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THE EFFECT OF ORGANIC SELENIUM ON SLAUGHTER VALUE, PHYSICAL-CHEMICAL AND TECHNOLOGICAL QUALITY CHARACTERISTIC OF PORK**

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Abstract: The work results clearly confirmed the suitability to use organic selenium in feed mixture for pigs with the purpose of improving production indicators, the slaughter value of animals as well as physical-chemical and technological quality characteristic of pork meat.

The results point out the main advantages of organic selenium application in pig rearing. These advantages are selenium retention in muscles and tissues of pigs, positive effect on meat quality with lower occurrence of pale, watery meat (PSE) syndrome, lower loses by dripping from slaughter halves and better nutritional value of meat which is significantly enriched by selenium.

According to the present knowledge, higher selenium content in groceries has the positive effect on people's health by lowering the occurrence of cardio-vascular diseases, brain and thyroid disorders and by improving of a body immune system.

The organic selenium form features enable effective transfer through the food chain and it is beginning to be utilised worldwide with modern concept of production, so called functional groceries, among which we can list also animal products enriched by organic selenium.

Key words: pigs, carcass value, physical-chemical value, pork

Introduction

Pork keeps prominent spot in the framework of its consumption in the world, representing almost 40% at an average daily consumption of approximately 41 kg/person/year (*Kvapilík, 2006*).

The total meat consumption, based on available statistical data in Slovakia, amounts to 65 kg/person/year, with pork sharing over 50 %, which suggests that this type of meat is significantly preferred by our population due to its quality characteristic enabling various ways of meal preparation as well as processing for meat products including pork specialities.

Within the last 15 years there has been a substantial change of production type as a result of purposeful breeding of pigs with preferred higher fleshy content. Lean musculature portion at the present final hybrids of pigs is within the range of 55-60 %, whereby many particular animals exceed this limit.

Fat content in slaughtered carcasses decreased, at which bacon thickness at the point of measurement is within 10-20 mm by utilizing classification method ZP (*Lagin et al. 2002*) and (*Lagin et al. 2005*).

Significant, even extreme musculature of slaughter carcasses of pigs is accompanied by lesser quality of meat, mainly from the viewpoint of dynamics of pH and EV changes in the process of meat ripening with potential occurrence of PSE and DFD meat and with subsequent lower ability to retain water, as well as lower ability to preserve it. *Šimeg et al.* (2002) outlines that pork with quality deviation PSE has lower technological utilization. Products of ham type from meat have no typical, pale colour, blank taste and mainly worse ability to retain water, which results in direct production loses along with quality deterioration of meat products.

Gregor and Scholtz (1993) declare that the selection in favour of high portion of lean meat in slaughtered pigs' carcasses causes lower content of intramuscular fat and the decrease in quality of meat and fat.

Along with lower content of fat in meat under 2 %, what is considered as a limiting factor from the viewpoint of favourable sensor meat profile, this tendency is manifested in lowered oxidation stability of fats (*Bahelka et al. 2006*).

Stability of fat component is very significant from the viewpoint of long term storage of pork meat, as well as for production of lasting products, salami and sausages where pork meat and bacon represent prevailing basic product with portion over 75 %.

For increase in oxidation stability of fats, the possibilities of utilizing some natural antioxidants are tested, for example rosemary extract added during mixing of meat products.

The possibilities to utilize food supplements show certain positive effect of E vitamin in combination with organic selenium. (*Ľahučký et al. 2001, Bobček et al. 2004*).

Utilizing specific feed complements for fattening of pigs can be accompanied with positive but also negative effect on quality characteristic of meat. The subject for examination of these effects is also the submitted contribution, aiming at utilizing supplemental organic selenium.

The goal of this experiment was to evaluate the effect of organic selenium supplement addition into pig feed components with aim at basic quality characteristic of pork meat and its technological utilization.

Materials and methods

In submitted work was elaborated the analysis of selected slaughter and qualitative meat indicators of slaughter pig hybrids combination BUL x YOPN from animal husbandry ZAD Dvory nad Žitavou. Production of typified feed components as well as premixes with addition of product Sel-Plex was supplied by company registered premix firm TEKRO ltd. Dvory nad Žitavou. Product Sel-Plex consists of dried beer brewery leaven with organically bound selenium. The producer and supplier is company Alltech Slovakia ltd. The feeding ad libidum with technological system of Weda company with unlimited drinking water intake by means of peg water bowl. Stabling is provided in group pens type BP 50 with lairage, excrement area and with plastic forage mangers for 10 animals in a group.

