

## THE PORK MEAT ENRICHED WITH ORGANIC SELENIUM AND ITS EFFECT ON SELENIUM CONCENTRATION AND TOTAL ANTIOXIDANT STATUS IN HEALTHY VOLUNTEERS

**B. Bobček<sup>1</sup>, J. Mrázová<sup>2</sup>, J. Mlynek<sup>1</sup>, O. Bučko<sup>1</sup>, I. Imrich<sup>3</sup>**

<sup>1</sup>Department of Animal Husbandry, Faculty of Agrobiolgy and Food Resources, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2 , 949 76 Nitra, Slovakia

<sup>2</sup>Department of Human Nutrition, Faculty of Agrobiolgy and Food Resources, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2 , 949 76 Nitra, Slovakia

<sup>3</sup>Department of Veterinary Disciplines, Faculty of Agrobiolgy and Food Resources, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2 , 949 76 Nitra, Slovakia

Corresponding author: bobcek.branislav@uniag.sk

Original scientific paper

**Abstract:** It is known that organic selenium (Sel Plex) supplemented to pig feed mixture is significant for effective transport of essential element selenium to the food chain. It enables to create important body deposits of selenium in skeletal muscles and it also increases selenium transfer in natural metabolic form of selenomethionine into functional food. The intake of feed mixture with increased organic selenium at the dose of 0.3 mg kg<sup>-1</sup> probably increases selenium concentration in MSM (musculus semimembranosus) - experimental selenium group 1.293 mg kg<sup>-1</sup> and control group 0.513 mg kg<sup>-1</sup> and in MLT (musculus longissimus thoracis) - experimental selenium group 1.364 mg kg<sup>-1</sup> and control group 0.506 mg kg<sup>-1</sup>. The aim of this study was to evaluate the selenium and total antioxidant status (TAS) in a selected group of healthy people. Twenty-five volunteers consumed pork meat enriched with organic selenium three times a week during one month (average age in 9 men was 51.2 years, in 16 women 39.06 years, respectively). Daily selenium intake of 110 µg was calculated by Alimenta software, version 4.3 on the basis of nutrition statement. Recommended daily selenium intake of 50 – 200 µg was stated by the World Health Organization (WHO). During the research, the volunteers consumed pork enriched with 35 µg of selenium. At the beginning the mean selenium concentration in blood serum was at 75.41 ± 14.18 µg l<sup>-1</sup> in men, 75.21 ± 15.20 µg l<sup>-1</sup> in women. After two weeks of consumption pork enriched with selenium, the average selenium concentration in blood serum in men and women increased to 86.69 ± 11.72 µg l<sup>-1</sup> and 87.93 ± 16.22 µg l<sup>-1</sup> respectively. At the end of the study the average selenium concentration decreased in men and women to 85.75 ± 2.72 µg l<sup>-1</sup> to 84.07 ± 15.62 µg l<sup>-1</sup> respectively. In the selected group of healthy people the total antioxidant

status increased from 1,68 mmol.l<sup>-1</sup> to 1,86 mmol.l<sup>-1</sup> after two weeks of consumption of pork enriched with selenium. However, at the end of the research the decrease in TAS was recorded. Improvement in selenium status has positive impact on human health, and thus our results could contribute to the new trends in the production of functional food.

**Key words:** supplementation of pork, organic selenium, selenium status, total antioxidant status

## Introduction

At present much attention is devoted to the impact of nutrition on health with respect to the antioxidant intake, especially that of vitamins and essential trace elements such as zinc, copper and selenium, which are constituents of antioxidant enzymes. One of the vital nutritional antioxidant element is the trace element selenium (Se). It was found out that its nutritional deficit in people caused cardiomyopathia, degenerative osteoarthropathia and thyroid function disorders. Selenium belongs to the group of antioxidants since it is a co-factor of antioxidant enzyme glutathionperoxidase (GPx) which catalyzes the reduction of organic hydroperoxide and oxygen peroxide protecting cells against damaging. The status of essential microelement selenium is primarily determined by its food intake. The low selenium levels in food chain elements correspond to its low levels in people. Selenium levels in plasm/serum in European countries ranges 63-110 µg l<sup>-1</sup> whereas the selenium status in Slovak population is at the bottom of this range (*Kadrabová and Maďarič, 1997*).

