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EFFECT OF VARIOUS SELENIUM SOURCES ON SELENIUM BIOAVAILABILITY, CHICKEN GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND MEAT COMPOSITION OF BROILER CHICKENS

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ABSTRACT

One hundred and eighty unsexed Isa Vendeta broiler chickens were used to study bioavailability of inorganic (sodium selenite) and organic (selenium enriched yeast) form of selenium. Chickens were fed for 6 wk concentrate mixtures containing 0.36 $mg \cdot kg^{-1}$ in starter and finisher 0.37 $mg \cdot kg^{-1}$ in grower. Selenium content in some birds' tissues was used to determine selenium bioavailability from different, applied in experiment, compounds. Se content in legs muscles, kidneys and femurs of birds that received selenium enriched yeast (gr. II) was clearly higher ($P \leq 0.01$) than in control group (gr. I). No treatment differences in Se content in breast muscles, liver and blood serum as well as growth performance and results of post-slaughter analysis of broiler chickens were detected during the trial. Dry matter content in breast and legs muscles ($P \leq 0.05$), crude fat content ($P \leq 0.01$) in breast muscles as well as crude protein content ($P \leq 0.05$) in legs muscles were lower in selenium enriched yeast-fed chickens compared to sodium selenite-fed birds. The findings suggest that selenium from enriched yeast applied concentrate mixtures for broiler chicken are better absorbed than their inorganic equivalent – sodium selenite what was confirmed by higher Se level in some birds' tissues.

Key words: broiler chickens, sodium selenite, selenium enriched yeast, selenium bioavailability, meat composition

INTRODUCTION

Selenium deficiency poses serious problem not only in Poland but also on the whole world and its consequences more and more often occurring are more dangerous than selenium toxicity. Therefore all possibilities of reducing or totally eliminating selenium deficiency are in the limelight's many researchers, especially by virtue of fact that direct cause of hiposelenosis is lack of this element in feed rations for animals. Although selenium deficiency not necessarily can be defined as a disease, it makes organism more subject to various infections or metabolic stresses [3].

$^{-1}$Element bioavailability mainly depends on chemical form and animal species. Organic forms of selenium (selenocysteine, selenomethionine) are more effectively absorbed than inorganic compounds (selenites or selenates). It is a result of active transport of selenium amino acid complexes through epithelial cells of intestine compared with passive diffusion of selenates' or selenites' ions [7, 19]. Grela and Sembratowicz [12] indicate that bioavailability of various selenium compounds is varied and depends on animal species. According to Coenders [6] higher selenium bioavailability of organic forms, especially from selenium enriched yeast, in ruminant feeding is an effect of selenium protection against bacterial reduction. On the other hand in sheep nutrition about 29% of selenium from selenite is reabsorbed in digestive tract while in monogastric animals selenium from selenites is available in about 77% [6], or according to Underwood and Suttle [19], even in 85%.

The results of the studies on bioavailability of various chemical bounds of selenium are not clear-cut what cause the need of further researches on selenium bioavailability in animals from various chemical compounds justified.

The aim of this study was to estimate and compare selenium bioavailability of inorganic (sodium selenite) and organic (selenium enriched yeast) forms. For this purpose the selenium level in some tissues - breast and leg muscles, liver, kidneys, blood serum as well as femur were determined. Moreover the effect of various selenium forms on growth performance and meat composition of broiler chickens was estimated.

MATERIAL AND METHODS

Animals, diet and experimental design

The research material consisted of 180 unsexed Isa Vedetta chickens that were randomly allocated to 2 groups (90 heads per each) with 3 repetitions per group (30 heads per each).

The chickens were kept in boxes on dry sawdust bedding. The poultry house was fitted with a mechanical ventilation system and the air exchange rate was adequate to the requirements of Isa Vedetta chickens. The relative humidity during the experimental rearing ranged from 67 to 77 %.

The broilers were fed with the following dry mash: Starter – from day 1 to 21, Grower – from day 21st to 35th, Finisher - from day 35th to 42nd of their life (Table 1). The factors differentiating all-mash concentrate mixtures for the chickens were selenium compounds applied in the mineral - vitamin mixtures (premixes): sodium selenite (group I - control) and selenium enriched yeast (group II - experimental).

