PORK MEAT WITH THE ADDITION OF ORGANIC SELENIUM AND ITS EFFECT ON SELENIUM STATUS AND ANTIOXIDANT CAPACITY OF PEOPLE

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Abstract

The aim of the research was to evaluate the effect of feeding of compound feed with the addition of organic selenium in slaughter pigs to assess the nutritional characteristics of pork and the impact of selenium-enriched pork consumption for selected health indicators of probands. As far as the results are concerned, we can conclude that there has been an improvement in the nutritional quality of pork in the total protein level of 22.32 ± 0.91 g.100g^{-1}, in the intramuscular fat content of 2.95 ± 1.35 g.100g^{-1} at significance $p<0.05$, as well as by the lower energy value of 484.46 ± 46.63 KJ.100g^{-1}. In the pork enriched with organic selenium the concentration was higher 1.045 ± 0.10 mg.kg^{-1} compared with the control group 0.701 ± 0.05 mg.kg^{-1} at significance $p<0.001$. By consumption of the enriched pork there has been an increase of the selenium concentration in blood serum of probands traced with an increase from 73.19 ± 15.68 µg.l^{-1} to 83.18 ± 15.13 µg.l^{-1} at significance level $p < 0.001$. In connection to increased selenium status of probands, we have detected an increase in antioxidant capacity from 1.38 ± 0.41 mmol l^{-1} to 1.52 ± 0.42 mmol.l^{-1}. Pork seems to be a suitable component of a balanced diet as it is possible to increase the selenium content in its muscles and subsequently increase the selenium status of its consumers.

Key Words: selenium, selenium in pork, selenium status, antioxidant capacity

Selenium is one of the most important mineral trace elements; its deficiency has influence on utility and health state of animals, and also to health state of humans. 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 glutationperoxidaze (GPx) which catalyzes the reduction of organic hydroperoxide and oxygen peroxide protecting cells against damaging.

The primary source of selenium level in human body is from food income and secondary is given due to physiological state of the organism (Sharmasarkar and Vance, 2002). 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^{-1} whereas the selenium status in Slovak population is at the bottom of this range (Kadrabová, Maďarič, 1997). Combs (2001) has compiled a table of reported concentrations of selenium in serum, plasma or whole blood from sixty-nine countries. Using the minimum value of 70 µg.l^{-1} in serum / plasma as a criterion of nutritional selenium adequacy as described earlier (Nève, 1996), he estimated nutritional selenium deficiency to be highly prevalent (> 50%) in twenty – one countries and moderately prevalent (10-50 %) in a further sixteen countries (Combs, 2001).

Thomson (2004) confirmed that the initial concentration of selenium in blood serum is 100 - 122 µg.l^{-1} for a protection against the effect of free radicals. The most natural way how to bring enough essential nutrients in usable form suitable for human body through the food chain is the bigger consumption of targeted produced functional foods. These are foodstuffs which are by the help of special animal diet enriched with substances, which content in the normal diet is deficient (Leng et al., 2004).

Material and Methods

Carcass hybrid pigs were tested in the Experimental centre of livestock at the Department of Special animal husbandry of the Slovak Agricultural University in Nitra. The individual groups of tested pigs were as follows: control group – 20 pigs and experimental group – 20 pigs. The experimental group was fed by standard mixtures OŠ-3 and OŠ-6 supplemented with 0.3 mg.kg^{-1} of organic selenium (Selenized Yeast). After slaughter the carcass parameters were analysed - nutritional quality of pork and MSM (*musculus semimembranosus*) samples were also taken for analysis selenium. The concentrations of selenium in dry mater of meat were measured fluorimetrically by Rodriquez et.al. (1994). In the second period of the experiment the influence of increased intake of selenium was evaluated in a selected group of people who were consuming supplemented pork from experimental groups of fattening pigs. Enriched pork was technologically processed by sterilization canning of 200 g of meat in 1% saline solution in a thermostatic pan at 100 ˚C. Thus prepared and processed pork was served to a

selected group of people. Sixteen persons participating in the experiment were represented by 8 men at the average age of 41.5 ± 11.9 years and 8 women at the average age of 41.4 ± 7.9 years. All the volunteers consumed meat enriched with selenium three times a week during one month. After filling out the nutritional protocol by volunteers, the daily intake of selenium in men and women was evaluated by means of Alimenta software, version 4.3. From 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 atomic absorption spectrometric method in Perkin-Elmer 4100 ZL. The overall antioxidant status of heparined plasm was estimated by means of a diagnostic device (TAS®, fy Randox) in biochemical analyser LISA 200 (BIOCODE-HYCEL). The achieved results were statistically processed and evaluated by Anova programme and t-test.

