the effect of zinc-L-selenomethioine on performance and egg Se concentration in laying hens as compared with sodium selenite.

* Corresponding Author: A. Chantiratikul. Tel: +66-87-173-8777, Fax: +66-43-742-823, E-mail: anut.c@msu.ac.th
[1] Department of Chemistry, Faculty of Science, Mahasarakham University, Kantarawichai, Maha Sarakham, 44150, Thailand.
Received October 4, 2007; Accepted March 4, 2008

MATERIALS AND METHODS

Two hundred and twenty four CP Brown laying hens aged 71 weeks were housed in evaporative cooling system. The internal temperature was set at 24°C. Lights were on

Table 1. Feed ingredient and chemical composition of basal diet[1]

Ingredients	%
Corn	59.00
Rice bran	4.25
Soybean meal (44% CP)	16.00
Fish meal	6.36
Soybean oil	2.78
Dicalcium phosphate	1.65
Oyster shell meal	8.44
DL-methionine	0.15
Salt	1.12
Vitamin-mineral premix[2]	0.25
Analyzed chemical composition (% DM)	
Dry matter	91.37
Crude protein	15.86
Ether extract	3.52
Crude fiber	2.87
Ash	12.85
ME[3] (kcal/kg)	2,950.12

[1] Sodium selenite and zinc-L-selenomethionine were mixed in corn and added to the diet to achieve the treatment levels.

[2] Vitamin-mineral premix provide (per kg diet): 10,000 IU vitamin A; 2,000 IU vitamin D_3; 11 mg vitamin E; 1.5 mg vitamin K_3; 1.5 mg thiamin; 4 mg riboflavin; 10 mg pantothenic acid; 0.4 folic acid; 4 mg pyridoxine; 22 mg niacin; 0.4 mg colabamin; 0.1 mg biotin; 60 mg Fe; 70 mg Mn; 50 mg Zn; 8 mg Cu; 0.5 mg Co; 0.7 mg I.

[3] Calculated value.

continuously. The hens were randomly divided into 7 groups. Each group consisted of 4 replicates with 8 hens per replicate. The basal diet (Table 1) was formulated to meet or exceed nutrient requirement recommendation (NRC, 1994) without additional Se supplementation. The 0.3, 1.0, and 3.0 mg Se/kg from sodium selenite or zinc-L-selenomethionine (Availa®Se, Zinpro Corporation) were supplemented to the basal diet. Total Se concentration of zinc-L-selenomethionine was 1,000 mg Se/kg. The diets were determined for chemical composition (AOAC, 1999) and Se content. The hens received the basal diet or Se supplemented diets and water *ad libitum* throughout 6 weeks.

Feed intake and egg production of each replicate was examined daily. Feed conversion rate was estimated as kilograms of feed consumed per kilogram of eggs. Two eggs from each replicate were randomly collected at the end of each week (eight eggs per experimental group). Four of sampled eggs were determined for egg weight, Haugh units, and eggshell thickness. Haugh units and eggshell thickness were measured using albumen height gauge (TSS-QCD instrument, England) and micrometer (395-541-30 BMD-25DM, Mitutoya, Japan), respectively.

Whole egg Se concentration was determined in two sampled eggs. The liquid eggs were mixed well, dried at 65°C for 12 h and ground prior to determining Se content. Egg yolk and egg albumin of another two eggs were separated, dried at 65°C for 12 h and ground for Se analysis.

Table 2. Analyzed selenium concentration in the diets

Diets	Se (mg/kg)
Basal diet	0.30
Basal diet plus 0.3 mg Se/kg from sodium selenite	0.68
Basal diet plus 1.0 mg Se/kg from sodium selenite	1.14
Basal diet plus 3.0 mg Se/kg from sodium selenite	3.37
Basal diet plus 0.3 mg Se/kg from zinc-L-selenomethionine	0.77
Basal diet plus 1.0 mg Se/kg from zinc-L-selenomethionine	1.43
Basal diet plus 3.0 mg Se/kg from zinc-L-selenomethionine	3.47

Approximately 0.5 g of dried and ground whole egg, egg yolk and egg albumin were digested in a mixture of 1 ml HNO_3 and 9 ml deionized water until the solution was cleared. The mineralisates were diluted with deionized water to the final volume of 25 ml. Se was determined by inductively coupled plasma mass spectrometer (ICP-MS model Elan-e, Perkin-Elmer SCIEX, USA) according to Joaquim et al. (1997).

