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REGULAR ARTICLE

EFFECT OF DIETARY SELENIUM FORMS ON SELENIUM BLOOD CONCENTRATION IN LAYING HENS

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ABSTRACT

The aim of this study was to evaluate the effect of inorganic and organic selenium in the diets on its concentrations in blood of laying hens. 12 ISA Brown laying hens kept conventional housing were used. Group A (six hens in group) received during whole laying period (22 - 75 week of age) selenium as a Na_2SeO_3 (0.8 $mg.kg^{-1}$) in the diet. Group B (six hens in group) received in the diet organic forms of selenium Sel-plex (0.8 $mg.kg^{-1}$).The blood was sampled at 22, 47 and 75 week of age. The selenium concentrations in whole blood were measured. The level of selenium in blood decreased in both group (A 251.6 ± 15.1 $\mu g.l^{-1}$, B 240.6 ± 21.6 $\mu g.l^{-1}$) from the beginning of the experiment to 47week of age. Selenium concentration increased from week 47 to end of experiment in group B from 150.0 ± 11.9 $\mu g.l^{-1}$ to 156.9 ± 14.8 $\mu g.l^{-1}$, contrary to group A, in which selenium blood level decreased from 147.7 ± 11.2 $\mu g.l^{-1}$ to 133.7 ± 9.6 $\mu g.l^{-1}$. No significant differences were found between the groups during all period of experiment.

Keywords: (laying hens, selenium forms, blood)

INTRODUCTION

The element selenium (Se) was discovered in 1817 and it is essential for normal life processes (Köhrle, 2004), and all animals, including poultry, need these inorganic elements. However, a biologically active form was found only in 1973, when glutathione peroxidase was identified as a very potent antioxidant protecting the body from damage due to oxidation by free radicals (Rotruck *et al*., 1973). The activity level of this enzyme in liver or plasma is indicative of selenium supply to the organism. Glutathione peroxide protects cells and membranes from oxidative damage by destroying hydrogen peroxide and hydroperoxides employing reducing equivalents from glutathione (Watanabe *et al*., 1997). Selenium has been researched in finishing pigs (Mahan *et al*., 1999; Zhan *et al*., 2007), fishes (Vidal *et al*., 2005; Wang *et al*., 2007) and poultry (He *et al*., 2000; Zuberbuehler et al., 2002, 2006; Mahmoud and Edens, 2005; Utterback *et al*., 2005; Singh *et al*., 2006).

Selenium was associated with protein in animal tissues (Burk and Hill, 1993). Deteriorative oxidative reactions in meat led to losses of both nutritional value and food quality. To increase the oxidative stability of meat, antioxidants such as selenium had been added to the feed of farm animals, leading to an improved meat quality (Mahan et al., 1999; Downs *et al*., 2000). Selenium has an important function in combination with vitamin E in decreasing the toxicity of heavy metals. McDowell *et al.* (1978) and Underwood (1981) established that selenium decreased the toxicity of cadmium and lead. Vitamin E reduces the toxicity of silver and arsenic; selenium reduces the toxicity only at high levels (McDowell *et al.* 1978; Underwood 1981).

Selenium is introduced into the food chain by plants, which absorb inorganic selenium salts from the soil and convert them into organic forms of the element (mainly as selenomethionine), which are then incorporated into proteins. The concentration of selenium in plants varies widely and depends on the selenium content and characteristics of soil. Many regions in Czech Republic is selenium deficient, and that is why selenium must be in many farms supplemented (Pavlata *et al*., 2002, 2005).

Selenium deficiency in young turkeys, especially when accompanied by vitamin E deficiency, causes Se-deficiency diseases and dysfunctions, including exudative diathesis, pancreatic dystrophy, and nutritional muscle dystrophy of the gizzard, heart and skeletal muscle (Cantor *et al*., 1982). Increased tissue concentrations of selenium not only decrease oxidative stress, including protection of unsaturated fatty acids from peroxidation damage (Tapiero *et al*., 2003; Korniluk *et al*., 2007), but can also reduce drip loss from breast meat

and the incidence of pale soft, exudative meat (Downs *et al*., 2000; Naylor *et al*., 2000). This indicates that dietary selenium can improve the quality and oxidative stability of meat.

The aim of this study was to evaluate the effect of inorganic and organic selenium in the diets on its concentrations in blood of laying hens.

MATERIAL AND METHODS

Animals and breeding conditions

The experiments were performed in ISA BROWN pullets, kept in a hall with deep litter technology. The available area, complete feeding mixture, light-dark (L:D) cycle, temperature of housing, relative humidity of air changed according to technological instructions for ISA BROWN pullets. During rearing period standard vaccinations were provided.