Optimum activity of this antioxidant enzyme is achieved in serum/plasm at Se levels between 90-100 µg/l. It was found out that certain simple nucleotide polymorphisms (SNPs) in seleno-proteine genes can affect the risk of cancer and hence increase the demand on selenium intake by organism (*Rayman, 2005*). This trace element is included in the overall antioxidant capacity of the organism.

The paper aims at the evaluation of pig feed mixtures supplemented with organic selenium in form of yeast preparations. The main attention was focused on the significant selenium deposits in pig carcass. Moreover, selenium status and overall antioxidant capacity was evaluated in a selected group of people who consumed pork enriched with organic selenium.

## Materials and Methods

Carcass hybrid pigs were tested in the experimental centre of farm animals at the Department of Special Zootechnics of the Slovak Agricultural University in Nitra. The individual groups of tested pigs were as follows: control group – 16 pigs

and experimental group – 17 pigs. The experimental group was fed on standard mixtures OŠ-3 and OŠ-6 supplemented with 0.3 mg kg<sup>-1</sup> organic selenium (SelPlex). After disjuncting the carcass parameters were analyzed and MLT samples of 700 g weight were also taken for analysis. Some samples were analysed in the Institute of Physiology of Farm Animals (IPFA) of the Slovak Academy of Sciences (SAS) Košice where selenium ratio in meat was estimated by spectrophotometric method.

After the meat having been analysed, the heat processed pork supplemented with organic selenium was served to volunteers as dinner menu (all volunteers were healthy people without any pathological changes concerning the basic hematological and biochemical parameters). Twenty-five persons participating in the experiment were represented by 9 men at the average age 51.2 years and 16 women at the average age 39.06 years. All the volunteers consumed meat enriched with selenium three times a week during one month (in total 450 g/week). After the volunteers having filled out the nutritional protocol, the daily intake of selenium in men and women was evaluated by means of Alimenta software, version 4.3. The experimental group of people was taken blood samples in the following intervals: at the beginning, after two weeks and after the finishing of consumption. The concentration of selenium in blood serum was estimated by means of spectrophotometric method in IPFA SAS in Košice. The overall antioxidant status of heparined plasm was estimated by means of a diagnostic device (TAS<sup>®</sup>, fy Randox) in biochemical analyser LISA 200 (BICODE-HYCEL) at the University of Agriculture in Nitra. The achieved results were statistically processed and evaluated by Anova programme, Tukey test.

## Results and Discussion

Selenium concentration in meat dry matter was found higher in the experimental group SE where in MSM (musculus semimembranosus) represented 1.293 mg kg<sup>-1</sup> and in MLT (musculus longissimus thoracis) 1.364 mg kg<sup>-1</sup> compared with the control group where the values were lower, namely in MSM 0.513 mg kg<sup>-1</sup> and MLT 0.506 mg kg<sup>-1</sup> respectively. These differences were also confirmed by Anova and Tukey test at significance  $P < 0.001$  in the experimental group with organic selenium (Table 1).

Higher manifestation of selenium in meat with higher selenium supplement into feed mixture was also confirmed by Mahan *et al.* (1999), Lahučký *et al.* (2001) and Vernerová *et al.* (2008) who claimed that organic selenium supplement into feed mixture during pig fattening increased selenium content in pork meat.

**Table 1. Characteristics of selenium concentration in pork dry matter MSM and MLT**

Parameter	Control group			Experimental group			
	$\bar{x}$	s	min-max	$\bar{x}$	s	min-max	Tukey test
Selenium in meat dry matter MSM (mg kg <sup>-1</sup> )	0.513	0.041	0.422–0.545	1.293	0.158	1.113–1.351	+++
Selenium in meat dry matter MLT (mg kg <sup>-1</sup> )	0.506	0.036	0.443–0.562	1.364	0.206	1.134–1.463	+++