In our experiment we used organic selenium product additive in amount of 300 $mg.kg^{-1}$ of feed in experimental group, which was applied to standard feed component OŠ-3, OŠ-6 at hybrid slaughter pigs, combination BULxYOPN, during fattening period from 30 to 105 kg of live weight. After the completion of fattening, randomly selected individual animals of test control group in amount of 10 + 10 pieces were transferred approximately 40 km away to experimental slaughterhouse in SAU in Nitra. Then they were processed by standard procedure in accordance with the State Norm STN 46 6164 and STN 46 6150. After slaughter processing of pigs, approximately 45 minutes after slaughtering, the classification of slaughtered carcasses was performed by ZP method, based on the indicators of fat and musculature thickness. Also pH_1value of meat was determined by the needle insertion type of pH meter as well as meat electric conductivity EV_1. Slaughtered carcasses were placed in a refrigerator for 24 hours at + 4°C. After 24 hours in a refrigerator, the pH_{24} and EV_{24} values were determined in thigh musculature MSM (Musculus Semimembranosus). Within the subsequent disjointing of carcasses, a meat sample was taken weighing 700 g for analysis of technological and nutritional

quality of meat. Meat samples of experimental and control group were stored by hanging on a hook in laboratory refrigerator at the temperature from +2°C to +4 °C during 7 days, by which was limited the required time for ripening of pork meat before treatment for consumption or before further technological processing. During the process of meat ripening, in set time intervals were determined selected marks of chemical, physical and technological quality in pork meat samples. After the completion of 7 day ripening process, the test was performed on individual samples by thermal treatment (70°C for 10 min in the sample nucleus) with aim to ascertain loses as well as meat texture and to determine the shear strength on Varner – Bratzler device.

The evaluation of nutritional value was performed at SCPV VÚŽV in Nitra by device Analyzer 1265 (fi. Infratech, srn). Selenium concentration in dry matter of meat was determined by spectro-photometric method at the Institute of Physiology of Farm Animals in Košice.

For the purpose of statistical evaluation of results we used basic variability indicators to test the differences between individual groups of pigs by student t-test.

Results and discussion

The comparison of slaughter value indicators is listed in table 1. The weight of slaughter processed pig carcasses, determined in warm condition 45 min after slaughter, reached 85.5 kg within the range from 77.5 kg to 93.5 kg. In the control group the average weight of 82.0 kg was determined ranging from 71.05 kg to 91 kg. The difference among the groups of slaughter processed carcasses represented + 3.55 kg in the test group.

At the evaluation of slaughter indicators, mainly in meatiness, the test group achieved 54.4 % in valuable meat portions (with addition of organic selenium), and the control group of pigs 52.08 %. This represents 1.96 % difference at significance $P<0.05^{+}$. More significant portion of meat was detected in thigh with test group (22.39%) than with control group (20.47 %), with a difference of 1.92 at notable significance $P<0.01^{++}$. The same statistically notable significance was the area MLT, where the difference represented 5.31 cm^2 at notable significance $P<0.01^{+}$ in favour of tested group with organic selenium. In back bacon thickness was detected lower values of 15.13 mm with test group in comparison with control group (18.65 mm), which represented 3.52 mm difference.

Table 1 The indicators of slaughter value in hybrid pigs
Tabela 1 Pokazatelji klanične vrednosti hibridnih svinja

Indicator/ Pokazatelj	Control group/Kontrolna grupa Ko-hyb			Test group/Eksperimentalna grupa SE-hyb			T-test	Difference/ Razlika
	$\bar{x}$	s	min-max	$\bar{x}$	s	min-max		
Average daily gain/ Prosečan dnevni prirast (g)	843,0	0,38	758,0-870,0	885,0	0,29	797,0-928,0	0,63	+42,0
Live weight/Živa masa (kg)	103,30	7,29	92,00-13,00	103,15	5,97	94,00-113,00	0,96	-0,15
Weight portion/Masa toplih polutki (kg)	82,00	6,89	71,50-91,00	85,55	5,03	77,50-93,50	0,20	+3,55
Weight of slaughter/Masa hladne polutke (kg)	40,48	3,56	35,03-45,31	42,40	3,36	36,00-47,50	0,22	+1,92
Valuable carcass loin/Slabina trupa (%)	52,08	3,13	47,71-56,84	54,04	1,36	51,86-56,91	$0,05^{+}$	+1,96
Thigh portion/But (%)	20,47	1,76	17,72-22,57	22,39	1,27	20,38-23,87	$0,01^{++}$	+1,92
Back bacon thickness/Debljina leđne slanine (mm)	18,65	6,22	12,67-29,67	15,13	3,36	11,67-21,33	0,13	+3,52
MLT area/MLT (cm^2)	36,56	2,89	31,10-41,82	41,87	4,77	33,72-48,04	$0,01^{++}$	+5,31
Dressing percentage/Randman (%)	79,32	1,44	77,08-80,86	83,29	1,40	81,37-85,26	0,20	+3,97