Traditional cage technology – four-floor, total (available) area 550 cm^2/bird (2 birds kept on 1120cm^2 – 32x35x45cm), 2 nipple drinkers, belt feeder 15cm/bird, device for claw shortening,

Experimental group consisting of 12 birds were established with the mean body weight of 1300 ± 50 g. Throughout the study, the hens were fed using a complete feeding mixture for laying hens containing 875 $g.kg^{-1}$ of dry matter, energy content ME_N 11.1 $MJ.kg^{-1}$, content of nitrogen substances 170.7 $g.kg^{-1}$, Ca 35.9 $g.kg^{-1}$ and P 6.3 $g.kg^{-1}$. Group A (six hens in group) received during whole laying period (22 - 75 week of age) selenium as a Na_2SeO_3 (0.8 $mg.kg^{-1}$) in the diet. Group B (six hens in group) received in the diet organic forms of selenium Sel-plex (Alltech, USA) (0.8 $mg.kg^{-1}$).

A constant light-dark (L:D) cycle (15:9, switching on at 4.00 AM, switching off at 19.00 PM) was maintained as recommended in technological instructions for ISA BROWN hens. The temperature of housing was in the range from 18 to 22^oC; relative humidity of air was ranging from 65 to 70%. No red mite and other parasite or viral infection was presented during experimental period.

Collection of blood samples

Whole blood samples (3 ml) of all hens in experimental group were collected from a *brachial vein* of hens at the age of 22, 47 and 75 weeks, always between 7.00 and 8.30 am. Heparin was used as anticoagulant. Whole blood samples were stored at -20^oC until analyzed.

Measurement of selenium

Selenium was measured in whole blood samples using the HG-AAS method and the AAS Solaar M6 (Unicam, Great Britain) device, after microwave mineralization of samples in the Milestone Ethos TC (Milestone, Italy) unit using Pechova *et al*. (2005) method.

Statistical evaluation

The data is expressed as means ± SEM. Changes in selenium blood concentration were analyzed by One-way ANOVA for factor selenium source. ANOVA was followed by post-hoc Fischer LSD test for pairwise comparisons, when appropriate. All statistical analyses were performed by Statistica 7.0 statistical software (StatSoft Inc., Tulsa, USA). The overall level of statistical significance was defined as $p < 0.05$.

RESULTS

The level of selenium in blood decreased in both group (A 251.6 ± 15.1 $\mu g.l^{-1}$, B 240.6 ± 21.6 $\mu g.l^{-1}$) from the beginning of the experiment to 47week of age (Fig. 1). Selenium concentration increased from week 47 to end of experiment in group B from 150.0 ± 11.9 $\mu g.l^{-1}$ to 156.9 ± 14.8 $\mu g.l^{-1}$, contrary to group A, in which selenium blood level decreased from 147.7 ± 11.2 $\mu g.l^{-1}$ to 133.7 ± 9.6 $\mu g.l^{-1}$. No significant differences were found between the groups during all period of experiment.

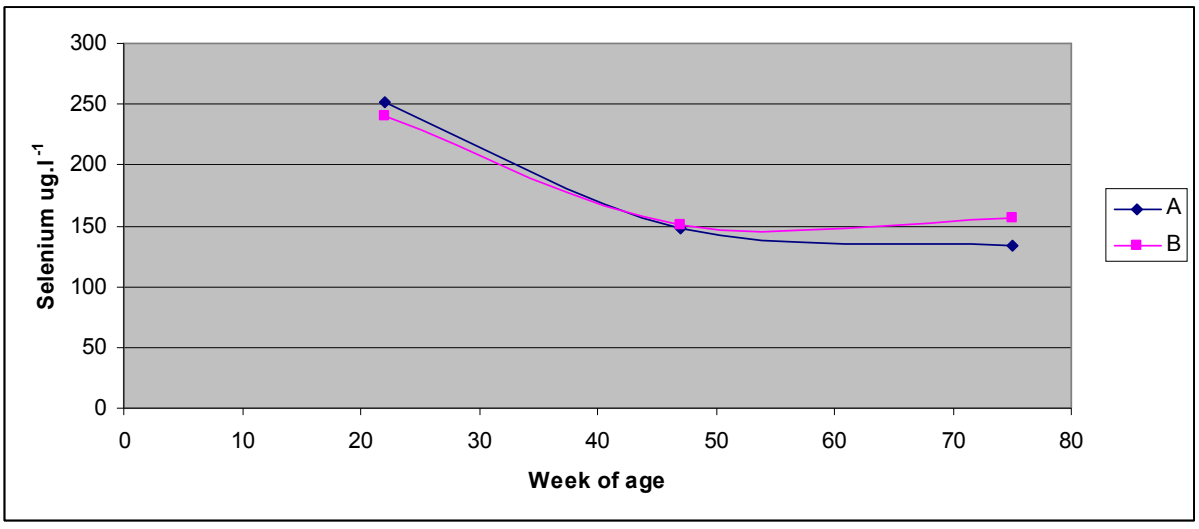

Figure 1 Full blood selenium concentration in groups A and B during the laying period

DISCUSSION

In our study no effect of organic or inorganic dietary selenium form on blood selenium concentration was found. This result doesn't correspond to other similar studies.

