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

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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 x 3 factorial in a completely randomized design. One 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 results 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 0.5 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-selenomethionine on performance and egg Se concentration in laying hens as compared with sodium selenite.

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

| 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 | 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 (kJ/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 D3; 11 mg vitamin E; 1.5 mg vitamin K3; 1.5 mg thiamine; 4 mg riboflavin; 10 mg pantothenic acid; 0.4 mg 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.

The hen 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-OCD 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 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.

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Approximately 0.5 g of dried and ground whole egg yolk and egg albumin were digested in a mixture of 1 ml HNO3 and 9 ml deionized water until the solution was cleared. The mineral was 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 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 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
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 lay rate, egg weight or feed efficiency. In addition, the selenium levels in egg, yolk and albumin were significantly increased (p<0.05) when compared to the basal diet. This result is consistent with previous studies (Durduran et al., 2006; Akar et al., 2007) who reported that the Selenium levels in egg, yolk and albumin were significantly increased (p<0.05) when compared to the basal diet.

### 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-value¹ |
|------------------------------|------------|-------------------------|---------------------------------|-----|----------|
|                              | 0.3        | 1.0                     | 3.0                             | 0.3 | 1.0      |
| Feed intake (g/d)            | 101.9      | 102.1                   | 102.6                           | 103.4| 103.8    |
| Feed conversion rate/kg eggs (kg) | 1.65      | 1.64                    | 1.57                            | 1.56| 1.59     |
| Egg production (%)           | 63.46      | 61.14                   | 63.95                           | 60.84| 55.72    |
| Egg weight (g)               | 63.03      | 63.33                   | 65.26                           | 65.66| 62.56    |
| Haugh units                  | 69.83      | 62.79                   | 64.82                           | 68.98| 65.54    |
| Eggshell thickness (mm)      | 0.32       | 0.31                    | 0.29                            | 0.30| 0.31     |

¹B = Basal diet vs. others, S = Sodium selenite vs. zinc-L-selenomethionine, L = Levels of Se supplementation. SxL = Se sources x levels.

**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-value¹ |
|-------------------|------------|-------------------------|---------------------------------|-----|----------|
|                   | 0.3        | 1.0                     | 3.0                             | 0.3 | 1.0      |
| Whole egg         | 1.06       | 1.65                    | 2.01                            | 1.74| 3.50     |
|                   | 0.79       | 1.13                    | 1.11                            | 1.38| 2.10     |
|                   | 0.56       | 0.68                    | 0.94                            | 0.98| 2.81     |
|                   | 0.80       | 1.06                    | 1.16                            | 0.88| 1.78     |
|                   | 0.34       | 0.51                    | 1.00                            | 0.97| 2.14     |
|                   | 0.40       | 0.73                    | 1.15                            | 0.84| 1.19     |
|                   | 0.66       | 0.96                    | 1.12                            | 0.88| 2.25     |
| Egg yolk          | 0.88       | 1.22                    | 1.44                            | 1.36| 1.66     |
|                   | 1.05       | 1.07                    | 1.75                            | 1.28| 1.84     |
|                   | 0.41       | 0.69                    | 0.88                            | 0.67| 1.49     |
|                   | 0.43       | 0.74                    | 1.11                            | 0.75| 1.55     |
|                   | 0.54       | 0.87                    | 1.08                            | 0.75| 2.57     |
|                   | 0.70       | 1.27                    | 1.76                            | 0.65| 1.34     |
|                   | 0.67       | 0.98                    | 1.34                            | 0.98| 1.74     |
| Egg albumin       | 1.25       | 1.51                    | 2.46                            | 3.21| 4.61     |
|                   | 1.42       | 2.42                    | 2.52                            | 3.01| 2.67     |
|                   | 0.93       | 1.71                    | 2.50                            | 3.98| 1.86     |
|                   | 0.63       | 0.99                    | 1.20                            | 2.22| 1.66     |
|                   | 0.70       | 0.78                    | 3.00                            | 4.79| 1.50     |
|                   | 0.71       | 0.68                    | 0.98                            | 2.37| 1.54     |

¹B = Basal diet vs. others, S = Sodium selenite vs. zinc-L-selenomethionine, L = Levels of Se supplementation. SxL = Se sources x levels.

* Significantly difference at p<0.05. NS = Not significantly difference at p>0.05.
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 (Jakui 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.

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