$^{+}$ $P < 0.05$, $^{++}$ $P < 0.01$, $^{+++}$ $P < 0.001$

By application of 2-point classification method (ZP –method), the 58.5 % average portion of musculature was detected in JOT test group, which is more than with control group. This evaluation corresponds to average back bacon thickness measured on middle Musculus Gluteus Medius, which measured 12.1 mm in test group, with range from 8 mm to 20 mm and at control group 14.6 mm ranging from 8 mm to 28 mm.

Dressing losses by refrigeration of slaughter carcasses during the first 24 hours after slaughtering varied in range from 2 % to 3 %, while no notable differences were detected.

The occurrence of individuals with non typical development of biochemical quality characteristic was monitored, based on pH_1 and pH_{24} values. The obtained results indicate that in test group the average pH_1 value

was 6.69, ranging from 6.50 to 6.85. In control group the average pH_1 value was 6.49 ranging from 6.24 to 6.99. From presented data it is obvious that in the evaluated files of pigs in test and control group, there was no individual present with PSE meat characteristic. pH_{24} values reached an average value of 5.77 in test group, ranging from 5.65 to 5.89. In control group was detected average value of pH_{24}, ranging from 5.51 to 5.81. None of the monitored samples showed meat character DFD and their pH_{24} was significantly lower than its critical border DFD of meat – pH_{24}>6.2. Losses of unbound water in 24-48 hours from samples weighing 50 g reached 4.09 % in control group, ranging from 3.52 to 6.42 %. Control group contained 4.83 % of dripped water ranging from 2.38 to 6.59 %. The difference between groups was statistically significant at $P<0.05^{+}$. By evaluation of meat electrical conductivity in thigh (MSM), control group reached lower values EV_{24} = 2.67 μS in comparison with control group EV_{24} = 2.83 μS and EV_{24} showed 7.41 μS and with control group 7.78 μS, which represented difference of 0.37 μS in favour of test group. As to the meat colour indicator, the test group gained higher values of 28.09, whereas control group 26.03. The quality characteristic of meat samples during the ripening process. Meat samples of test and control group were individually hanged in refrigerator at the temperature ranging from 2°C to 4°C with relative air humidity between 90 % and 95 %. The values of monitored quality indicators are listed in table 2.

The obtained results indicate that the average pH value of samples measured 48 hours after slaughtering of animals reached 5.89 in test group and 5.75 in control group. This difference was statistically significant at $P<0.05^{+}$. The pH value of meat samples after 7 days of ripening was 5.88 in test group and 5.81 in control group. This difference was statistically significant at $P<0.01^{++}$. Loses by dripping and drying of sample surfaces weighing 700 g in drying period from 24 to 48 hours, represented 1.90 % ranging from 1.31 % to 2.39 %. Meat colour for cutlets after 7 days of ripening, evaluated by 12-grade Hirtzel colour scale showed darker shade and the average value of 4.3 with test group, and 2.5 in control group which showed average shade value paler. Loses by thermal treatment of meat samples (70°C for 10 min) represented in the total sample volume 11.99 % with test group, ranging from 8.5 to 15.0 % with control group, the loses by thermal treatment were 12.66 % in average, ranging from 10.10 % to 15.6 %. The total sum of loses during 7 day refrigerated storage of meat samples and subsequent minimal required thermal processing was almost the same in both samples, where it represented 20.54 % in test group and 20.78 % in control group. The texture of thermally processed meat samples, expressed as shear strength value by Warner-Bratzler was 11.4 WB, which was the same in both groups. This represents approx. 5.7 $kg.^{-2}$.

