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Effects of Dietary Supplementation of Selenium Enriched Yeast on Egg Selenium Content and Egg production of North China Hens

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Authors' Contribution
Liuan Li designed the experiments. Li Lv, RZ and ZD performed the experiments. Li Lv analyzed the data. Li Lv and Liuan Li wrote the paper.

Key words
Selenium enriched yeast, Egg white, Egg yolk, Total egg, Selenium content.

ABSTRACT

This study determined the effect of dietary supplementation with selenium enriched yeast on egg selenium levels and egg production of North China laying hens. Healthy 60-week-old hens (n = 160) were randomly divided into four experimental groups and fed a basal diet supplemented with selenium enriched yeast at differing levels: 0.0 mg/kg (control group), 0.3 mg/kg (low-dose group), 0.6 mg/kg (medium-dose group) and 1.2 mg/kg (high-dose group). Each experimental group had four cohorts and each cohort had 10 hens. Experimental diets were fed for 28 d and daily egg production was recorded. Eggs were collected every seven days for determination of egg white, egg yolk and total egg selenium using hydride generation-atomic fluorescence spectrometry. Selenium dietary supplementation significantly increased egg white, egg yolk and total egg levels, as well as daily egg production (P < 0.05). During the study, egg white, egg yolk and total egg selenium, as well as egg production, initially increased for low- and medium-dose groups and then plateaued. In contrast, these parameters initially increased and subsequently decreased for the high-dose group. Increasing levels of selenium supplementation proportionately increased egg white, egg yolk and total egg selenium levels, as well as egg production (P < 0.05). Dietary supplementation with selenium enriched yeast increases the egg white, egg yolk and total egg selenium levels, as well as egg production of North China hens (P < 0.05). This effect increased with increasing levels of supplementation with selenium enriched yeast.

INTRODUCTION

Selenium is one of 14 trace elements that are essential for animal health (Sayiner *et al.,* 2017). Selenium is an important constituent of glutathione peroxidase (GSH-Px) and participates in the metabolic regulation of many important hormones such as androgens, insulin, and thyroid hormones. Selenium improves animal's antioxidant capacity, immune function, and production performance, and also has vision and detoxification functions (Zhan *et al.*, 2011; Patrick, 2004). Selenium deficiency in humans causes a variety of endemic diseases, including Keshan disease, Kaschin-Beck disease, and goiters. Selenium deficiency in birds decreases immunity and egg production, and increases early embryonic death, exudative diathesis diseases and muscular dystrophy. In contrast, excess selenium intake is toxic (Wan *et al.*, 2017).

The Chinese Nutrition Society documented a selenium intake of 26 μg/d among people in China (Saini *et al.*, 2014). This is below individual's minimum daily nutritional requirements (55 μg/d). Therefore, the development of selenium-rich foods is of great significance for meeting the nutritional needs of the North Chinese population.

Eggs have high protein and lipid levels, contain a variety of amino acids and minerals, and have a moderate level of calories. The human body can absorb 80% of egg's organic selenium. Therefore, eggs are a potential source of dietary selenium supplementation for humans.

Long-term inorganic selenium dietary supplementation can meet production animal's growth requirements. However, use of selenium supplements has been limited, due to risks of toxicity, low bioavailability, and environmental pollution. In contrast, organic selenium dietary supplementation has recently been shown to have high bioavailability, low toxicity, and high biological safety. These findings have stimulated animal nutrition research in China and internationally (Surai *et al.*, 2015).

Selenium enriched yeast is a high-quality, highly bioavailable, source of organic selenium that is mostly in

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the form of selenocysteine (SeCys) (approximately 20%) and selenomethionine (SeMet) (approximately 70%). Organic selenium can be stored in the body when fed in excess of animal's physiological requirements, and can therefore buffer short-term dietary selenium deficiencies (Payne *et al*., 2005).