In the second stage of our research the heat processed pork meat enriched with selenium was integrated in the menu of a selected group of people. Before consumption the concentration of selenium in blood serum on average  $75.41 \pm 14.18 \mu\text{g l}^{-1}$  in men and  $75.21 \pm 15.20 \mu\text{g l}^{-1}$  in women was set up. After the consumption of the average selenium for two weeks, the concentration in blood serum in men and women increased to  $86.69 \pm 11.72 \mu\text{g l}^{-1}$  and  $87.93 \pm 16.22 \mu\text{g l}^{-1}$  respectively. At the end of the study the mean selenium concentration decreased in men and women to  $85.75 \pm 2.72 \mu\text{g l}^{-1}$  and  $84.07 \pm 15.62 \mu\text{g l}^{-1}$  respectively (Table 2; Graph 1). In the tested group of people significantly increased concentration of selenium at  $P < 0,01$  (after the second blood taking) was found in the blood serum after the consumption of pork enriched with selenium for two weeks. The difference between the initial and after consumption blood samples was also significant at  $P < 0,05$ . Clinical and experimental studies confirmed the relation between selenium and oncological or cardiovascular diseases. Critical Se level in blood serum was reported at  $45 \mu\text{g l}^{-1}$ . Our research has not recorded Se values in serum lower than the reported critical level. The concentration of selenium in plasm lower than  $60 \mu\text{g l}^{-1}$  was reported by *Hać (2001)*. In his study *Hać* reported the concentration of selenium  $60 \mu\text{g l}^{-1}$  in 22 % examined individuals and the level of selenium in blood serum lower than  $60 \mu\text{g l}^{-1}$  in 12 % examined individuals.

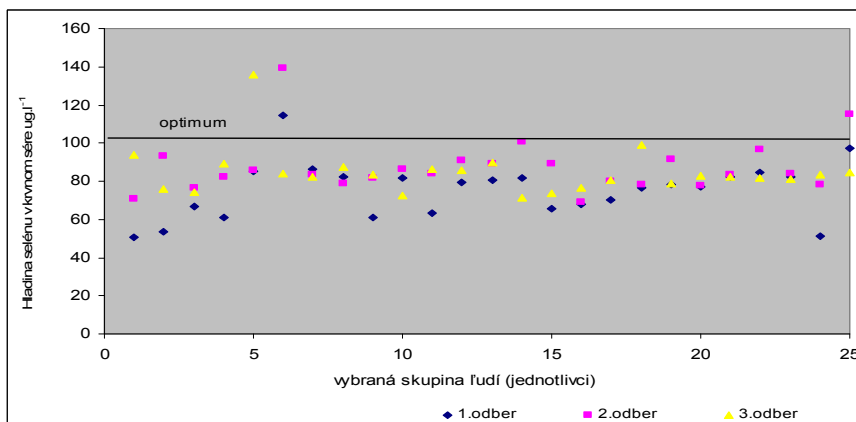
*Kadrová and Madarič (1997)* reported the results of clinical studies which included 1056 tested people coming from various regions of Slovakia where the concentrations of selenium in plasm ranged within  $45.8\text{--}76,9 \mu\text{g l}^{-1}$ . Comparing the results it was found out that at the first blood sample the concentration of selenium ranged from  $50.42$  to  $114.65 \mu\text{g l}^{-1}$  whereas at the second blood sample the concentration increased ranging from  $69.05\text{--}139.5 \mu\text{g l}^{-1}$ . These results indicate that the higher concentration of selenium in blood serum is conditioned by the intake of this element in food.

According to the filled out nutritional protocol before the consumption of supplemented pork the average daily intake in men and women was  $110 \mu\text{g}$ . During the consumption of pork enriched with selenium there was an increase by

110  $\mu\text{g}$ . Recommended daily selenium intake stated by the World Health Organization (WHO) is 50-200  $\mu\text{g}$ .