Statistical analysis

The data of feed intake, feed conversion rate, egg production, egg quality and Se content in whole egg, egg yolk and egg albumin were analyzed using GLM procedure appropriate for Factorial in Completely Randomized Design (SAS, 1996). Treatment differences were determined by orthogonal contrasts (1) basal diet vs. others, (2) sodium selenite vs. zinc-L-selenomethionine, (3) levels of Se supplementation. A probability level of $p<0.05$ was considered to be statistically significant.

RESULTS

The Se concentrations of experimental diets are presented in Table 2. The basal diets supplemented with 0.3, 1.0 and 3.0 mg Se/kg from sodium selenite contained 0.68, 1.14 and 3.37 mg Se/kg, respectively. The diets supplemented with 0.3, 1.0 and 3.0 mg Se/kg from zinc-L-selenomethionine contained 0.77, 1.43 and 3.47 mg Se/kg, respectively.

Feed intake, feed conversion rate/kg eggs, egg production, egg weight, Haugh units and eggshell thickness of laying hens were not affected ($p<0.05$) by both Se sources and Se supplemental levels (Table 3).

Selenium concentrations in whole egg, egg yolk and egg albumin of laying hens fed basal diet were dramatically lower ($p<0.05$) than those of laying hens fed Se supplemented diets throughout 6 experimental weeks (Table 4). However, Se supplementation from zinc-L-selenomethionine

Table 3. Performance of laying hens fed sodium selenite or zinc-L-selenomethionine (n = 24)

Items	Basal diet	Sodium selenite (mg/kg)			Zinc-L-selenomethionine (mg/kg)			SEM	p-value[1]			
		0.3	1.0	3.0	0.3	1.0	3.0		B	S	L	S×L
Feed intake (g/d)	103.93	102.91	102.61	102.56	100.34	103.80	104.39	0.35	NS	NS	NS	NS
Feed conversion rate/kg eggs (kg)	1.65	1.64	1.57	1.56	1.62	1.59	1.65	0.01	NS	NS	NS	NS
Egg production (%)	63.46	61.14	63.95	60.84	55.72	57.53	63.72	0.86	NS	NS	NS	NS
Egg weight (g)	63.03	63.33	65.26	65.66	62.56	65.38	63.46	0.35	NS	NS	NS	NS
Haugh units	69.83	62.79	64.82	68.08	65.54	63.91	65.25	0.002	NS	NS	NS	NS
Eggshell thickness (mm)	0.32	0.31	0.29	0.30	0.31	0.31	0.31	0.04	NS	NS	NS	NS

[1] B = Basal diet vs. others, S = Sodium selenite vs. zinc-L-selenomethionine, L = Levels of Se supplementation.
S×L = Se sources×evels. NS = Not significantly difference at p>0.05.

markedly increased ($p<0.05$) Se concentration in whole egg, egg yolk and egg albumin when compared to Se from sodium selenite. Selenium concentration in whole egg, egg yolk and egg albumin significantly increased ($p<0.05$) with increasing Se supplemental levels since the first week of the experiment. Therefore, the interaction between Se sources and Se supplemental levels on Se concentration in egg was statistically detected ($p<0.05$).

