ACTA VET. BRNO 2009, 78: 373-377; doi:10.2754/avb200978030373

Effect of Organic Selenium from Se-enriched Alga (*Chlorella* spp.) on Selenium Transfer from Sows to Their Progeny

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Received November 4, 2008
Accepted March 9, 2009

Abstract

The study was conducted to determine the efficacy of organic Se from Se-enriched alga *Chlorella* spp. in placental transfer to piglets. In group A (n = 8) the sows were fed during the gestation a diet supplemented with inorganic Se (sodium selenite, 0.3 mg/kg). In group B (n = 8) the diet of the sows was supplemented with organic Se from Se-enriched alga (0.3 mg/kg). The Se concentrations in the whole blood ($P < 0.05$) and in colostrums ($P < 0.05$) were higher in the group of sows provided with the organic Se form. No differences in GSH-Px activities were found between the two groups. The concentrations of Se in piglet tissues were also higher when the organic form was provided. It is concluded that the use of the organic Se from Se-enriched alga *Chlorella* spp. in sows resulted in greater transfer of Se to their progeny.

Glutathione peroxidase, piglet, inorganic selenium, colostrum

Selenium is an essential element. It is involved in the active centre of the glutathione peroxidase enzyme where it acts as an antioxidant by reducing hydrogen peroxide (Tappel 1974). Selenium is principally available to piglets from both placental and mammary transfer (Mahan et al. 1977). Inorganic and organic forms of Se have been used in swine production. It has been demonstrated that organic Se has higher bioavailability and greater accumulation in tissues than the inorganic form (Mahan and Parrett 1996; Taylor et al. 2005). Studies in growing-finishing pigs have demonstrated that organic Se is much more effective in accumulating Se in tissues than the inorganic form (Mateo et al. 2007). According to Mahan and Kim (1996) and Mahan (2000), the selenium content in tissues of newborn piglets and in colostrum and milk is higher when organic vs. inorganic Se is fed to sows. It should be noted that most of the studies were based on organic Se from Se-enriched yeast.

There is still limited information regarding the effect of different organic forms of Se on Se transfer from sows to their progeny. In our study organic Se from Se-enriched freshwater alga *Chlorella* spp. was used. The goal of our trial was to evaluate the effects of organic Se from Se-enriched alga (*Chlorella* spp.) on selenium transfer from sows to their progeny.

Materials and Methods

Experimental conditions

A total of 16 pregnant sows (Landrace × Czech Large White) were used in our study. The sows were divided into two groups. The sows of both groups were fed feed mixtures composed of a basal diet and a mineral supplement. The mineral supplement differed in the form of Se source. The basal diet contained 0.08 mg/kg of endogenous selenium. Composition of the basal diet and the mineral supplement is presented in Table 1.

In group A (8 sows) the sows received a feed mixture supplemented with inorganic Se (0.3 mg/kg of Se as sodium selenite).

Group B's (8 sows) feed mixture was supplemented with organic selenium in the form of Se-from Se-enriched alga *Chlorella* spp. (0.3 mg/kg of Se). Chlorella was manufactured in the Institute of Microbiology of the Czech Academy of Sciences, Třeboň. The cultivation proceeded heterotophically in fermentors on nutrient medium containing glucose and selenite salts.

The product, spray-dried biomass of disintegrated algal cells was characterized by a high level of Se determined by inductively coupled plasma mass spectrometry (Doucha et al. 2006).

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Table 1. Percentage composition of the basal diet

Ingredient	Percentage
Barley	53
Cornflour	9
Wheat	21
Wheat pollard	5
Soybean pollard	6.5
Soybean oil	0.5
Trace mineral and vitamin premix[a]	5

[a]Supplied per kilogram of diet: 0.30 mg of Se, 3.02 g of Ca, 0.11 g of K, 3.33 g of Cl, 0.08 g of Mg, 36.64 mg of Mn, 83.72 mg of Fe, 12.07 mg of Cu, 0.54 mg of Co, 97.37 mg of Zn, 1.11 mg of J, 12149.99 I.U. of vit. A, 1800.00 I.U. of vit D3, 49.72 mg of vit. E, 1.89 mg of vit. K3, 4.07 mg of vit. B1, 6.87 mg of vit. B2, 5.63 mg of vit. B6, 45.02 µg of vit. B12, 18.47 mg of niacin, 20.84 mg of pantotenic acid, 0.19 mg of biotin, 0.37 mg of folic acid, 54.57 mg of cholin

The diets were fed to sows from the beginning of the experiment (day 1 of gestation) till 3 days after parturition. Diets were provided at 2.5 kg daily during the gestation period.