This is the first investigation of the use of selenium enriched yeast as a dietary supplement for local North China hens, with the objective of producing selenium-enriched eggs that can contribute to meeting the selenium nutritional requirements of the North China populace. Selenium levels in the egg white, egg yolk and total egg were documented at several levels of supplementation. Egg production at each level of supplementation was also documented.

MATERIALS AND METHODS

Test animals, materials and reagents

Mature (60-week-old) North China hens (n = 160) (Jinguo Woodland Farming Cooperative Agency, Wuqing District of Tianjin) with similar egg laying rates were randomly distributed into four treatment groups. All animals were healthy. The basal corn-soybean diet (containing 0.314 mg/kg selenium) (Tianjin Ming Men Animal Food Co., Ltd.) met National Research Council and feeding standards for laying hens. The selenium enriched yeast supplement (SY) contained 2,000 mg/kg Se (Angel Yeast Co., Ltd.).

Experimental design

The hens were raised under free range conditions with unrestricted access to food and water. The experimental groups were fed diets supplemented with 0 mg/kg (control group), 0.3 mg/kg (low-dose group), 0.6 mg/kg (medium-dose group) or 1.2 mg/kg (high-dose group) of selenium enriched yeast. Each group had four cohorts of 10 hens. These diets were fed for three days prior to initiation of the experiment and during the 28 d experimental period. Daily egg production was recorded for each treatment group. Five eggs were randomly collected from each cohort on days 7, 14, 21, and 28 and stored at 4°C for subsequent selenium analyses. Selenium analyses of egg white, egg yolk and total egg were determined using hydride generation atomic fluorescence spectrometry (Smrkolj *et al*., 2004). The research protocol was reviewed and approved by the regional Animal Ethics Committee.

Data analysis

All measurements were expressed as mean ± standard deviation. All data were expressed as mean ± SEM. The general linear model (GLM) procedure was used to determine treatment effects using one way analysis of variance. The level of significance was set at $P < 0.05$ in all analyses.

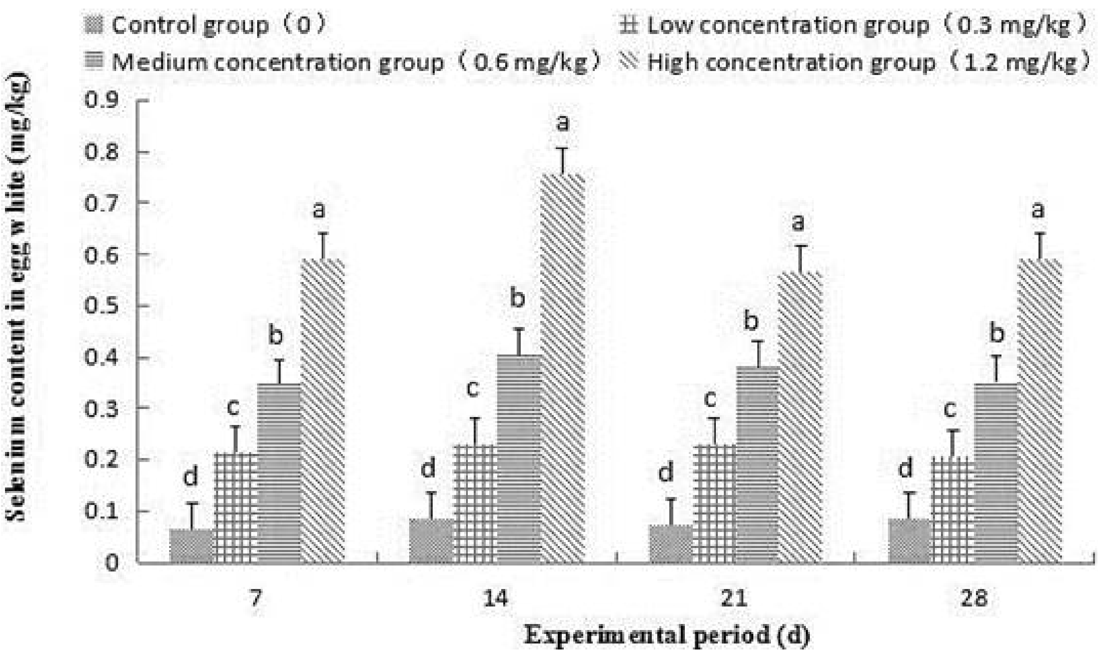

Fig. 1. Effect of selenium enriched yeast on selenium content in egg white. The lowercase letters represent the significant differences among different groups (P <0.05).