Results and Discussion

Based on the results of meat quality and nutritional parameters it is important to evaluate these indicators such as total protein content, intramuscular fat content, total water content and energy value, complexly. We can conclude that there has been an improvement in the nutritional quality of pork in the total protein level of 22.32 ± 0.91 g.100g^{-1}, in the intramuscular fat content of 2.95 ± 1.35 g.100g^{-1} at significance $p<0.05$, as well as by the lower energy value of 484.46 ± 46.63 KJ.100g^{-1} (Tab.1).

Selenium concentration in meat dry matter was found higher in the experimental group where in MSM (*Musculus semimembranosus*) represented 1.045 mg.kg^{-1} ± 0.10 compared with the control group where the values were lower 0.701 mg.kg^{-1} ± 0.05. These differences were also confirmed by t- test at significance $p< 0.001$ in the experimental group with organic selenium (Tab.2).

Table 1. Characteristics of nutritional quality of pork

Nutritional parameters	Control Group			Experimental group			differences CG:EG
	average	s	min-max	average	s	min-max	
Total water in g.100g^{-1}	73.36	1.26	70.10-75.30	73.73	1.25	70.40-76.50	0.37
Total protein level in g.100g^{-1}	22.10	0.67	20.70-23.30	22.32	0.91	20.80-23.60	0.22
Intramuscular fat in g.100g^{-1}	3.71	1.38	1.80-7.80	2.95	1.35	1.10-5.40	0.76 ^{c}
Energy value in KJ.100g^{-1}	503.27	52.51	405.34-647.32	484.46	46.63	394.30-592.07	18.80

c – significance $p<0,05$

Table 2. Characteristics of selenium concentration in pork dry matter in MSM

	Selenium concentration in pork MSM in mg.kg^{-1}			Differences CG:EG
	average	s	min-max	
Control group	0.701	0.05	0.620-0.780	0.344 ^{a}
Experimental group	1.045	0.10	0.920-1.180	

a - significance $p < 0,001$

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

In the second period of our research the heat processed pork meat enriched with selenium was integrated in the diet of probands. It was determined that the concentration of selenium in blood serum of probands, at an average 73.19 ± 15.68 μg.l^{-1} before the consumption of pork. We found out the slight increase in concentration of selenium after two weeks of consumption at average of 73.73 ± 15.21 μg.l^{-1}. After the experiment the concentration of selenium in blood serum of probands increased to 83.18 ± 15:13 μg.l^{-1} (fig.1). Statistically significant differences were confirmed after income supplemented pork in this group of people, where we found significant increase in selenium concentration in the blood serum level of significance $p < 0.001$.

The average levels of selenium concentration were determined in female probands and they are different compared to levels of males. Before the beginning of consumption it was determined that the concentration of selenium in the blood serum of women was at an average 73.44 ± 20.16 μg.l^{-1}, in males the concentration was 72.93 ± 10.97 μg.l^{-1}. After two weeks of consumption the concentration of selenium in men increased at an average 74.88 ± 13.19 μg.l^{-1} . We noticed the increase in concentration was at an average 75.02 ± 18:28 μg.l^{-1} in women after the end of experiment (Table 3).

Clinical and experimental studies confirmed that there is a relation between selenium and oncological or cardiovascular diseases. Critical selenium level in blood serum was reported at 45 μg.l^{-1}. Our research has not recorded Se values in serum lower than the reported critical level. The concentration of selenium in plasm was lower than 60 μg.l^{-1} which was reported by Hać (2001). In his study Hać reported the concentration of selenium was 60 μg.l^{-1} in 22 % examined individuals and the level of selenium in blood serum was lower than 60 μg.l^{-1} in 12 % examined individuals.

Střítecká et al. (2009) evaluated the selenium concentration in a group of 386 healthy persons; the concentration in blood serum was in the range of 52.9 - 73.43 μg.l^{-1}. This study confirmed the slight deficiency, as also showed the results of this research. Kadrabová, Maďarič (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 45.8-76.9 μg.l^{-1}. According to the filled nutritional protocol before the consumption of supplemented pork the average daily intake in men and women was 110 μg.

During the consumption of pork enriched with selenium there was an increase in recommended intake. Recommended daily selenium intake stated by the World Health Organization (WHO) is 50-200 μg.

