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BIOAVAILABILITY OF SELENIUM AND ZINC SUPPLIED TO THE FEED FOR LAYING HENS IN ORGANIC AND INORGANIC FORM

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ABSTRACT

Standard DJ feed mixture for laying hens (ISA Brown) was supplemented with organic or inorganic forms of selenium and zinc. The organic forms consisted *Saccharomyces cerevisiae* yeast enriched with Se (Y-Se) and Zn (Y-Zn). The inorganic forms were sodium selenite (Na-Se) and zinc oxide (ZnO). The concentrations of elements in the experimental feed were ($mg \cdot kg^{-1}$): selenium 1.414 (Y-Se) and 1.393 (Na-Se); zinc 79.3 (Y-Zn) and 78.9 (ZnO). After 6 days of feeding treatment, for the next 5 days there were collected droppings and eggs to determine Se and Zn concentrations with the use of ICP method. It was stated that in hens availability of elements (as apparent absorption) was respectively (%): Y-Se 63.65, Y-Zn 38.5, Na-Se 61.12 and ZnO 35.41. In eggs content of Y-Se hens the increase of Se was proved if compared to Na-Se eggs ($p<0.05$).

Key words: hen, selenium, zinc, bioavailability.

INTRODUCTION

Microelements play an important metabolic role and many of them must be balanced in the poultry diet. Different mineral supplements are currently applied, either organic (bioplexes, chelates) or inorganic (oxides, sulfates).

For laying hens microelements of a special meaning are Zn [12] and Se [21]. Their availability depends on chemical form, feed composition, age and physiological state of bird and mineral interactions. It was reported [15] 60-86% availability of Se from components of plants origin and 15-25% of animal origin. Zinc was absorbed in 14-67% depending on chemical form and concentrations of elements acting antagonistically (Cd, Cu, S, P, Mg) [11]. Noy et al. [15] evaluated the rate of absorption of several elements present in commercially mixed feed for hens and proved that rate about 30 for Zn and 60% for Se.

Dry yeast makes a valuable source of microelements, amino acids and B-group vitamins. The cultures of *Saccharomyces cerevisiae and Candida (Turolopsis) utilis* are frequently used in poultry feeding [1, 19, 20], specially if enriched with elements as Zn, Se, Cr, Mg [4, 8, 17].

The aim of the study was to compare in laying hens availability of Se and Zn applied to the feed in organic (yeast cultures of *Saccharomyces cerevisiae* enriched with Se and Zn) and inorganic form (sodium selenite and zinc oxide).

MATERIALS AND METHODS

The experiment was carried out with the use of ISA Brown hens (mean b.w. 1.76 kg) at the productive period following peak of the I cycle laying (laying rate 80%). The birds were kept in batteries (Specht) installing in an experimental room at the Agricultural University of Wrocław. Microclimate conditions (air temperature and humidity, lighting, ventilation) were controlled. There were established 4 experimental groups, each group of 5 cages, 4 hens per cage (80 hens in total).

To the 1st group (the group Y-Se) it was applied the feed supplemented with Se- *Saccharo-myces cerevisiae* yeast. The next three groups received feed supplemented with Zn- *Saccharomyces cerevisiae* yeast (the group Y-Zn), sodium selenite (the group Na-Se) or zinc oxide (the group ZnO).

Experimental feed was commercial DJ-type mixture with modified concentrations of Se and Zn (Table 1). For feed manufacturing the following compounds were used: ground maize, ground wheat, ground triticale and extracted soybean meal, wheat bran, malt sprouts, plant oil, rapeseed cake, liprot, amino acid and mineral premix of DJ-type. Mineral premix was fully balanced according to the hens requirements, besides Se and Zn. Selenium was replaced with Se enriched *Saccharomyces cerevisiae* yeast (Y-Se) or sodium selenite (Na-Se) and zinc was replaced with Zn enriched *Saccharomyces cerevisiae* yeast (Y-Zn) or zinc oxide (ZnO). Se-yeast and Zn-yeast were produced on saccharose medium according to the procedure described by Ryszka et al. [17].