RESULTS

Selenium concentration of egg white

As shown in Figure 1, dietary supplementation with selenium enriched yeast significantly increased egg white selenium levels ($P < 0.05$). Egg white selenium levels in each group were significantly increased with increasing levels of dietary selenium supplementation ($P < 0.05$); the egg white selenium levels for the high-dose group were the highest, whereas the control group had the lowest egg white selenium levels. The egg white selenium levels of the low- and medium-dose groups initially increased during the study and then plateaued at a consistent level. In contrast, egg white selenium levels for the high-dose group peaked on day 14 and subsequently decreased. The increase in egg white selenium levels was relatively large in the high-dose group, and more modest in other groups.

Selenium concentration of egg yolk

As shown in Figure 2, dietary supplementation with selenium enriched yeast significantly increased egg yolk selenium levels ($P < 0.05$). Egg yolk selenium levels in each group were significantly increased ($P < 0.05$) with increasing levels of dietary selenium supplementation on days 14 and 28; the egg yolk selenium levels for the high-dose group were the highest, whereas the control group had the lowest selenium levels. Egg yolk selenium levels for the high-, medium-, and low-dose groups were significantly greater than control group levels ($P < 0.05$) on day 7, although the egg yolk selenium levels of the medium- and high-dose groups did not differ significantly ($P < 0.05$). Egg yolk selenium levels of the low-dose group did not differ significantly from the control group on day 21 ($P > 0.05$), whereas egg yolk selenium levels for the high- and medium-dose groups were significantly greater than the control group's levels ($P < 0.05$).

Selenium concentration of total egg

As shown in Figure 3, dietary supplementation with selenium enriched yeast significantly increased total egg selenium levels ($P < 0.05$). Total egg selenium levels in each group were significantly increased ($P < 0.05$) with increasing levels of dietary selenium supplementation; the total egg selenium levels for the high-dose group were the highest, whereas the control group had the lowest total egg selenium levels ($P < 0.05$). The total egg selenium levels of the low- and medium-dose groups initially increased during the study and then plateaued at a consistent level. In contrast, total egg selenium levels for the high-dose group peaked on day 14 and subsequently decreased.