The concentration of selenium in blood serum of individuals in selected group of people before the beginning of the experiment reached the optimum level in only one case 109.94 μg.l^{-1} and the initial concentration for protective effect of the body was not achieved in a whole group of people, even during the consumption of selenium-enriched pork (fig.2).

Figure 1. A comparison of selenium concentration of blood serum in probands

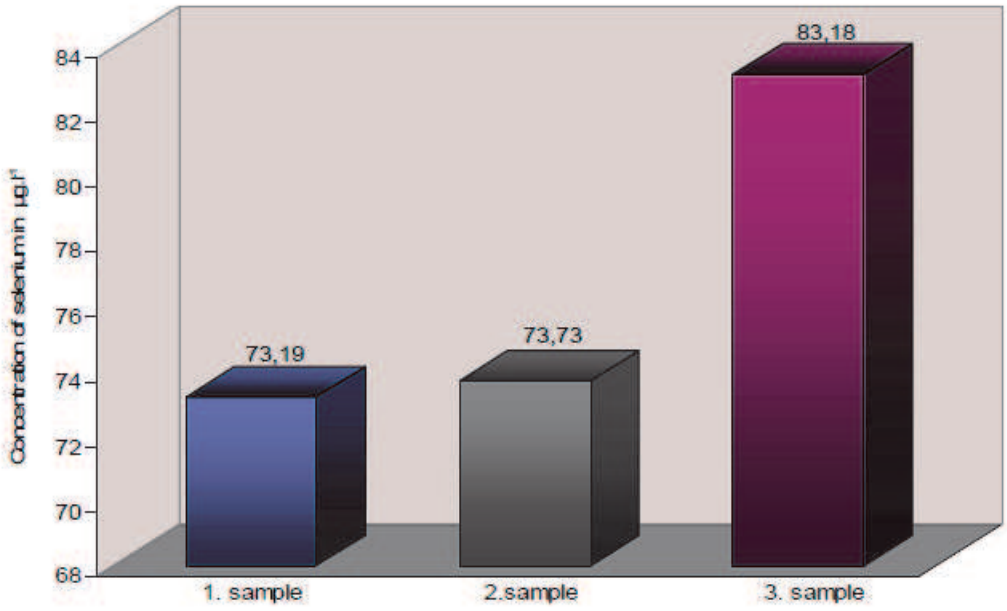
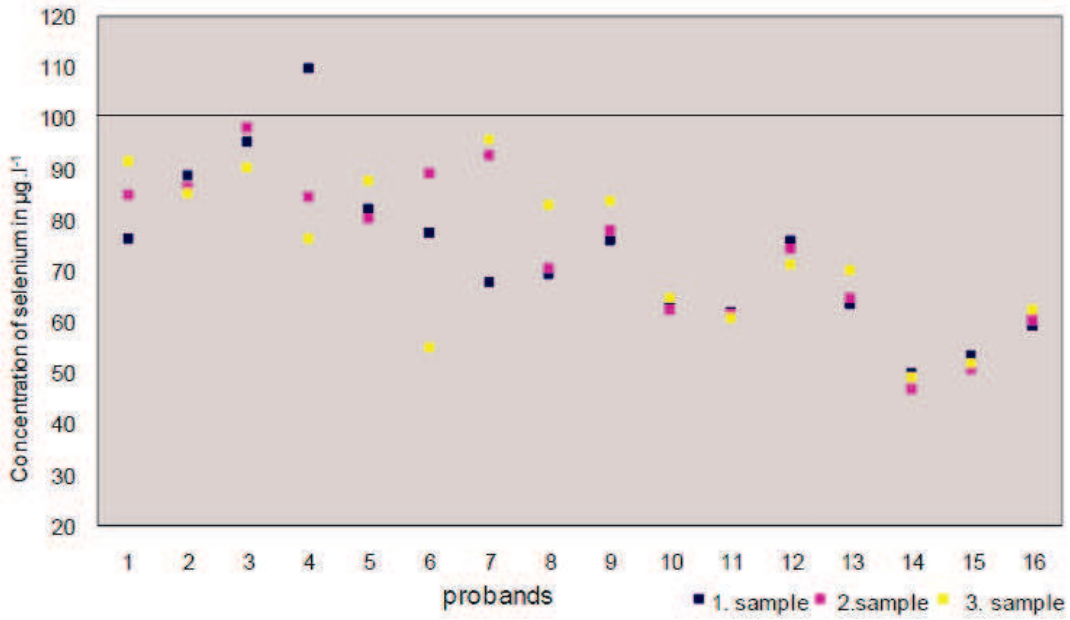