At the age of 3 days the piglets were injected with 200 mg of Fe i.m. (iron dextran, Ferridextran 10%, Spofa).

Sampling and analysis

The colostrum was collected by hand expression from several glands. The collected colostrum was frozen and stored for later determination of Se content.

Two neonatal piglets from each litter were randomly selected, killed using T61 preparation prior to colostrum consumption and tissue samples were collected (liver, heart, gluteal muscles).

The sows were bled from vena jugularis at the beginning of the experiment (day 1 of gestation) and 3 days after parturition. The piglets were bled at the age of 3 days from anterior vena cava.

Concentrations of Se in colostrum, whole blood and piglet tissues (heart, liver, gluteal muscles) were measured using the following steps: samples of whole heparinised blood were mineralised in a closed system using a microwave (MLS-1200, Milestone, Italy) digestion technique with HNO_3 and H_2O_2. Samples were evaporated and the mineral residue was dissolved in water to which 20% HCl was added. Selenium was then determined with Solar 939 AA Spectrometer (Unicam, UK) using a hydride AAS technique.

Whole blood GSH-Px activities were determined according to the method of Paglia and Valentin (1967) using the test kit RANSEL (Randox Laboratories, Ltd., United Kingdom).

Statistical analyses

The results were evaluated statistically by Student's *t*-test.

The experiment was approved by the Ethics Commitee of the University of Veterinary and Pharmaceutical Sciences, Brno, Czech Republic.

Results

Table 2. Reproductive performance

Item	Group A Mean ± SD	Group B Mean ± SD
Total number of piglets born	11.85 ± 2.09	11.37 ± 1.65
Number of live piglets born	10.42 ± 2.12	10.62 ± 1.72
Number of stillborn piglets	1.42 ± 0.72	0.75 ± 0.82
Piglets birth weight (kg)	1.45 ± 0.36	1.47 ± 0.32

The results are presented as mean and standard deviation of each index in Table 2 and Figs 1-5. Values with * ($P < 0.05$) and ** ($P < 0.01$) express significant differences between groups A and B.

Reproductive performance

The reproductive data are summarized in Table 3. The number of piglets born (total, live, stillborn) was not affected by the form of Se supplement (organic vs. inorganic). The individual piglet birth weights were comparable between the experimental groups.

Selenium status of the sows

The indices presenting selenium status of the sows are presented in Figs 1-2. No differences in indices of selenium status were found between the two groups at the beginning of the experiment (day 1 of gestation).The Se concentrations in the whole blood were higher in the group of sows fed Se from Se-enriched alga than in inorganic group 3 days after parturition ($P < 0.01$). GSH-Px activities of the whole blood were comparable for both organic and inorganic Se at each measurement period. The use of organic Se from Se-enriched alga resulted in significantly higher Se concentration in colostrum ($P < 0.05$).