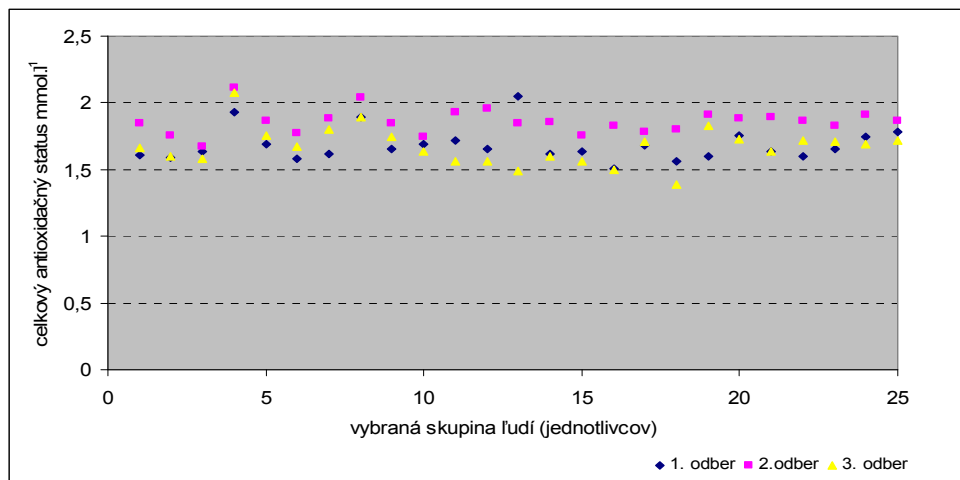
**Table 2. Evaluation of selenium concentration in human blood serum**

Sex	1. sample $\mu\text{g l}^{-1}$			2. sample $\mu\text{g l}^{-1}$			3. sample $\mu\text{g l}^{-1}$		
	$\bar{X}$	s	min-max	$\bar{X}$	s	min-max	$\bar{X}$	s	min-max
Men (n=9)	75,41	14,18	51,23 -97,15	86,69	11,72	77,70-115,34	85,75	2,72	82,28-89,62
Women (n=16)	75,21	15,20	50,42 -114,65	87,93	16,22	69,05-139,50	84,07	15,62	71,15-135,57
Total (n=25)	75,28	14,54	50,42 -114,65	87,48	14,51	69,05-139,50	84,68	12,48	71,15-135,57



**Graph 1. Selenium status of individuals in a selected group of people**

The estimation of antioxidant substances is based on the radical of a well-known concentration, which eliminates antioxidants of the assessed sample to the extent proportional to its content (*Béderová, 1997*). Total antioxidant status was estimated in heparinized plasma in the first blood sample averaged at  $1.68 \pm 0.12 \text{ mmol.l}^{-1}$ , in the second blood sample at  $1.86 \pm 0.09 \text{ mmol.l}^{-1}$  and in the last blood sample at  $1.67 \pm 0.14 \text{ mmol.l}^{-1}$ . The total antioxidant status increased proportionally to the selenium status during a two-week consumption of pork enriched with selenium. The experiment having been finished, the values in a selected group of people decreased to those measured at the beginning of the experiment.



**Graph 2. Total antioxidant status of individuals in a selected group of people**

In the evaluation of total antioxidant capacity a significant increase  $P < 0,001$  was found after the second sample. The experiment having been finished, the overall antioxidant status decreased again to the initial level. The difference between initial sample and after consumption sample was statistically insignificant.

## Conclusion

The research results provided the evidence that the addition of selenium supplement (SEL PLEX) into the feed mixtures of carcass hybrid pigs significantly contributed to the effective transport of essential microelement-selenium into the food chain. The achieved results pointed out to the main advantages of organic selenium application in carcass pigs, namely to the selenium retention in muscles and tissues of carcass body. Supplemented pork in human nutrition leads to increased selenium status and hence to protection of immune system cells against the damaging caused by oxidation stress.

## Acknowledgment

This work has been supported by grant of VEGA 1/0434/10 and 1/0372/09.

## Svinjsko meso obogaćeno organskim selenom i njegov uticaj na koncentraciju selena i status ukupnih oksidanata kod zdravih ljudi