Table 1. Composition [in %] and nutritive value of all-mash mixtures

Item		Starter	Grower	Finisher
Maize	%	24.75	20.0	30.0
Wheat	%	35.0	42.0	38.3
Soybean meal 46%	%	32.0	29.3	23.5
Dicalcium phosphate	%	1.7	1.5	1.2
Salt (NaCl)	%	0.25	0.25	0.25
Soybean oil	%	4.0	4.8	5.0
Limestone	%	1.3	1.15	0.75
Premix*	%	1.0*	1.0*	1.0*
Nutritive value				
Metabolizable energy	$MJ \cdot kg^{-1}$	12.84	12.88	13.22
Crude protein	%	22.00	19.75	18.45
Crude fibre	%	2.50	2.50	2.50
Lysine	%	1.20	1.17	1.05
Methionine	%	0.54	0.52	0.48
Methionine + Cystine	%	0.92	0.88	0.81
Tryptophan	%	0.25	0.22	0.21
Treonine	%	0.78	0.73	0.65
Total calcium	%	0.87	0.82	0.70
Available phosphorus	%	0.46	0.42	0.35
Total sodium	%	0.16	0.15	0.16
Selenium	$mg \cdot kg^{-1}$	0.36	0.37	0.36

*According to the fixed scheme of the experiment, the premixes contained selenium as a sodium selenite (group I) and selenium enriched yeast (group II).

Before commencing the experiment, all feed mixture components were chemically analysed in order to determine the content of the basic nutrients and mineral components, i.e. calcium, sodium [2] and phosphorus [11] as well as selenium after wet mineralization of the samples using Zeiss AAS-3 spectrometer [2]. The results of the analyses made possible determination of the nutritive value of the concentrate mixtures for chickens (Table 1).

On the day 21st and 42nd of the experiment, the chickens were weighted and the feed intake as well as mortality were recorded. In this way, the birds' body weight and feed conversion rate were measured.

Blood and tissues' samples collection

At the end of the experiment, on day 42nd of rearing, 12 birds (6 cockerels and 6 hens) were randomly selected for blood sampling, killing and dissection. Afterward carcass yield, gutted carcass weight and the breast, leg and wings yields were measured. Samples of breast and leg muscles, livers and kidneys, blood serum and femurs including the joint tissues prepared from the carcass were analysed. The qualitative parameters were expressed as a percentage of the total weight of each carcass.

The following parameters were determined for the breast and leg muscles: dry matter, crude protein [2] and crude fat according to the applicable Polish Standard (PN - 737 A - 8211). The selenium level was determined in the muscles, liver, kidneys and femurs as well as in the blood serum of the birds after wet mineralization of the samples with nitric acid using plasma spectrometer with mass detection (VARIAN ICP-MS instrument). The breast and leg muscles were sensually analysed according to PN-ISO 6564:1999 using the multiple comparison method and a 5 grade scale to evaluate the properties: colour, taste, smell, tenderness and juiciness.

Statistical analysis

All obtained in the course of the experiment data were statistically analysed using the t-student test and a single-factor analysis of variation and the relevance of the differences was estimated applying the Duncan's multiple range test in STATISTICA 7.2 program.

RESULTS

Applied in mineral-vitamin mixture selenium compounds did no effect on broilers' body weight on day 21st. Average body weight of 42 days broilers receiving selenium enriched yeast increased by 2.32% compared to the body weight of birds that received sodium selenite but the difference was not statistically significant (Table 2). Selenium enriched yeast as well as sodium selenite applied in concentrate mixtures did not effect on feed conversion on day 21st and 42nd their life although feed conversion in birds that received selenium enriched yeast in fodder was slightly better (Table 2). The lower mortality of broiler chicken that received selenium enriched yeast than birds which sodium selenite was applied in concentrate mixture was showed.

Table 2. Growth performance of broiler chickens

Item		Feeding groups		
		Unit	I - Sodium selenite	II - Selenium enriched yeast
Body weight [g]:	21 day of life	$\bar{x}$ ±sd	735 ±41.6	730 ±32.2
	42 day of life	$\bar{x}$ ±sd	2413 ±168.8	2469 ±231.6
Feed conversion [kg·kg^{-1} b.w.]	1-21	$\bar{x}$ ±sd	1.37 ±0.10	1.36 ±0.10
	22-42	$\bar{x}$ ±sd	2.03 ±0.19	1.95 ±0.14
Mortality		[%]	8.89	7.78