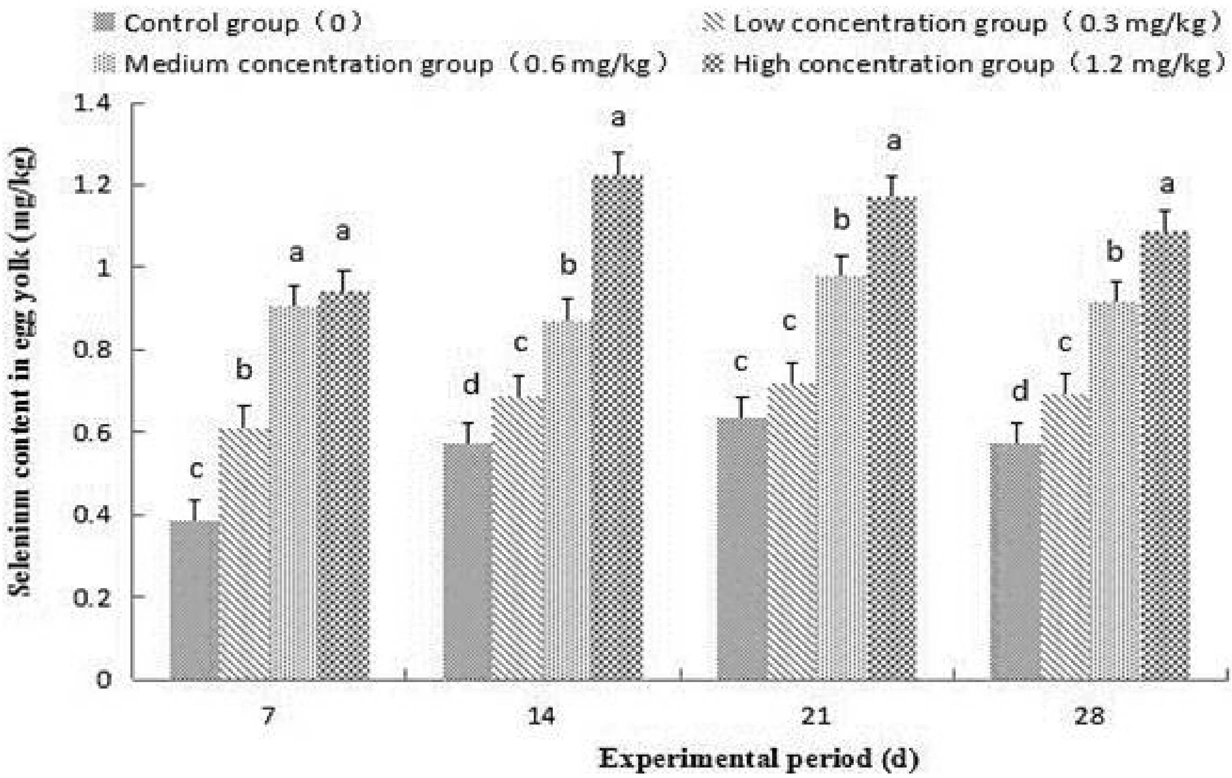

Fig. 2. Effect of selenium enriched yeast on selenium content in egg yolk.