*B. Bobček, J. Mrázová, J. Mlynek, O. Bučko, I. Imrich*

### Rezime

Poznato je da je organski selen (Sel Plex) dodat mešavini stočne hrane za svinje značajan za efektivan transport esencijalnog elementa selena u lancu ishrane. On omogućava stvaranje značajnih telesnih rezervi selena u skeletnim mišićima i takođe povećava prelazak selena iz prirodne metaboličke forme selen-metionina u funkcionalnu hranu. Unos mešavine stočne hrane sa većim sadržajem organskog selena od  $0,3 \text{ mg kg}^{-1}$  verovatno povećava koncentraciju selena u MSM (musculus semimembranosus) -eksperimentalna selen grupa  $1,293 \text{ mg kg}^{-1}$  i kontrolna grupa  $0,513 \text{ mg kg}^{-1}$  i u MLT (musculus longissimus thoracis) – eksperimentalna selen grupa  $1,364 \text{ mg kg}^{-1}$  i kontrolna grupa  $0,506 \text{ mg kg}^{-1}$ . Cilj ovog istraživanja bio je da se oceni selenijum i ukupni antioksidativni status (TAS) u izabranoj grupi zdravih ljudi. Dvadeset pet volontera konzumiralo je svinjsko meso obogaćeno organskim selenom tri puta nedeljno tokom mesec dana (prosečna starost 9 muškaraca bila je 51,2 godine a 16 žena 39,06 godina respektivno). Dnevni unos selena od  $110 \mu\text{g}$  obračunat je putem Alimenta software, verzija 4,3 na bazi nutritivnog izveštaja. Svetska zdravstvena organizacija (WHO) navela je preporučeni dnevni unos selena od  $50 - 200 \mu\text{g}$ . Tokom istraživanja, volonteri su konzumirali svinjetinu obogaćenu sa  $35 \mu\text{g}$  of selenium. Na početku je prosečna koncentracija selena u krvnom serumu bila  $75,41 \pm 14,18 \mu\text{g l}^{-1}$  kod muškaraca i  $75,21 \pm 15,20 \mu\text{g l}^{-1}$  kod žena. Nakon dve nedelje konzumacije svinjetine obogaćene selenom prosečna koncentracija selena u krvnom serumu muškaraca i žena povećana je na  $86,69 \pm 11,72 \mu\text{g l}^{-1}$  i  $87,93 \pm 16,22 \mu\text{g l}^{-1}$  respektivno. Na kraju istraživanja prosečna koncentracija selena smanjena je kod muškaraca i žena na  $85,75 \pm 2,72 \mu\text{g l}^{-1}$  to  $84,07 \pm 15,62 \mu\text{g l}^{-1}$  respektivno. U odabranoj grupi zdravih ljudi ukupni antioksidativni status povećao se od  $1,68 \text{ mmol.l}^{-1}$  na  $1,86 \text{ mmol.l}^{-1}$  nakon dve nedelje konzumacije svinjetine obogaćene selenom. Ipak, na kraju istraživanja utvrđeno je smanjenje TAS-a. Pобољшanje statusa selena ima pozitivan uticaj na ljudsko zdravlje zbog čega naši rezultati mogu doprineti novim trendovima u proizvodnji funkcionalne hrane.

## References

- KADRABOVÁ J., MAĎARIČ A. (1997): Úloha selénu vo výžive. *Výživa a zdravie*, 3, 42, 50-52.
- RAYMAN M.P. (2005): Selenium in cancer prevention: a review of the evidence and mechanism of action. *Proceedings of the Nutrition Society*, 64, 4, 527-542.
- LAHUČKÝ R. (2001): Záverečná správa za etapu č. 00-27-21-03-02. Možnosti zlepšenia technologickej, nutričnej a senzorickej kvality mäsa aplikáciou biologicky účinných látok. VÚŽV Nitra.
- MAHAN D.C., CLINET T.R., RICHERT B. (1999): Effects of dietary levels of selenium. *Journal of Animal Science*, 77, 2172-2179.
- VERNEROVÁ J., PIPEK P., SKLENÁŘOVÁ M. (2008): Kvalita vepřového masa obohateného selénem. *Věda a výskum. Maso*, 1, 86-89.
- BÉDEROVÁ A., KUDLÁČKOVÁ M., ŠIMONČIČ R., GRANČIČOVÁ E., MAGÁLOVÁ T., BRŤKOVÁ A. (1997): Celkový antioxidačný stav a antioxidačné vitamíny u vybranej skupiny detí a dospelých. *Hygiena*, 42, 2, 92-98.
- HAĆ E., KRECHNIAK J., SZYSZKO M. (2001): Selenium in plasma of inhabitants of the Gdansk region. *Polish Journal of Environmental Studies*, 10, 4, 275-278.

Received 30 June 2011; accepted for publication 15 August 2011