DISCUSSION

The previous studies reported that supplementations with 0.3 (Utterback et al., 2005) up to 3.0 (Payne et al., 2005) mg/kg of Se from sodium selenite or Se-enriched yeast in the diets did not negatively affect the performances of laying hens. The results of the present study are in agreement with those reports. Although, NRC (1994) recommended the Se content in laying hens ration at 0.05 mg/kg, the hens received diets contained Se ranged from 0.3 to 3.47 mg/kg in current study (Table 2) did not show any adverse clinical sign. The result repeatedly confirmed the foregoing report of Payne et al. (2005) who revealed that up to 3 mgSe/kg of sodium selenite or Se-enriched yeast can be used to supplement in the diets for laying hens without detrimental effects on laying rate, eggs/kg of feed, Haugh unit and egg weight. Furthermore, Ort and Latshaw

Table 4. Selenium concentrations (mg/kg) in whole egg, egg yolk, egg albumin of laying hens fed sodium selenite or zinc-L-selenomethionine (n = 12)

Experimental week	Basal diet	Sodium selenite (mg/kg)			Zinc-L-selenomethionine (mg/kg)			SEM	p-value[1]			
		0.3	1.0	3.0	0.3	1.0	3.0		B	S	L	S×L
Whole egg												
1	1.06	1.65	2.01	3.31	1.74	3.50	6.53	0.40	*	*	*	*
2	0.79	1.13	1.11	3.08	1.39	2.10	4.29	0.27	*	*	*	NS
3	0.56	0.68	0.94	2.14	0.98	2.81	5.73	0.39	*	*	*	*
4	0.80	1.06	1.11	1.80	0.88	1.78	4.56	0.27	*	*	*	*
5	0.34	0.51	1.00	1.80	0.97	2.14	3.35	0.22	*	*	*	*
6	0.40	0.73	1.15	2.07	0.84	1.19	3.69	0.25	*	*	*	*
Average	0.66	0.96	1.22	2.34	1.15	2.25	4.60	0.21	*	*	*	*
Egg yolk												
1	0.88	1.22	1.44	2.24	1.36	1.66	2.74	0.17	*	NS	*	NS
2	1.05	1.07	1.75	2.89	1.28	1.84	4.15	0.29	*	*	*	*
3	0.41	0.69	0.88	2.04	0.67	1.49	2.19	0.18	*	*	*	NS
4	0.43	0.74	1.11	2.15	1.16	1.55	4.51	0.35	*	*	*	*
5	0.54	0.87	1.08	1.52	0.75	2.57	3.09	0.25	*	*	*	*
6	0.70	1.27	1.76	1.52	0.65	1.34	2.10	0.13	*	NS	*	*
Average	0.67	0.98	1.34	2.06	0.98	1.74	3.13	0.14	*	*	*	*
Egg albumin												
1	1.25	1.51	2.46	7.97	2.26	4.61	13.75	1.17	*	*	*	*
2	1.42	2.42	2.52	3.01	2.67	9.79	17.08	1.48	*	*	*	*
3	0.93	1.71	2.50	3.98	1.86	4.34	8.63	0.72	*	*	*	NS
4	0.63	0.99	1.20	2.22	1.66	3.80	10.09	0.85	*	*	*	*
5	0.70	0.78	3.00	4.79	1.50	3.30	8.44	0.70	*	*	*	*
6	0.71	0.68	0.98	2.37	1.54	4.02	9.86	0.85	*	*	*	*
Average	0.94	1.35	2.11	4.06	1.92	4.98	11.31	0.58	*	*	*	*

[1] B = Basal diet vs. others, S = Sodium selenite vs. zinc-L-selenomethionine, L = Levels of Se supplementation, S×L = Se sources× levels.
* Significantly difference at $p<0.05$. NS = Not significantly difference at $p>0.05$.

(1978) found that egg production and egg weight decreased significantly ($p<0.05$) in laying hens consumed diet containing 9 mgSe/kg of sodium selenite.