Prior to killing, the body weight of broilers that received selenium enriched yeast (group II) in concentrate mixture was slightly higher (by 2.48%) than birds in control group. This statement was confirmed by higher gutted carcass weights of chickens that were fed on concentrate mixture containing selenium enriched yeast. The carcass yield of broilers which were given selenium enriched yeast in concentrate mixture was higher (74.01%) than in birds that received sodium selenite in fodder (Table 3). Breast and leg meat yield as well as wings yield depend on chemical forms of selenium applied in broilers' fodder. The breast and leg yield in gutted carcass of broiler chickens that received selenium enriched yeast in mineral-vitamin mixture was lower while wings yield was higher than in birds which were given sodium selenite in concentrate mixture.

Table 3. Results of post-slaughter analysis

Item		Feeding groups	
		I - Sodium selenite	II - Selenium enriched yeast
		$\bar{x}$ ±sd	$\bar{x}$ ±sd
Body weight prior to killing [g]		2419 ±113.9	2479 ±195.0
Gutted carcass weight [g]		1754 ±263.1	1832 ±235.5
Carcass yield [%]		72.46 ±8.43	74.01 ±8.48
Meat yield [%]	breast	22.77 ±2.72	21.92 ±3.59
	leg	35.59 ±4.20	33.70 ±7.40
Wing yield [%]		9.96 ±3.25	10.71 ±0.66

The content of selenium in leg muscles, kidneys and femurs was clearly higher ($P \leq 0.01$) in chickens that received selenium enriched yeast than in broilers from group I receiving sodium selenite in concentrate mixture (Table 4).

The content of this microelement in breast muscles, liver and blood serum was slightly higher in birds from experimental group – II (selenium enriched yeast).

Table 4. Selenium content in selected soft tissues, femur ($mg \cdot kg^{-1}$ of fresh tissue) and in blood serum ($\mu mol \cdot L^{-1}$) of broilers

Item	Feeding groups	
	I - Sodium selenite	II - Selenium enriched yeast
	$\bar{x}$ ±sd	$\bar{x}$ ±sd
breast muscles	0.736±0.0254	0.796±0.061
leg muscles	0.377^{A}±0.012	0.634^{B}±0.039
liver	0.616±0.097	0.631±0.035
kidneys	0.528^{A}±0.066	0.978^{B}±0.076
femur	1.516^{A} ±0.332	2.436^{B} ±0.520
blood serum	0.083±0.020	0.088±0.019

A, B - values in rows with different letters differ high significantly ($P \le 0.01$)

Higher ($P \le 0.05$) content of dry matter (29.81%) was stated in breast muscles of chickens in group I, which received concentrate mixture containing selenium as a sodium selenite than in birds from group II (29.14%). Crude protein and fat content in legs muscles, and crude fat content in breast muscles ($P \le 0.01$) of broilers receiving selenium enriched yeast decreased in comparison with the birds that received sodium selenite (Table 5).

Table 5. Chemical composition of muscles (in %)

Item	Feeding groups	
	I – sodium selenite	II – selenium enriched yeast
	$\bar{x}$ ±sd	$\bar{x}$ ±sd
Breast muscles		
dry matter	29.81a ±0.50	29.14b ±0.45
crude protein	22.41±0.56	22.25 ±0.40
crude fat	2.86A ±0.18	2.59B ±0.12
Leg muscles		
dry matter	30.67a ±0.77	29.90b ±0.61
crude protein	19.08a ±0.48	18.37b ±0.65
crude fat	8.28 ±0.41	8.63 ±0.56

a, b - values in rows with different letters differ significantly ($P \le 0.05$)
A, B - values in rows with different letters differ high significantly ($P \le 0.01$)

Dry matter content in leg muscles of chickens from group I (control) was higher ($P \le 0.05$) than in birds from group II, which received selenium enriched yeast. Crude protein content in leg muscles of broilers receiving selenium enriched yeast applied in concentrate mixture clearly ($P \le 0.05$) decreased (about 3.72%), whereas crude fat content in these muscles increased, but the differences were not statistically confirmed (Table 5).

Breast meat of chickens that received in mineral-vitamin mixtures inorganic form of selenium, sodium selenite, were characterized by slightly better colour, taste, flavour and juiciness while tenderness was poorer quality than breast muscles of birds receiving selenium enriched yeast. Thus the total sensory evaluation of breast meat was slightly lower in chickens receiving selenium enriched yeast in fodder.