Table 2. The characteristic of physical-chemical and technological indicators in pork meat with organic selenium addition
Tabela 2. Karakteristike fizičko-hemijskih i tehnoloških pokazatelja u svinjskom mesu sa dodatim organskim selenom

Indicator/ Pokazatelj	Control group/Kontrolna grupa Ko-hyb			Test group/ Eksperimentalna grupa SE-hyb			T-test	Difference/Razlika CG:TG
	$\bar{x}$	s	min-max	$\bar{x}$	s	min-max		
Meat portion from thigh/Deo mesa sa buta	20,50	1,76	17,72-22,57	22,39	1,27	20,38-23,87	$0,01^{++}$	+1,92
pH_1 MSM	6,49	0,24	6,24-6,99	6,69	0,13	6,50-6,85	0,0253	+0,2
pH_{24} MSM	5,60	0,09	5,51-5,81	5,77	0,07	5,65-5,89	$0,0131^{++}$	+0,17
pH_{48}MSM	5,75	0,03	5,70-5,81	5,89	0,03	5,52-5,63	$0,0503^{+}$	+0,14
$pH_{7\ days}$ MSM	5,81	0,07	5,74-5,96	5,88	0,05	5,80-5,97	$0,0153^{++}$	+0,07
EV_1 MSM in µS	2,83	0,48	2,20-3,80	2,67	0,29	2,30-3,30	0,3798	+0,16
EV_{24} MSM in µS	7,78	1,4	5,30-9,60	7,41	1,89	5,0-10,10	0,6247	+0,37
Meat colour specol /Boja mesaMSM	26,03	2,57	22,20-29,30	28,09	2,65	24,80-32,30	0,0948	+2,06
Free water/Slobodna voda, 24-48 h. MSM	4,83	1,51	2,38-6,59	4,09	1,01	3,25-6,42	$0,0528^{+}$	+0,74
Loses by dripping/Kalo, 24-48 h	1,99	0,39	1,31-2,39	1,9	0,39	1,37-2,30	0,6307	+0,09
Loses by dripping 7 days/Kalo, 7 dana	9,38	1,51	6,48-11,0	7,64	1,24	5,19-8,93	$0,01^{++}$	+1,74
Loses by cooking 70 °C/Kalo kuvanjem na 70 °C	12,66	1,72	10,10-15,60	11,99	2,00	8,50-15,00	0,4329	+0,67
Shear strength/ Snaga rasecanja WB	11,48	1,53	9,80-14,60	11,45	1,62	7,90-12,50	0,5499	+0,43

The characteristic of meat nutrition values, macro and microelements with aim at selenium content in table 3.

Table 3. The characteristic of nutritional values, micro, macro elements in pork meat with organic selenium addition
Tabela 3. Karakteristike nutritivne vrednosti, mikro, makro elemenata u svinjskom mesu sa dodatkom organskog selena

Indicator/ Pokazatelj	Control group/Kontrolna grupa Ko-hyb			Test group/Eksperimentalna grupa Se-hyb			Difference/Raz. CS:TS	t-test
	$\bar{x}$	s	min-max	$\bar{x}$	s	min-max		
Total water content in g/100g/ Ukupni sadržaj vode g/100g	74,31	0,45	73,6-75,0	74,59	0,41	0,549	+0,28	0,16
Dry matter in g/100g/ SM u g/100g	25,69	0,36	25,0-26,4	25,41	0,39	0,432	-0,28	0,26
Total protein in g/100g/ UP u g/100g	22,60	0,39	22,1-23,2	22,5	0,18	0,779	-0,1	0,43
Total fat in g/100g/ UM u g/100g	2,06	0,36	1,6-2,5	1,9	0,53	27,85	+0,16	0,43
Energetic value in KJ/100g/ En.vred. KJ/100g	456,01	12,95	439,26-476,52	448,13	18,1	4,039	+7,88	0,27
Selenium/Selen								
Selenium MSM in dry meat matter in mg/kg/ Selen MSM u SM u mg/kg	0,51	0,041	0,422-0,545	1,293	0,1584	12,25	+0,787	$0,001^{+++}$
Selenium MLT in dry meat matter in mg/kg/ Selen MLT u SM u mg/kg	0,50	0,036	0,443-0,562	1,364	0,2066	15,15	+0,867	$0,001^{+++}$
Macro-micro elements/makro-mikro elementi								
Phosphorus-P mg/kg	3755,30	24,44	3719,9-3794,5	3102,9	14,39	0,464	-652,4	
Calcium - Ca mg/kg	57,46	0,01	57,42-57,46	52,16	0,002	0,006	-5,3	
Iron - Fe mg/kg	17,28	0,15	17,02-17,43	18,54	0,35	1,911	+1,26	
Zinc – Zn mg/kg	28,99	0,33	28,85-29,94	30,99	0,01	0,048	+2,0	
Magnesia – Mg mg/kg	521,33	4,82	514,02-528,43	546,84	2,93	0,536	+25,51	
Sodium – Na mg/kg	975,05	3,92	969,88-980,74	912,95	8,32	0,912	-62,10	
Potassium – K mg/kg	2379,22	21,9	2351,05-2404,52	2823,26	82,02	2,905	+444,04	