Selenium content of the egg was shown to depend on its concentration in the diet and also on the form of dietary Se used (Golubkina and Papazyan, 2006). Selenium concentrations in eggs increased statistically ($p<0.05$) with levels of Se supplementation. However, the zinc-L-selenomethionine supplemented diets resulted in a 1.7 to 6.7-folds increase in egg Se concentration compared with a 1.5 to 3.5-folds for the sodium selenite supplemented diets ($p<0.05$). The results are consistent with other researchers (Paton et al., 2002; Payne et al., 2005; Utterback et al., 2005; Skrivan et al., 2006; Pan et al., 2007) who observed egg Se concentration increased significantly ($p<0.05$) in hens fed Se-enriched yeast as compared with hens fed sodium selenite. Both of zinc-L-selenomethionine and Se-enriched yeast which mainly contain Se in the form of selenomethionine (Schrauzer, 2000) are organic forms of Se. Normally, the absorption of selenomethionine is accelerated by the specific amino acid active transport mechanisms in the gut mucosa. Sodium selenite is absorbed more slowly, possibly by simple diffusion through the intestinal mucosa, than the amino acid-bound selenium compounds (Reasbeck et al., 1985). Following the absorption, selenomethionine is readily incorporated into tissue proteins in a non-specific and unregulated manner. Whereas selenite and other inorganic forms of selenium are incorporated into a body pool which is used exclusively for functional forms of selenium and appears to be under homeostatic regulation (Thomson, 1998). These inorganic forms, thus, have a quite limited impact on the Se content in animal products because Se can be retained only by incorporated into the selenocysteine protein (Olivera and Sladana, 2005). Therefore, Se from zinc-L-selenomethionine was more effective in being transferred to the egg than Se from sodium selenite.

Both sodium selenite and zinc-L-selenomethionine increased ($p<0.05$) the Se content in egg yolk and egg albumin. However, Se deposit was higher in egg albumin than in egg yolk, especially in hens fed zinc-L-selenomethionine (Table 4). Skrivan et al. (2006) also observed the increase of Se in egg albumin was higher than in egg yolk when they used Se-enriched yeast and Se-enriched Chlorella. Generally, selenomethionine mainly deposits in egg albumin, while inorganic Se or non-selenomethionine mainly deposits in egg yolk (Sheng et al., 2002). On the other hand, the previous reports found that organic Se being more efficiently deposited the egg yolk (Paton and Canton, 2000; Paton et al., 2002; Golubkina and Papazyan, 2006). The different results are probably due to organic Se source that contains various amounts or ratio of selenoamino acids, such as selenocysteine, selenomethionine, Se-methylselenocysteine, which have a different metabolism in animals (Combs and Combs, 1986).

The results indicated that egg Se concentration reflected directly to levels of Se supplementation since the first week of the experiment (Table 4). Payne et al. (2005) found that whole-egg Se concentrations increased rapidly with increasing dietary Se since d 4 of the study. However, Ort and Latshaw (1978) reported that there was a lag of 14 to 21 days before the Se content of the egg reflected the Se content of the diet. The Se content in the eggs of hens fed either sodium selenite or organic Se reached the top within 14 to 16 days from the start of feeding Se-enriched diets (Jiakui and Xiaolong, 2004; Skrivan et al., 2006). The above findings revealed that egg Se content can be increased within 4 to 21 days after the hen received dietary Se. However, the further research is needed to study egg Se incorporation rate.

CONCLUSION

The performance was not affected in laying hens fed either sodium selenite or zinc-L-selenomethionine ($p>0.05$). Zinc-L-selenomethionine increased significantly ($p<0.05$) egg Se concentration when compared with sodium selenite.

ACKNOWLEDGMENTS

This work was financially supported by Masasarakham University. Zinpro Animal Nutrition (Thailand), Inc. provided zinc-L-selenomethionine (Availa®Se).

REFERENCES

AOAC. 1999. Official Methods of Analysis. 16th ed. Association of Official Analysis Chemists, Washington, DC.

Arthur, J. R. 1997. Non-glutathione peroxidase peroxidase functions of selenium. pp. 143-154. In: Biotechnogy in the Feed Industry (Ed. T. P. Lyons and K. A. Jacques). Redwood Books, Wiltshire, England.

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

Combs, G. F. and S. B. Combs. 1986. The Role of Selenium in Nutrition. Academic Press, Inc., New York.

Geoge, B., S. Davis and T. L. Ward. 2004. A novel organic selenium source (zinc-L-selenomethionine, Availa® Se) for broilers. J. Anim. Sci. 82 (Suppl. 1):319.

Girling, C. A. 1984. Selenium in agriculture and the environment. Agric. Eco. Eviron. 11:37-65.

Golubkina, N. A. and T. T. Papazyan. 2006. Selenium distribution in eggs of avian species. Comp. Biochem. Physiol. B 145:384-388.