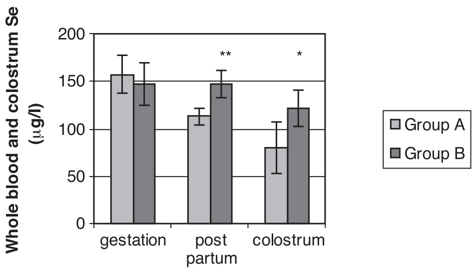

Fig. 1. Whole blood and colostrum Se of sows

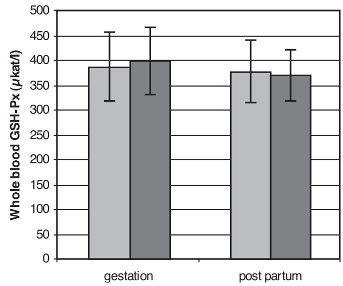

Fig. 2. Whole blood GSH-Px of sows

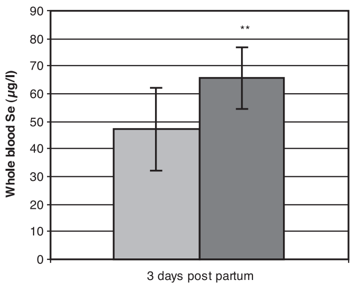

Fig. 3. Whole blood Se of piglets

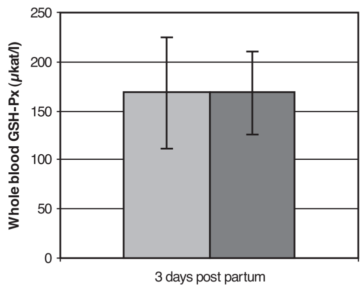

Fig. 4. Whole blood GSH-Px of piglets

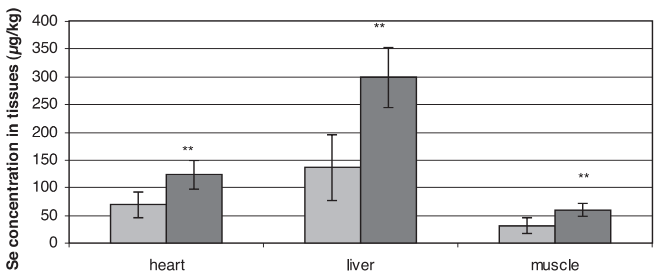

Fig. 5. Se concentration in piglet tissues

Selenium status of the piglets

The indices presenting selenium status of the piglets are presented in Figs 3-5. The concentration of Se in neonatal tissues (liver, heart, gluteal muscles) was significantly higher when Se from Se-enriched alga was fed ($P < 0.01$). The Se concentration in the whole blood at the age of 3 days was higher when organic Se was provided to the sows ($P < 0.01$). GSH-Px activities of the whole blood were comparable for both organic and inorganic Se.

Discussion

To our knowledge there are no literature data so far concerning the use of Se from Se-enriched alga *Chlorella* spp. in sows. The freshwater alga *Chlorella* spp. is well-known for its positive effects on health (Konishi et al. 1990). Therefore, it can be considered as a convenient carrier for organic-bound selenium. According to Alcantara and Lopes

(1998) selenomethionine represents a major part of seleno-amino acid analogues in the alga cell.

Our results indicate that bioavailability of Se from Se-enriched alga was high and compared with inorganic form it resulted in significantly greater concentrations of Se in the colostrum and piglet tissues. Piglets from the sows fed Se from Se-enriched alga had also higher concentration of Se in the whole blood.

We found that Se concentration in the whole blood of sows fed Se from Se-enriched alga were superior to the inorganic form. This corresponds with the findings of Mahan and Peters (2004) who reported higher Se concentrations in group of sows fed Se from Se-enriched yeast.

GSH-Px activities of the whole blood in both sows and piglets did not differ between groups. This is in agreement with Mahan and Peters (2004) and Yoon and McMillan (2006) who found that both Se from Se-enriched yeast and inorganic form are adequate for the synthesis of GSH-Px.

We suggest that the good effectiveness of Se from Se-enriched alga can be explained by the high bioavailability of selenomethionine. Although inorganic selenite can be utilized for selenoprotein biosynthesis, only selenomethionine can be incorporated non-specifically into body proteins in place of methionine (McConnell and Hoffman 1972). Selenomethionine can be incorporated directly into body proteins in place of methionine, because tRNA Met does not discriminate between Met and Se-Met (Schrauzer 2000). The high bioavailability of selenomethionine was demonstrated in experiments with Se-enriched yeast where selenomethionine represents the major part of seleno-amino-acid analogs (McSheehy et al. 2005).

Mahan and Parrett (1996) reported that selenium retention in the organism is higher when Se-enriched yeast rather than sodium selenite is used as a dietary Se source. At about 64% of consumed Se is excreted in case of sodium selenite, 47% of Se is excreted when Se-enriched yeast is fed. The main excretion route for inorganic Se is the urinary route, whereas faeces are the major excretion route for organic Se (Hitchcock et al. 1978; Mahan and Parrett 1996). Mahan and Parrett (1996) demonstrated that Se from Se-enriched yeast does not have a higher absorption from the gastrointestinal tract compared to sodium selenite. Therefore the high bioavailability of Se from Se-enriched yeast is not caused by higher absorption.

The experiments with Se from Se-enriched yeast also showed that Se content in newborn piglet tissues and sow colostrum was higher when organic vs. inorganic Se was fed (Mahan and Kim 1996).

It is concluded that the use of the organic Se from Se-enriched alga *Chlorella* spp. in sows resulted in greater transfer of Se to piglets and colostrum compared to inorganic Se.

