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STUDY ON ENRICHMENT OF HEN EGGS WITH SELENIUM AND IODINE

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ABSTRACT

Standard mineral–vitamin premix (with 15 mg of Se and 150 mg of I) was applied to NK–Lohmann feed for the control group (C), and enriched premix, with doubled concentration of Se (30 mg·kg^{-1}) and I (300 mg·kg^{-1}), was

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fed to the experimental group (E) of Lohmann Brown laying hens in an egg production farm. The enriched premix contained also 50% more vitamin E (1500 mg·kg^{-1}). After four weeks of application of the increased levels of Se and I, increased concentrations of selenium, by mean 13.9% ($\bar{x}$ = 0.401 mg·kg^{-1} of wet weight), and of iodine, by 52.6% ($\bar{x}$ = 1.055 mg·kg^{-1} of wet weight), were observed in egg content of the experimental group. No antagonistic effects were observed of selenium or iodine against the egg – content concentration of calcium, magnesium, manganese or copper. Consumption of two enriched eggs can cover the reference daily intakes (RDIs) of an adult human in 67% for selenium and 71% for iodine.

Key words: hen, egg, selenium, iodine

INTRODUCTION

Nutrient enrichment of hen egg content with unsaturated fatty acids, including omega–3 PUFAs, some vitamins, such as A, D, K and E, as well as with some minerals (iodine, selenium), which is achieved through diet of laying hens enhancement, is practiced in some countries [6, 12, 14, 15, 16]. The compounds are easily available within a short period of time, being deposited in the egg content, mainly in yolk.

Such feeding manipulation remains physiologically testified, as it results in health improvement of hens [5, 6]. Enriched eggs may became an attractive food product improving human diet with valuable biocomponents, including minerals [3, 4].

In Poland, actual daily selenium intake per capita has been evaluated to be approx. 40 µg, with the recommended value being 60 µg [3], whereas the upper safety limit amounts 400 µg of selenium per adult human daily [9]. This denotes a possible selenium deficiency in the Poles' diet, which was shown by Lozak [11]. Iodine deficiency in Poland are rather common, except for the coastal zone of the Baltic Sea. The recommended level of iodine consumption for an adult human has been determined at 150 µg per day [4, 9], however, most of the population in Poland do not receive more than 80 µg in their diet [12], which again implies iodine deficiency in both the food and the organism of Pole. The most extensive deficit of iodine is observed in the southern part of Poland, however, it also occurs in Germany, Czech Republic and Austria [6].

The study was aimed at a comparative evaluation of selenium and iodine content in eggs of hens that were fed on diets with different amounts of selenium and iodine supplements, with regard to the RDIs for these elements by consuming either 1 or 2 enriched eggs per day.

MATERIALS AND METHODS

The studies were carried out on two production flocks of Lohman Brown hens (12 thousand hens in each flock), managed in the cage system. The hens of the control group (C) were fed on standard NK–Lohman mixture with typical vitamin–mineral DJ premix (1%), contained 15 mg of selenium and 150 mg of iodine in 1 kg. The experimental group of hens (E), from 24 days of age on, received similar though enriched premix, with 30 mg of selenium and 300 mg of iodine in 1 kg. Moreover, the enriched premix contained by 50% more vitamin E (1.500 mg·kg^{-1}). Actual concentrations of Se and I were assayed in the samples of the premixes.

The eggs were collected four times, in one – week intervals (series I), in the beginning of the laying period (from 25 weeks of layers' age), and the fifth time, after 6 months from the last collection of eggs (series II), always 10 eggs from each group of hens.

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Iodine was analysed with ionometric method – by use Orion Research EA– 940 instrument, whereas selenium, calcium, magnesium, manganese and copper were analysed with using ICP (Inductively Coupled Plasma) method with Ultra Mass spectrometer (Varian type). Premixes, mixtures and egg content were mineralised with microwave method using an MD–2000 CEM station. The results were statistically analysed with Statgraphics v. 5.1 procedure.