Total sensory evaluation as well as note related colour, taste and juiciness of leg meat of birds that received in concentrate mixtures selenium enriched yeast were similar as sensory evaluation of breast meat (Table 6).

Table 6. Results of sensually evaluation of chicken meat [in pts]

Item	Feeding groups	
	I – sodium selenite	II-selenium enriched yeast
Breast meat		
colour	4.28±0,39	4.24±0,64
taste	4.14 ±0,66	3.89 ±0,80
flavour	4.08 ±0,58	3.88 ±0,73
tenderness	4.15 ±0,58	4.27 ±0,66
juiciness	4.17 ±0,52	4.08 ±0,69
total note	4.21 ±0,52	4.08 ±0,68
Leg meat		
colour	4.08 ±0,67	4.04 ±0,77
taste	3.97 ±0,70	3.94 ±0,84
flavour	3.86 ±0,77	3.89 ±0,81
tenderness	4.13 ±0,64	4.16 ±0,69
juiciness	4.17 ±0,57	4.08 ±0,77
total note	4.06 ±0,64	4.00 ±0,73

DISCUSSION

Obtained data, related to selenium content in some chickens' tissues in our experiment, showed that applied in concentrate mixtures for broilers selenium organic form made possibility of increasing content of this microelement in animal origin products which could be a good selenium source in human nutrition. It is allowed to suppose that chemical form of selenium applied in mineral-vitamin mixture effects on selenium content in birds' tissues. Selenium enriched yeast used in concentrate mixtures for chickens [4] increased selenium content in meat in comparison with this microelement content in meat of animals which were sodium given selenite in feed. Supplementation of feed ration for ISA Brown hens with selenium enriched yeast significantly increased selenium content in tissues (liver, kidney, heart, lungs, breast muscles) and also in blood serum [14] compared to hens that received sodium selenite in feed. Echevarria *et al.* [9] after giving to broilers sodium selenite in amount 0, 3, 6 and 9mg Se/kg of concentrate mixture stated that selenium content in tissues, especially in kidneys and liver increased proportional to supply of this element in feed.

Choct *et al.* [5] in experiment on broilers fed on premixes containing various forms of selenium did not show any differences in broilers body weight gains. On the other hand in the experiment carried out by Payne and Southern [18] on broiler chickens receiving sodium selenite higher body weight gain in 17^{th}, 17^{th} and 17^{th} days of their life was shown than in birds that received this microelement as a selenium enriched yeast whereas chickens' mortality was kept on similar level and amounted respectively: 6.35 and 7.53%. Obtained in our experiment data related to chickens' body weight gains correspond with results obtained in experiment conducted by Choct *et al.* [5] and Jianhua *et al.* [13] on broiler chickens which receiving selenium enriched yeast in feed. Naylor *et al.* [16] after applying organic form of selenium in broiler feeding, indicated positive influence of this form on degree of feed utilization by chickens. However according to Edens [10] improvement of feed utilization could be a result of better feathering of birds whom feed was supplemented with selenium as a selenium enriched yeast. Acda and Chae [1] in experiment carried out on swine proved that organic forms of selenium applied in fatteners' feed in amount 0.05, 0.20 and 0.30 mg/kg of feed did not influence on fatteners' body weight gains as well as fodder intake and feed conversion.

Choct *et al.* [5] noted higher carcass and breast meat yield in broilers' carcass that received selenium enriched yeast in feed. On the other hand, Payne and Southern [18] in experiment carried out on broilers receiving sodium selenite and selenium enriched yeast stated that carcass yield and breast meat yield in carcass did not depend on chemical form of this microelement in feed. Downs *et al.* [8] and also Payne and Southern [18] in their researches related to applying selenium enriched yeast in broilers feeding indicated similar dependency.

There are not many articles in available literature concerning effect of various chemical forms of selenium on sensory evaluation of broiler chickens' meat. Nielsen and Rasmussen [17] in their investigation on antioxidants, like a tocopherol and selenium, applied in animal nutrition, indicated that antioxidants have positive effect on improvement of quality parameters of poultry, pork and fish meat. Naylor *et al* [16] as well as Downs *et al.* [8] noted clearly in chickens that received selenium in organic form (selenium enriched yeast) ($P \leq 0.01$) lower meat's water losses in comparison with meat of broilers receiving that microelements as a sodium selenite. On the other hand Mahan *et al.* [15] showed that 120 hours after slaughter water losses in meat of fatteners that received sodium selenite were higher than in animals which selenium were not given or selenium enriched yeast was applied in feed. It could be a result of meat's prooxidants decaying by inorganic form of selenium.