Table 3. Evaluation of selenium concentration in human blood serum

Sex	1. sample µg.l^{-1}			2. sample µg.l^{-1}			3. sample µg.l^{-1}		
	average	s	min-max	average	s	min-max	average	s	min-max
Men (n=8)	72.93	10.97	62.10-95.27	74.88	13.19	61.70-98.27	72.45	12.35	55.18-90.41
Women (n=8)	73.44	20.16	49.90-109.94	73.34	17.90	46.90-92.73	75.02	18.28	49.20-95.85
Total (n=16)	73.19	15.68	49.90-109.94	73.73	15.21	46.90-98.27	83.18	15.13	49.20-95.85

significance 1/3. sample $p < 0,001$

Figure 2. 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). The average level of the total antioxidant capacity determined in heparinized plasma during the whole experiment in monitored group of people reaches the levels in range of the reference interval 1.3-1.77 mmol.l^{-1}.Total antioxidant status was estimated in the first blood sample averaged at 1.38 ± 0.41 mmol.l^{-1}, in the second blood sample at 1.48 ± 0.42 mmol.l^{-1} and in the last blood sample at 1.52 ± 0.42 mmol.l^{-1}. The total antioxidant status increased proportionally to the selenium status during consumption of pork enriched with selenium.

We noticed a similar increase tendency of total antioxidant capacity in both men and women, whereby men reached higher levels in the upper limit of the reference interval (fig.3).

This implies that the man body accumulates antioxidants from animal products more quickly than woman body, what indicated the higher parameters of antioxidant capacity of blood plasma after end of consumption.

We noticed an increase in total antioxidant capacity in relation with increase in the selenium status of probands, where we did not confirm the linear dependence of serum levels of selenium and total antioxidant status through the correlation analysis (Table 4).

Figure 3. Comparison of average values of total antioxidant capacity in monitored group of men and women

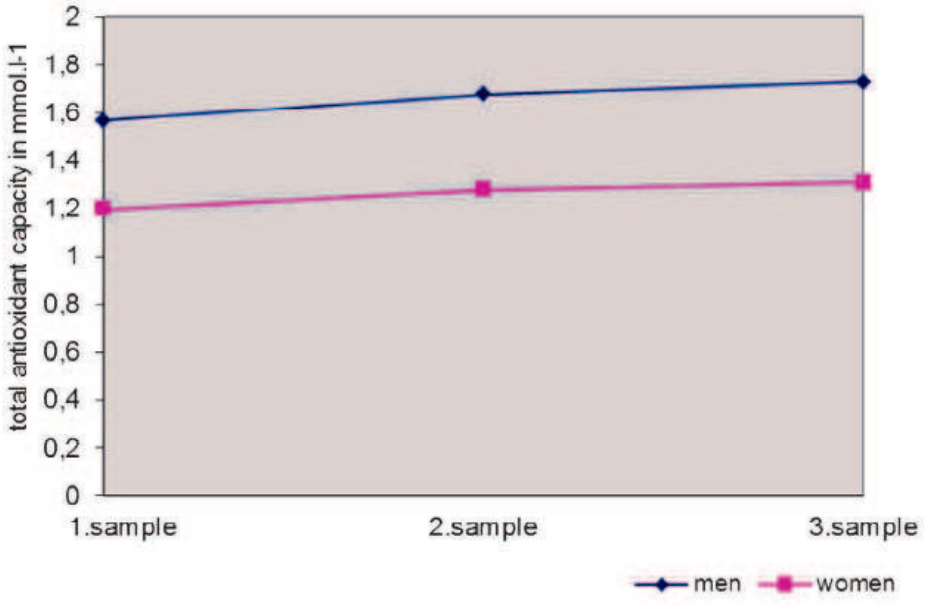


Table 4. Average levels of selenium concentration and total antioxidant capacity of probands during the consumption of pork meat enriched with selenium

	1.sample	2.sample	3.sample	min-max	differences 1./3. sample
Concentration of selenium in $\mu g.l^{-1}$	73.19 ± 15.68	73.73 ± 15.21	83.18 ± 15.13	46.90 - 109.94	9.99 [a]
Total antioxidant capacity in $mmol.l^{-1}$	1.38 ± 0.41	1.48 ± 0.42	1.52 ± 0.42	0.95 – 2.2	0.14 [a]

a – significance $p<0,001$

Conclusion

The research results provided that the evidence of the addition of selenium suplement (Selenized Yeast) 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 fattening pigs, are namely 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.

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This work has been supported by VEGA 1/0493/12 and KEGA 025SPU-4/2012.