RESULTS AND DISCUSSION

An increase of selenium and iodine concentration by 100% in the feed premix should result in a growth by 0.15 mg of selenium and by 1.5 mg of iodine in 1 kg of the feed mixture. Actually, the growth was respectively 0.17 and 1.29 mg·kg^{-1}. Slightly more iodine and selenium was found in the standard premix, whereas in the enriched premix, the concentrations were lower than those declared by the producer. The differences would probably be smaller, if the samples had been taken repeatedly from different lots of the premixes and mixtures. In Poland, the selenium and iodine contents of 0.12 mg·kg^{-1} and 0.7–1.0 mg·kg^{-1} (Table 1), respectively, are recommended for laying hens' feeds [13], however, some poultry companies recommend higher or lower levels of selenium and iodine in their feeding program [7, 8, 14].

Table 1. Iodine (I) and selenium (Se) concentration in premixes and mixtures (mg·kg^{-1})

Element	Premix		Mixture		Norm
	standard	enriched	standard	enriched	
Iodine	162	264	1.34	2.61	0.7–1.0
Selenium	16.5	29.4	0.18	0.35	0.12

As presented in Table 2, after the first week, the concentration of selenium was stable, and its highest level was found in the second sampling (42.9 µg·100 g^{-1}). Mean selenium concentrations were: 35.2 in group C and 40.1 µg·100 g^{-1} in group E (difference 13.9%, $p<0.05$). Mean iodine concentrations were: 69.3 in group C and 40.1 µg·100 g^{-1} in group E (difference 52.2%, $p<0.01$). Similar to selenium, the level of iodine stabilised after the first week (Table 3), however, the highest concentrations of iodine were found in the third sampling (126.4 µg·100 g^{-1}).

Table 2. Selenium concentration in the egg content of control (C) and experimental (E) groups in µg·100g^{-1} (series I of analyses)

Sampling	Group n = 10	$\bar{x} \pm s$
1	C	32.6 ± 2.89
	E	37.8 ± 4.95
2	C	35.2 ± 3.43
	E	42.9 ± 6.06
3	C	36.6 ± 3.97
	E	39.4 ± 5.91
4	C	35.4 ± 3.69

	E	40.3 ± 4.82
Mean	C	35.2 ± 4.02
	E	40.1 ± 2.14*

*** p<0.05 (for means, between groups E and C).**

Table 3. Iodine concentration in the egg content of control (C) and experimental (E) groups in μg·100 g^{-1} (series I of analyses)

Sampling	Group n=10	$\bar{x} \pm s$
1	C	67.2 ± 20.32
	E	83.0 ± 15.91
2	C	76.7 ± 13.60
	E	100.7 ± 11.82
3	C	64.7 ± 16.38
	E	126.4 ± 42.44
4	C	68.5 ± 22.53
	E	111.8 ± 29.87
Mean	C	69.3 ± 13.26
	E	105.5 ± 18.31**

**** p<0.01 (for means, between groups E and C).**

Different results were observed in the series II of analyses, after 6 months from the fourth egg sampling (Table 4). In group C, the concentration of Se decreased to 28.2, and in group E, to 33.9 mg·kg^{-1}. At the same time the difference between four samples (series I) and series II was 20.2% ($p<0.01$), and was higher than means between groups C and E of the series I. In the case of iodine, these trends were slightly different. Namely, its concentration remained within the limits of the mean from the four samplings and was 72.6 in group C, and 93.5 μg·100 g^{-1} in group E. Mean difference was 28.8% ($p<0.05$), being nearly twice lower in comparison with the first series of analyses. These changes may have had physiological background, since the hens were characterised by high laying yield, approx. 95%, during the series I, whereas in the series II – approx. 82%. Perhaps further studies in the next stage of laying (after moult) in would describe the changes in the concentrations of Se and I in egg content.