Mahan (1999) refers that different Selenium forms follow distinct metabolic pathways in the organism. In the study Wang and Xu (2008), the glutathione peroxidase activity in blood of broiler chickens was remarkably higher ($P<0.05$) in animals supplemented with selenium yeast compared with them supplemented with sodium selenite. Thus, this result also suggested the bioavailability of organic forms of Se was higher than that obtained for inorganic forms (sodium selenite). In the contrary, Payne and Southern (2005) reported that glutathione peroxidase activity was not affected by Se source or concentration.

Mahan and Parrett (1996) reported that inorganic Se (sodium selenite) was retained at a much lower concentration in muscle tissue, was less efficiently absorbed and was excreted at a higher rate than organic Se due to their different metabolic pathways. This is probably due to different absorption mechanisms for organic and inorganic forms of selenium. Inorganic selenium is passively absorbed from the intestine by a simple diffusion process, whereas organic selenium is actively absorbed through the amino acid transport mechanisms (Wolfram *et al.*, 1989).

Jiakui and Xiaolong found that increasing both blood and kidney Se, inorganic form (sodium selenite) equalled organic (Se-Malt), while in enhancing Se content in the liver, sodium selenite was more effective than Se-Malt.

CONCLUSION

In summary, the current study shown that different Se source (sodium selenite and Sel-plex) treated with supplemented diet didn't effect on blood selenium concentration in laying hens kept in conventional housing technology.

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REFERENCES

BURK, R.F. – HILL, K.E. 1993. Regulation of selenoproteins. In *Annual Review of Nutrition*. vol. 13, 1993, p. 65–81.

CANTOR, A.H. – MOOREHEAD, P.D. – MUSSER, M.A. 1982. Comparative effects of sodium selenite and selenomethionine upon nutritional muscular dystrophy, selenium-dependent glutathione peroxidase, and tissue selenium concentrations of turkey poults. In *Poultry Science*, vol. 61, 1982, p. 478-484.

DOWNS, K.M. – HESS, J.B. – BILGILI – S.F. 2000. Selenium source effect on broiler carcass characteristics, meat duality and drip loss. In *Journal of Applied Animal Research*, vol. 18, 2000, p. 61–72.

HE, J.H. – OHTSUKA, A. – HAYASHI, K. 2000. Selenium influences growth via thyroid hormone status in broiler chickens. In *British Journal of Nutrition*, vol. 84, 2000, p. 727–732.

JIAKUI, L. – XIAOLONG, W. 2004. Effect of dietary organic versus inorganic selenium in laying hens on the productivity, selenium distribution in egg and selenium content in blood, liver and kidney. In *Journal of Trace Elements in Medicine and Biology*, vol. 18, 2004, p. 65–68.

KÖHRLE, J. 2004. Selenium in biology and medicine—further progress and increasing interest. In *Journal of Trace Elements in Medicine and Biology*, vol. 18, 2004, p. 61–63.

KORNILUK, K. – CZAUDERNA, M. – KOWALCZYK, J. 2007. The influence of dietary conjugated linoleic acid isomers and selenized yeast on the fatty acid profile of the spleen, pancreas and kidneys of rats. In *Journal of Animal Feed Science*, vol. 16, 2007, p. 121-139.

MAHAN, D.C. – PARRETT N.A. 1996. Evaluating the efficacy of selenium-enriched yeast and sodium selenite on tissue selenium retention and serum glutathione peroxidase activity in grower and finisher swine. In *Journal Of Animal Science*, vol. *74*, 1996, p. 2967–2974.

MAHAN, D.C. – CLONE, T.R. – RICHERT, B. 1999. Effects of dietary levels of Se-enriched yeast and sodium selenite as Se source fed to growing-finishing pigs on performance, tissue glutathione peroxidase activity, carcass characteristics and loin quality. In Journal of *Animal Science*, vol. 77, 1999, p. 2172–2179.

MAHMOUD, K.Z. – EDENS, F.W. 2005. Influence of organic selenium on hsp70 response of heat-stressed and enteropathogenic *Escherichia coli*-challenged broiler chickens (*Gallus gallus*). In *Comparative Biochemistry And Physiology - Part C: Toxicology & Pharmacology*, vol. 141, 2005, p. 69–75.