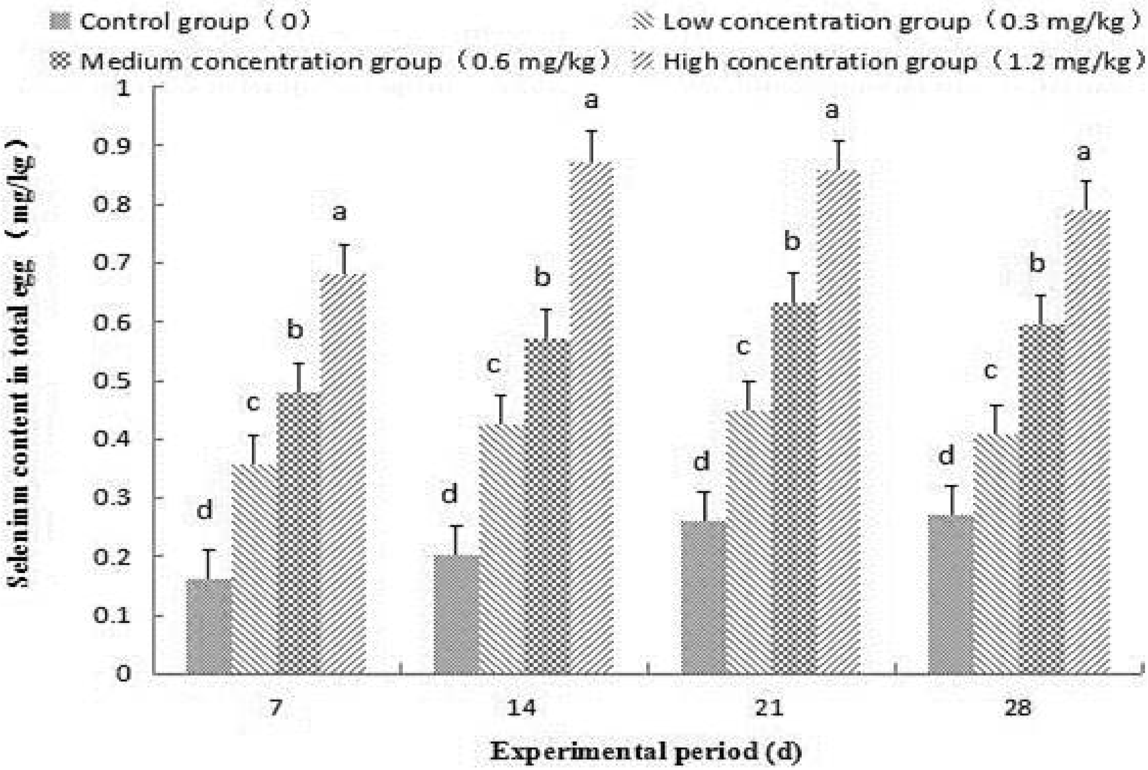

Fig. 3. Effect of selenium enriched yeast on selenium content in total egg.

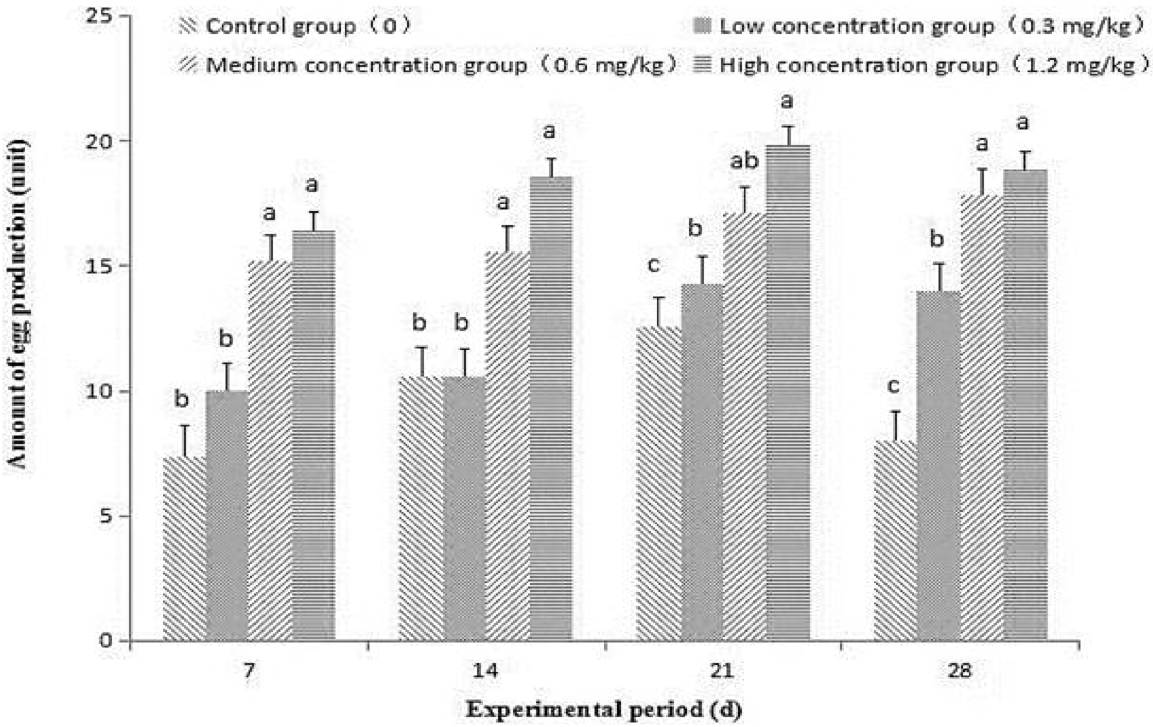

Fig. 4. Effect of selenium enriched yeast on egg production in North China hens.