Table 4. Concentration of Se and I (μg·100 g^{-1}), Ca, Mg, Mn and Cu (mg·kg^{-1}) in the egg content of control (C) and experimental (E) groups in μg·100 g^{-1} (series II of analyses)

Group	Se	I	Ca	Mg	Mn	Cu
C	28.2 ± 3.36	72.6 ± 16.07	30.52 ± 3.12	80.40 ± 11.3	0.274*± 0.036	0.433 ± 0.089
E	33.9**± 4.26	93.5*± 21.30	29.49 ± 3.36	86.23 ± 9.8	0.235 ± 0.029	0.428 ± 0.097

*** p < 0.05; ** p < 0.01.**

It is worth to compare the results of the present study with the data available in references. Dobrzanski *et al*. [1] reported iodine concentration of eggs from farm hens between 0.36 and 0.41 mg·kg^{-1}, whereas from backyard housed hens – only 0.049 mg·kg^{-1} of egg content. Other authors determined the concentration of this element to be between 0.026 mg per egg [2] and 0.097 mg·100 g^{-1} of egg content [3]. Rys *et al*. [14] reported even more different data. After administering of increased level of iodine (max 7.2 mg of iodine per 1 kg) in diets of laying hens of Leghorn, Astra D and Green–Leg, the authors observed its increase in egg content up to 87.2 µg·100 g^{-1} (Leghorn), and up to 266.2 µg·100 g^{-1} (Green–Leg). In the control group (0.5 mg I per 1 kg of feed), iodine concentration in the feed was between 11.9 µg·100 g^{-1} (Astra D) and 28.4 µg·100 g^{-1} (Green–Leg). Kelp and iodine chloride were the sources of increased concentration of iodine in feed mix.

There is little data on the concentration of selenium in hen eggs, and its mean levels are reported to be between 0.1 and 0.344 mg·kg^{-1} of wet weight of egg content, depending on the hens' housing and feeding systems [1, 10]. However, availability of selenium in animals (and in humans) to a large extent depends on vitamin E [5, 15].

Due to possible antagonistic action of iodine and selenium against calcium, magnesium, manganese and copper, one should have expected some changes in the concentrations of these elements. The differences that were found were not great, since in the case of Ca, Mg and Cu they did not exceed 10%. Only in the case of manganese, there was a decrease by 14.23% in group E as compared with group C ($p<0.05$, Table 4). However, it seems that the increased levels of Se and I in the hens' feed mixtures did not generate any disturbances in the metabolism of Ca, Mg, Mn or Cu, although additional studies on these elements in the hens' blood and livers should be carried out [9]. The concentrations of calcium and magnesium in the examined eggs were much lower than these reported in literature [2, 10], whereas the levels of manganese and copper were within the broad limits mentioned by other authors.

Assuming after Gawecki *et al*. [3] and Giese [4] that the reference daily intakes (RDIs) of an adult human for selenium and iodine are 60 µg and 150 µg respectively, that such enhancement of these elements, as it was applied in the present study, increase the per cent of daily values (% DV) by 33.3 and 35.3% for selenium and iodine respectively, by intake one egg per day. If two eggs were consumed per day, the % DV are respectively higher by 67 and 71%.

Table 5. Reference daily intakes (RDIs) for Se and I, actual their concentration in one enriched egg and per cent of daily value (% DV)

Nutrient	Daily demand [µg]	Actual concentration in 1 egg [µg]	Per cent of demand satisfaction [%]
Selenium	60	20	33.3
Iodine	150	53	35.3

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CONCLUSIONS

1. Due to increased concentration of selenium and iodine by 100% in standard premixture for laying hens, a significant increase of the elements was found in egg content, respectively by 13.6 and 52.2%, with no effect on the concentration of Ca, Mg, Mn and Cu.
2. Selenium and iodine enrichment of egg content increased coverage of the RIDs respectively to 33.3 and 35.3% if one egg consumed daily and by 67 and 71% if two eggs are consumed daily.
3. Further studies are necessary in order to determine optimal selenium and iodine concentrations and feed mixtures and their optimal levels in egg content, with regard to the phases of laying and age of hens.

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