Jiakui, L. and W. Xiaolong. 2004. Effect of dietary organic versus inorganic selenium in laying hens on the productivity, selenium distribution in egg and selenium content in blood, liver and kidney. J. Trace Elem. Med. Biol. 18:65-68.

Joaquim, A. N., Y. Gelinas. A. Krushevska and R. M. Barnes. 1997. Determination of elements in biological and botanical materials by inductively coupled plasma atomic emission and mass spectrometry after extraction with a tertiary amine reagent. J. Anal. At. Spectrom. 12:1239-1242.

Kim, Y. Y. and D. C. Mahan. 2003. Biological aspects of selenium in farm animals. Asian-Aust. J. Anim. Sci. 16:435-444.

Lyons, M. P., T. T. Papazyan and P. F. Surai. 2007. Selenium in food chain and animal nutrition: lesson from nature-review. Asian-Aust. J. Anim. Sci. 20:1135-1155.

National Research Council. 1994. Nutrition Requirement of Poultry, 9th ed. National Academy Press, Washington, DC. USA.

Olivera, P., D. Backovic and S. Sladana. 2005. Dietary selenium supplementation of pigs and broilers as a way of producing selenium enriched meat. Acta Veterinaria (Beograd). 55:483-492.

Ort, J. F. and J. D. Latshaw. 1978. The toxic level of sodium selenite in the diet of laying chickens. J. Nutr. 108:1114-1120.

Pan, C., K. Huang, Y. Zhao, S. Qin. F. Chen and Q. Hu. 2007. Effect of selenium source and level in hen's diet on tissue selenium deposition and egg selenium concentration. J. Agric. Food Chem. 55:1027-1032.

Paton, N. D., A. H. Cantor, A. J. Pescatore, M. J. Ford and C. A. Smith. 2002. The effect of dietary selenium source and level on the uptake of selenium by developing chick embryos. Poult. Sci. 81:1548-1554.

Payne, R. L., T. K. Lavergne and L. L. Southern. 2005. Effect of inorganic versus organic selenium on hen production and egg selenium concentration. Poult. Sci. 84:232-237.

Reasbeck, P. G., O. Gilbert, M. D. Barbezat, L. Fredrick, M. D. Weber, M. F. Robinson and C. D. Thomson. 1985. Selenium absorption by canine jejunum. Diges. Dis. Sci. 30:489-494.

Richardson, S. M., P. D. Siciliano, T. E. Engle, C. K. Larson and T. L. Ward. 2006. Effect of selenium supplementation and source on the selenium status of horses. J. Anim. Sci. 84:1742-1748.

SAS. 1996. SAS/STAT® User's Guide (Release 6.03 ed.). SAS Inst. Inc. Cary, NC.

Schrauzer, G. N. 2000. Selenomethionine: a review of its nutritional significance, metabolism and toxicity. J. Nutr. 130:1653-1656.

Sheng, Z., L. Jiakui, L. Haijian, L. Bin and W. Xiaolong. 2002. Investigation of selenium content of egg samples from three major commercial cities along the lower reaches of the Changjiang River. Res. Vet. Sci. 72:7-9.

Skrivan, M., J. Simane, G. Dlouha and J. Doucha. 2006. Effect of dietary sodium selenite, Se-enriched yeast and Se-enriched Chlorella on egg Se concentration, physical parameters on eggs and laying hens production. Czeck J. Anim. Sci. 51:163-167.

Song, Z., Y. Guo and J. Yuan. 2006. Effects of dietary iodine and selenium on the activities of blood lymphocytes in laying hens. Asian-Aust. J. Anim. Sci. 19:713-719.

Thomson, C. D. 1998. Selenium speciation in human body fluids. Analyst. 123:827-831.

Utterback, P. L., C. M. Parson, I. Yoon and J. Butler. 2005. Effect of supplementing selenium yeast in diets of laying hens on egg selenium content. Poult. Sci. 84:1900-1901.

Ward, T. 2003. Looking beyond selenium yeast. Feed Tech. 7(3):20-22.