Amount of egg production

As shown in Figure 4, dietary supplementation with selenium enriched yeast significantly increased egg production ($P < 0.05$). Egg production significantly increased with increasing levels of dietary selenium supplementation; the total egg selenium levels for the high-dose group were the highest, whereas the control group had the lowest total egg selenium levels ($P < 0.05$). Egg production levels for the low- and medium-dose groups continually increased during the study, whereas egg production in the high-dose group increased until day 21 and then decreased slightly. On days 7 and 14, egg production in the low-dose group did not differ from the control group ($P > 0.05$), whereas medium and high-dose groups' egg production were similar ($P > 0.05$), although these two groups had greater egg production than the control group ($P < 0.05$). On days 21 and 28, egg production in the low-dose, medium and high-dose groups was significantly different from that in the control group ($P > 0.05$), whereas egg production in the medium and high-dose groups was similar ($P > 0.05$), although these two groups had greater egg production than the control group ($P > 0.05$).

DISCUSSION

Research shows that the bioavailability of organic sources of selenium, such as selenium enriched yeast, is greater than for inorganic sources, such as sodium selenite (Qin *et al*., 2007; Li *et al*., 2017; Čobanováet *et al*., 2011). This study goes further in demonstrating that increasing levels of dietary supplementation with selenium enriched yeast translated to increasing levels of selenium in the eggs of North China hens. Furthermore, higher levels of supplementation with selenium enriched yeast corresponded to increased egg production, with hens with the highest levels of supplementation producing almost twice as many eggs as controls. Previous studies have similarly demonstrated that selenium enriched yeast can increase egg production (Wang *et al*., 1997; Rajashree *et al*., 2014). However, selenium supplementation must be provided in moderation because excessive supplementation can reduce egg production due to disrupted secretion of estrogen and progesterone and cause toxicosis (Siegel, 1979; Richards *et al*., 1987). The potential for toxicosis may have been evident in this study where the high-dose group's egg production decreased on day 28, while egg production for the groups with lower levels of supplementation continued to increase. Although no clinical abnormalities were observed for hens in the high-dose group, long-term effects at this level of supplementation should be investigated.

Whole egg selenium levels for the low- and medium-dose groups gradually increased and then plateaued, as reported in previous studies (Puerto *et al*., 2016; Mansoub *et al*., 2010; Payne *et al*., 2005). In contrast, whole egg selenium levels peaked on day 14 and then gradually decreased. Previous studies have shown that higher levels selenium supplementation (0.3 and 0.5 mg/kg of selenium) can increase the selenium content of egg white and/or egg yolk (Rajashree *et al*., 2014; Skrivan *et al*., 2008). Similarly, supplementation with selenium enriched kale sprout or malt can increase selenium levels in eggs, but the distribution of selenium in egg whites and yolk may not be uniform (Chantiratikul *et al*., 2017; Chinrasri *et al*., 2013; Whanger *et al*., 1988). This is likely because liver incorporates selenoproteins as a part of egg yolk synthesis, whereas the fallopian tubes incorporate selenomethionine as a part of egg white synthesis (Mahan *et al*., 2017). This study found that dietary supplementation with selenium enriched yeast increased egg white and yolk selenium levels.

The highest level of dietary supplementation in this study (1.5 mg/kg selenium) was extrapolated from previous studies as an estimate of supplementation levels where egg white, egg yolk and total egg selenium levels would increase without resulting in decreased egg production, environmental pollution, or signs of toxicosis (Richards *et al*., 1987; Chantiratikul *et al*., 2016). However, the slight declines in these parameters at later sample times suggests that 1.5 mg/kg selenium supplementation levels might be toxic with prolonged administration. Thus, the medium-dose level of supplementation may be more appropriate; this study showed that dietary supplementation with the equivalent of 1.2 mg/kg of selenium resulted in increased egg production and selenium content without clinical signs of toxicosis.

CONCLUSIONS

In summary, dietary supplementation with selenium enriched yeast significantly increased selenium levels in egg white, egg yolk, and the whole egg while also resulting in increased egg production. While these parameters plateaued for the low and medium supplementation groups, slight declines for the high supplementation group suggest that further investigation with a longer investigation time is needed to determine whether this level of supplementation is excessive for the studied population.

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Statement of conflict of interest

We declare no conflicts of interest in this study.

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