Based on the analysis of individual 150 g meat samples, performed on device Infratec, the basic nutritional value indicators were monitored – protein, fat and mineral element content. During the comparison of individual monitored indicators, the values were even with an exception of lower total fat content + 0.16 g/100 g and energetic value + 7.88 kJ/100 g in favour of test group.

During the evaluation of selenium concentration in dry meat content were found higher values in test group in thigh (MSM) 1.293 mg/kg an in cutlet (MLT) 1.364 mg/kg in comparison with control group, where lower MSM values were discovered (0.513 mg/kg and MLT 0.506 mg/kg). In the test group meat – the group with addition of organic selenium, the selenium content was 2.5 times higher, which we regard as a positive thing.

Higher selenium content in meat with feed of higher organic selenium content in rationed feeding was also confirmed by *Mahan et al.* (1999), *Muňou et al.* (1997). The obtained results confirmed the statements of other authors like *Bahelka et al.* (2006), *Bobček et al.* (2005), *Miller et al.* (1997) and *Ľahučký et al.* (2001). According to them, the addition of selenium substances during pig fattening increases selenium content in meat, while at the same time it does not make worse the slaughter value indicators.

Conclusion

The work results clearly confirmed the suitability to use organic selenium in feed mixture for pigs with the purpose of improving production indicators, the slaughter value of animals as well as physical-chemical and technological quality characteristic of pork meat.

The results point out the main advantages of organic selenium application in pig rearing. These advantages are selenium retention in muscles and tissues of pigs, positive effect on meat quality with lower occurrence of pale, watery meat (PSE) syndrome, lower loses by dripping from slaughter halves and better nutritional value of meat which is significantly enriched by selenium.

According to the present knowledge, higher selenium content in groceries has the positive effect on people's health by lowering the occurrence of cardio-vascular diseases, brain and thyroid disorders and by improving of a body immune system.

The organic selenium form features enable effective transfer through the food chain and it is beginning to be utilised worldwide with modern concept of production, so called functional groceries, among which we can list also animal products enriched by organic selenium.

Uticaj organskog selena na klaničnu vrednost, fizičko-hemijske i tehnološke osobine kvaliteta svinjskog mesa

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Rezime

Rezultati rada jasno ukazuju na pogodnost korišćenja organskog selena u smešama za svinje u cilju poboljšanja proizvodnih pokazatelja, klanične vrednosti životinja kao i fizičko-hemijskih i tehnoloških osobina kvaliteta svinjskog mesa.

Rezultati ukazuju na osnovne prednosti primene organskog selenau odgoju svinja. Ove prednosti su zadržavanje selena u mišićima i tkivima svinja, pozitivan efekat na kvalitet mesa sa smanjenom pojavom sindroma bledog, vodnjikavog mesa (PSE), manji gubici kod polutki i bolja nutritivna vrednost mesa koja je znatno poboljšana/obogaćena selenom.

Prema trenutnim saznanjima, veći sadržaj selena u prehrambenim proizvodima ima pozitivna efekat na zdravlje ljudi tako što se smanjuje pojava kardio-vaskularnih bolesti, bolesti mozga i tiroidnih poremećaja i poboljšava se imuno sistem organizma.

Osobine organskog selena omogućavaju efikasan transfer kroz lanac ishrane i počinje da se koristi širom sveta u modernim konceptima proizvodnje tzv. funkcionalnih namirnica među kojima možemo navesti i proizvode životinjskog porekla.

Ključne reči: svinje, klanična vrednost, fizičko-hemijska vrednost, svinjsko meso

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