REFERENCES

1. Acda S.P., Chae B.J. (2002). A review on the applications of organic trace minerals in pig nutrition. Pakistan J. Nutr., 1: 25-30.
2. AOAC (2000). Official Methods of Analysis. Association of Official Analytical Chemists. 17th Edition. Washington DC.
3. Beck M.A., Levander O., Handy J., (2003). Selenium deficiency and viral infection. J. Nutr., 133: 14635-14675.
4. Bou R., Guardiola F., Barroeta A.C., Codony R. (2005). Effect of dietary fat sources and zinc and selenium supplements on the composition and consumer acceptability of chicken meat. Poult. Sci., 84: 1129-1140.
5. Choct M., Naylor A.J., Reinke N. (2004). Selenium supplementation affects broiler growth performance, meat yield and feather coverage. Br. Poult. Sci., 45, 5: 677-83.
6. Coenders R.M.W. (1995). Chromium and organic selenium: two basic elements in nutrition. In: TP Lyons and KA Jacques (Eds): Nutritional Biotechnology in the Feed and Food Industries. Proceedings of Alltech' s 20th, Annual Symposium. Nottingham University Press, pp. 2-14, 3, 19-30.
7. Dobrzański Z., Jamroz D. (2003). Bioavailability of selenium and zinc supplied to the feed for laying hens in organic and inorganic form. http://www.ejpau.media.pl/volume6/issue2/animal/art-03.html
8. Downs K.M., Hess J.B., Bilgili S.F. (2000). Selenium sources effect on broiler carcass characteristics, meat quality and drip loss. J. Appl. Anim. Res. 18: 61-72.
9. Echevarria M.G., Henry P.R., Ammerman C.B., Roa P.V., Miles R.D. (1988). Estimation of the relative bioavailability of inorganic selenium sources for poultry. 2. Tissue uptake of selenium from high dietary selenium concentrations. Poult. Sci. 67: 1585-1592.
10. Edens F.W. (2002). Practical applications for selenomethionine: broiler breeder reproduction. In: TP Lyons and KA Jacques (Eds): Nutritional Biotechnology in the Feed and Food Industries. Proceedings of Alltech' s 18th, Annual Symposium. Nottingham University Press, pp. 29-42.
11. Fick K.R., Mcdowell L.R., Miles P.H., Wilkinson N.S., Funk J.D., Conrad J.H. (1979) Methods of mineral Analysis for Plant and Animal Tissue. Animal Science Department. University of Florida. Gainesville, FL.
12. Grela E., Sembratowicz I. (1997). Organic and inorganic compounds of selenium in animal nutrition. Med. Weter. 53, 7: 385-386.
13. Jianhua H., Ohtsuka A., Hayashi K. (2000). Selenium influences growth via thyroid hormone status in broiler chickens. Brit. J. Nutr. 84: 727-732.
14. Kurnicová S., Boldižárova I., Grešákova E., Bobček R., Leng Ĺ. (2003). Chicken selenium status when fed a diet supplemented with Se-Yeast. Acta Vet. Brno 73: 339-346.
15. Mahan D.C., Cline T.R., Richert B. (1999). Effect of dietary levels of selenium enriched yeast and sodium selenite as selenium sources fed to growing-finishing pig on performance, tissue selenium, serum glutathione peroxidase activity, carcass characteristics and loin quality. J. Anim. Sci. 77: 2172-2179.
16. Naylor A.J., Choct M., Jacques K.A. (2000). Effect of selenium sources and level on performance and meat quality in male broilers. Poult. Sci. 79: suppl, 117.
17. Nielsen H.E., Rasmussen O.K. (1979). The influence of selenium on performance, meat production and the quality of some edible tissues in pigs. Acta Agr. Scan. Suppl. 21: 246-257.
18. Payne R.L., Southern L.L. (2005). Comparison of inorganic and organic selenium sources for broilers. Poult. Sci. 84: 898-902.
19. Underwood E.J., Suttle N.F. (1999). The mineral nutrition of livestock. CABI. Publishing, New York, NY.

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