Table 1. Scheme of the experiment

Group	Source of Se or Zn	Supplement of Se or Zn to the feed mixture ($mg \cdot kg^{-1}$)	Concentration of Se or Zn in the feed mixture ($mg \cdot kg^{-1}$)
Se-groups	Na-Se	0.5	1.393
	Se-yeast	0.5	1.414
Zn-groups	ZnO	50	78.9
	Zn-yeast	50	79.3

Experimental procedure included chemical tests on Se- and Zn-yeast and feed samples as well, to prove true concentrations of studied elements in the feeding material (ICP-MS method). In Se-yeast the selenium concentration was 500, and in Zn-yeast zinc concentration was 1500 $mg \cdot kg^{-1}$ dry matter in biomass (water content ca. 5%, crude protein 36-40.5%, ME 25 MJ). Chemical composition of yeast was reported previously [4]. The concentrations of Se and Zn in the feed mixture are presented in Table 1.

With the use of standard methods [16], the feed was tested on the concentrations of dry matter, metabolizable energy, crude protein, ash, fibre, fat, total calcium, available phospho-rus and NaCl. Table 2 presents content of nutrients in the applied mixtures. All feed parame-ters were in agreement to the standards for laying hens [19], besides slightly higher content of protein and energy.

Table 2. Content of nutrients in the DJ-type feed mixture

Balance compounds	Analyzed value	Recommended value*
Dry matter (%)	90.3	minimum 88
Metabolizable energy:		
Kcal · kg^{-1}	2 790	2 650 – 2 700
MJ · kg^{-1}	11.68	11.1 – 11.3
Crude protein (%)	16.17	15.0
Crude fat (%)	4.61	-
Crude ash (%)	10.8	-
Crude fibre (%)	2.82	to 4.0
Ca total (%)	3.52	3.50
P available (%)	0.34	0.33
NaCl (%)	0.38	0.29

*According to Poultry Feeding Standards [19].

The experiment was carried out for consecutive 11 days. Starting from the day 1st until 6th hens were fed with differentiated diets (Table 1). From the day 7th until 11th feed intake was monitored and there were collected eggs and droppings, separately from each cage. Droppings were weighed daily, mixed and about 10% of the mass was frozen in a plastic containers. After termination of experiment all droppings of one cage were mixed thoroughly and 0.5 g of mass was mineralized. Eggs of were counted, weighted and stored in chilly place. In the end of experiment all eggs of one cage were mixed, separately shells (with under shell membrane) end egg content (albumen and yolk). The samples of eggs content and shells weighting 0.5 g were mineralized. Experimental monitoring displayed the weight of eggs in the range 60.7-62.6 g (laying rate 82-89%), droppings weight 120.7-128.7 mg·head^{-1}per day, feed conversion ratio 1.85-2.01 kg feed per 1 kg of eggs.

Mineralization procedure was carried out with the use of microwave, pressure organic sample digestion with microprocessor microwave station MDS-2000 (CEM, USA). Samples were digested with concentrated, spectrally pure, nitric acid. Chemical analysis of Se and Zn concentrations were performed with the use of ICP-MS technique from Varian, Ultra Mass 700 [9] in the Institute of Inorganic Technology and Mineral Fertilizers, University of Technology of Wrocław. Bioavailability of Se and Zn was calculated on the basis of balance in hens and presented as retention and apparent absorption [14, 18]. Se and Zn content in the eggs was calculated as retention but not as excretion.

The results were elaborated statistically (t-Student test) with the use of Statgraphics v. 5.0 software.

RESULTS AND DISCUSSION

The experimental results and balance calculations are presented in Table 3. In Y-Se hens Se retention amounted 0.45 mg·head^{-1} and was higher by 5.63% if compared to Na-Se group. Apparent absorption was 63.65% and was higher by 2.53% than that found in Na-Se hens. In Y-Zn hens Zn retention amounted 15.19 mg head^{-1} and was higher by 8.19% if compared to ZnO group. The apparent absorption was 38.5% and was higher by 3.09% than that found in ZnO hens. These differences were statistically insignificant.

Table 3. Balance and absorption of Se and Zn for the laying hens ($\bar{x} \pm s$)

Item	Se-groups		Zn-groups	
	Y-Se	Na-Se	Y-Zn	ZnO
Intake with feed (mg · head^{-1})	0.707 ±0.013	0.697 ±0.016	39.45 ±1.20	39.65 ±1.16
Excretion in droppings (mg · head^{-1})	0.257 ±0.022	0.271 ±0.020	24.26 ±1.81	25.61 ±2.07
Retention in the body * (mg · head^{-1})	0.450 ±0.017	0.426 ±0.011	15.19 ±0.93	14.04 ±1.14
Apparent absorption (%)	63.65 ±2.76	61.12 ±2.13	38.50 ±2.98	35.41 ±3.59

*Including eggs output.