MCDOWELL, L.R. – FROSETH, J.A. – PIPER, R.C. 1978. Influence of arsenic, sulphur, cadmium, tellurium, silver and selenium on the seleniumvitamin E deficiency in the pig. In *Nutrition Reports International*, vol. 17, 1978, p. 19–33.

NAYLOR, A.J. – CHOCT, M. – JACQUES, K.A. 2000. Effects of selenium source and level on performance and meat quality in male broilers. In *Poultry Science*, vol. 79, 2000, p. 117-124.

PAVLATA, L. – ILLEK, J. – PECHOVA, A. – MATEJICEK, M .2002. Selenium status of cattle in the Czech Republic. In *Acta Veterinaria Brno*, vol. 71, 2002, p. 3–8.

PAVLATA, L. – PODHORSKY, A. – PECHOVA, A. – CHOMAT, P. 2005. Differences in the occurrence of selenium, copper and zinc deficiencies in dairy cows, calves, heifers and bulls. In *Veterinary Medicine Czech*, vol. 50, 2005, p. 390–400.

PAYNE, R.L. – SOUTHERN, L.L. 2005. Comparison of inorganic and organic selenium sources for broilers. In *Poultry Science*, vol. 84, 2005, p. 898–902.

PECHOVA, A. – PAVLATA, L. – ILLEK, J. 2005. Blood and tissue selenium determination by hydride generation atomic absorption spectrophotometry. In *Acta Veterinaria Brno*, vol. 74, 2005, p. 483–490.

ROTRUCK, J.T. – POPE, A.L. – GANTHER, H.E. – SWANSON, A.B. – HAFEMAN, D.G. – HOEKSTRA, W.G. 1973. Selenium: biochemical role as a component of glutathione peroxidase. In *Science*, vol. 179, 1973, p. 585–590.

SINGH, H. – SODHI, S. – KAUR, R. 2006. Effects of dietary supplements of selenium, vitamin E or combinations of the two on antibody responses of broilers. In *British Poultry Science*, vol. 47, 2006, p. 714–719.

TAPIERO, H. – TOWNSEND, D.M. – TEW K.D. 2003. The antioxidant role of selenium and selenocompounds. In *Biomedicine and Pharmacotherapy*, vol. 57, 2003, p. 134-144.

UNDERWOOD, E.J. 1981. The mineral nutrition of livestock, 2nd ed. Commonwealth Agricultural Bureaux, London: 1981, 565 p.

UTTERBACK, P.L. – PARSONS, C.M. – YOON, I. – BUTLER, J. 2005. Effect of supplementing selenium yeast in diets of latiny hens on egg selenium content. In *Poultry Science*, vol. 84, 2005, p. 1900–1901.

VIDAL, D. – BAY, S.M. – SCHLENK, D. 2005. Effects of dietary selenomethionine on larval rainbowtrout (*Oncorhynchus mykiss*). In Archives *of Environmental Contamination and Toxicology*, vol. 49, 2005, p. 71–75.

WANG, Y. – XU, B. 2008. Effect of different selenium source (sodium seleniteand selenium yeast) on broiler chickens. In *Animal Feed Science and Technology*, vol. 144, 2008, p. 306–314.

WANG, Y. – HAN, J. – LI, W. – XU, Z. 2007. Effect of different selenium source on growth performances, glutathione peroxidase activities, muscle composition and selenium

concentration of allogynogenetic crucian carp (*Carassius auratus gibelio*). In *Animal Feed Science and Technology*, vol. 134, 2007, p. 243–251.

WATANABE, T. – KIRON, V. – SATOH, S. 1997. Trace minerals in fish nutrition. *Aquaculture*, vol. 151, 1997, p. 185–207.

WOLFRAM, S. – BERGER, B. – GRENACHER, B. – SCHARRER E. 1989. Transport of seleno amino acids and their sulphur analogues across the intestinal brush border membrane. In *Journal of Nutrition*, vol. *119*, 1989, p. 706–712.

ZHAN, X.A. – WANG, M. – ZHAO, R.Q. – LI, W.F. – XU, Z.R. 2007. Effects of different selenium source on selenium distribution, loin quality and antioxidant status in finishing pigs. In *Animal Feed Science and Technology*, vol. 132, 2007, p. 202–211.

ZUBERBUEHLER, C.A. – MESSIKOMMER, R.E. –WENK, C. 2002. Choice feeding of selenium-deficient laying hens affects diet selection, selenium intake and body weight. *Journal of Nutrition*, vol. 132, 2002, p. 3411–3417.