Účinek organického selenu ze selenem obohacené řasy (*Chlorella* spp.) na transplacentární transfer selenu na selata

Cílem studie bylo zjistit účinnost organického selenu ze selenem obohacené řasy *Chlorella* spp. v placentárním přenosu na selata. Ve skupině A (n = 8) byly prasnice krmeny po dobu březosti krmivem s přídavkem anorganické formy selenu (seleničitan sodný, 0,3 mg/kg). Ve skupině B (n = 8) byl použit jako přídavek do krmiva organický selen ze selenem obohacené řasy (0,3 mg/kg). Koncentrace selenu v plné krvi a v kolostru byly vyšší u skupiny prasnic, kterým byl podáván organický selen. Mezi skupinami nebyl zjištěn žádný rozdíl v aktivitě GSH-Px v plné krvi. Koncentrace selenu ve tkáních selat byly vyšší v případě použití organické formy selenu. Závěrem lze konstatovat, že použití organického selenu ze selenem obohacené řasy *Chlorella* spp. způsobilo větší placentární transport selenu na selata.

Acknowledgements

The study was supported by the project MSM 6215712403.

References

Alcantara S, Lopes CC 1998: Controlled introduction of selenium into Chlorella cells. Ind J Exp Biol **36**: 1286-1288

Doucha J, Livanský K, Kotrbáček V, Machát J 2006: Production of Chlorella biomass enriched by selenium and its use as a feed supplement. 6th Asia-Pacific Conference on Algal Biotechnology, Manila, Filippines. pp. 143-144

Hitchcock JP, Miller ER, Keahey KK, Ullrey DE 1978: Effect of arsanilic acid and vitamin E upon utilization of natural or supplemental selenium by swine. J Anim Sci **46**: 425

Konishi F, Tanaka K, Kumamoto S, Hasegawa T, Okuda M, Yano I, Yoshikai Y, Nomoto K 1990: Enhanced resistance against *Escherichia coli* infection by subcutaneous administration of hot-water extract of *Chlorella vulgaris* in cyclophosphamide-treated mice. Cancer Immunol Immunother **32**: 1-7

Mahan DC, Kim YY 1996: Effect of inorganic or organic selenium at two dietary levels on reproductive performance and tissue selenium concentrations in first-parity gilts and their progeny. J Anim Sci **74**: 2711-2718

Mahan DC, Moxon AL, Hubbard M 1977: Efficacy of inorganic selenium supplementation to sow diets on resulting carry-over to their progeny. J Anim Sci **45**: 738-746

Mahan DC, Parrett NA 1996: Evaluating the efficacy of Se enriched yeast and inorganic selenite on tissue retention and serum glutathione peroxidase activity in grower finisher swine. J Anim Sci **74**: 2967-2974

Mahan DC, Peters JC 2004: Long-term effects dietary organic and inorganic selenium sources and levels on reproducing sows and their progeny. J Anim Sci **82**: 1343-1358

Mahan DC 2000: Effect of organic and inorganic selenium sources and levels on sow colostrum and milk selenium content. J Anim Sci **78**: 100-105

Mateo RD, Spallholz JE, Doder R, Yoon I, Kim SW 2007: Efficacy of dietary selenium source on growth and carcass characteristics of growing-finishing pigs fed diets containing high endogenous selenium. J Anim Sci **85**: 1177-1183

McConnell KP, Hoffman JL 1972: Methionine-selenomethionine parallels in rat liver polypeptide chain synthesis. Fed Proc **31**: 691

McSheehy S, Kelly J, Tessier L, Mester Z 2005: Identification of selenomethionine in selenized yeast using two-dimensional liquid chromatography-mass spectrometry based proteomic analysis. Analyst **130**: 35-37

Paglia DE, Valentin WN 1967: Studies on quantitative and qualitative characterization of erythrocyte glutathione peroxidase. J Lab Clin Med **70**: 158-169

Schrauzer GN 2000: Selenomethionine: a review of its nutritional significance, metabolism and toxicity. J Nutr **130**: 1653-1656

Tappel AL 1974: Selenium-glutathione peroxidase and vitamin E. Amer J Clin Nutr **27**: 960-965

Taylor JB, Finley JW, Caton JS 2005: Effect of chemical form of supranutritional selenium on selenium load and selenoprotein activities in virgin, pregnant, and lactating rats. J Anim Sci, **83**: 422-429

Yoon I, McMillan E 2006: Comparative effects of organic and inorganic selenium on selenium transfer from sows to nursing pigs. J Anim Sci **84**: 1729-1733