According to the references [19], availability of Se from plant origin feed is high (60-80%) and from animal origin low (15-25%). Selenium was found to be of a higher availability if given in organic (Se-cysteine, Se-methionine) than in mineral form (Na-selenite, Na-selanate) [20, 21]. Vitamin E plays a significant role in Se metabolism [3]. Grela and Sembratowicz [10] reported higher availability of Se in monogastric species than that in ruminants, since selenium compounds are easily converted into non-available forms by rumen bacteria.

The results obtained for zinc (Table 3) were in the range reported by Noy et al. [12]. A numerous factors may influence on decreased Zn availability, as high content of phytine acid, non-starch polysaccharides and fat, Ca, Co, Cd excesses and the presence of other antagonists [11, 19, 23]. Świątkiewicz et al. [22] pointed out the meaning of chemical form of zinc for its availability to broilers. Zinc bound to amino acids was of higher availability by 3 – 14.4%, if compared to zinc in sulfates. Even higher difference (by 206%) was found for Zn-methionine vs. $ZnSO_4$ [24].

The results of balance studies obtained in the present study are not easy to discuss in the view of limited references concerning poultry. In pigs availability of Se and Zn (apparent absorp-tion) from Se- and Zn-*Saccharomyces cerevisiae* supplemented diet was respectively, 80.2 and 68.6% [14]. These results were significantly higher than displayed for hens.

The concentrations of Se and Zn in eggs are presented in Table 4. In egg content of Y-Se group, Se amounted 0.308 $mg \cdot kg^{-1}$ of fresh matter (f.m.). In egg content of Y-Zn hens, Zn amounted 9.03 $mg \cdot kg^{-1}$ of f.m. Those concentrations were higher by 10.47 ($p<0.05$) and 2.03%, if compared to Na-Se and ZnO eggs. It may be stated that Se in organic form is more efficiently transferred into egg content than inorganic Se, what was not observed for zinc.

Table 4. Concentration of Se and Zn in the eggs ($\bar{x} \pm s$)

Item	Se-groups		Zn-groups	
	Y-Se	Na-Se	Y-Zn	ZnO
Content (mg/kg)	0.308[a] ±0.023	0.279[b] ±0.019	9.03 ±1.59	8.85 ±1.30
Shell (mg/kg)	2.230 ±0.963	2.611 ±1.082	8.33 ±1.95	8.26 ±2.53
Whole egg (mg)	0.030 ±0.006	0.031 ±0.006	0.538 ±0.115	0.527 ±0.203

a, b - $p<0.05$.

The content of Se and Zn in eggs ranges widely depending on the maintenance system, composition of feed and physiological state of hens. In eggs content of free range system [2] Zn varied ($mg \cdot kg^{-1}$ f.m.) from 10.61 to 19.40 (mean 14.29) and of commercial farm from 9.72 to 19.85 (12.91). Dobrzański et al. [6] compared the concentrations of Se and Zn in eggs of hens maintained in three housing systems (cage, litter and free range). Selenium varied from 0.117 to 0.344 and Zn from 9.77 to 13.11 $mg \cdot kg^{-1}$ f.m. Other authors [5] found that differences in Se concentration in eggs of Lohman Brown hens depend on laying phase and vary from 0.282 to 0.352 $mg \cdot kg^{-1}$ dry matter. The doubling of Se concentration in the diet (0.35 $mg \cdot kg^{-1}$ of feed) caused linear increase of Se in egg (0.401 $mg \cdot kg^{-1}$ f.m).

There were not found significant differences between organic (Y-Se, Y-Zn) and inorganic groups (Na-Se, ZnO) in Se and Zn concentrations in egg shells Obtained results differ from previously reported [13]. Dobrzański et al. [7] proved in egg shell the concentration ($mg \cdot kg^{-1}$) of Se from 0.1 to 0.32 and Zn from 2.36 to 8.11. This was due to a specific role of shell for elemental deposal. Taking into account the concentrations of Se and Zn in the whole egg (mean mass 60 g) there were not significant differences stated between the groups studied.

CONCLUSIONS

1. Selenium and zinc supplemented to the feed of laying hens in organic forms (dry yeast *Saccharomyces cerevisiae* enriched with Se and Zn) were of a higher availability by 2.5 and 3.1%, if compared to sodium selenite (61.1%) and zinc oxide (35.4%).
2. Content of eggs from hens received selenium enriched yeast contained a higher concentration of Se by 10.47% ($p<0.05$), if compared to sodium selenite group.

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