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CONTENT OF MACROMINERALS IN THE *M. semimembranosus* AND *M. longissimus thoracis et lumborum* FROM FIVE PUREBRED PIGS PRODUCED IN VOJVODINA

SADRŽAJ MAKROMINERALA U *M. semimembranosus* I *M. longissimus thoracis et lumborum* PET ČISTIH RASA SVINJA OGDAJANIH U VOJVODINI

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ABSTRACT

The contents of phosphorus, potassium, sodium, magnesium and calcium were investigated in the M. semimembranosus (SM) and M. longissimus thoracis et lumborum (LTL) from Large White, Landrace, Duroc, Hampshire and Pietrain pigs, produced in Vojvodina. Phosphorous was determined by the standard spectrophotometric method. Metals were determined by the flame atomic absorption spectrometry after mineralisation of samples by dry ashing.

The differences in the content of all investigated macrominerals in the SM muscles and in the LTL muscles among the five purebred pigs were not significant (P>0.05). The type of the muscles had no significant effect (P>0.05) on the macromineral content, except on P (P=0.011) content for Landrace, and on K (P=0.026) and Mg (P=0.019) content for Large White.

The Vojvodian pork showed slightly higher Ca content and slightly lower K content compared with the values found in other countries.

***Key words**: pigs, macrominerals, M. semimembranosus, M. longissimus thoracis et lumborum.*

REZIME

Glavni izvori varijabilnosti nutritivnog sastava mesa su velika raznolikost zemljišta i klimatskih uslova (geografska varijabilnost), sezona, fiziološko stanje i starost životinje, kao i vrsta i rasa. U komercijalnoj proizvodnji mesa u Vojvodini dominantno se koristi pet čistih rasa svinja (Velika Bela, Landras, Durok, Hempšir i Pietren) i njihovi hibridi. Nutritivni faktori kvaliteta mesa uključuju: proteine i njihov sastav, masti i njihov sastav, vitamine, minerale, iskorišćenje, svarljivost i biološku vrednost. Minerali su obično podeljeni u dve grupe – makrominerali (kalcijum, magnezijum, fosfor, kalijum, natrijum, sumpor) i mikrominerali (hrom, kobalt, bakar, jod, gvožđe, mangan, molibden, selen, zink). M. semimembranosus (SM) i M. longissimus thoracis et lumborum (LTL) su dva ekonomski najznačajnija mišića na trupu svinja. Sadržaj fosfora, kalijuma, natrijuma, magnezijuma i kalcijuma je ispitan u SM i LTL mišićima svinja Velika Bela, Landras, Durok, Hempšir i Pietren, koje su odgajane u Vojvodini. Fosfor je određen standardnom spektrofotometrijskom metodom. Metali su određeni plamenom atomskom apsorpcionom spektrometrijom nakon suvog spaljivanja uzoraka. Razlike u sadržajima svih ispitanih makrominerala u mišićima SM kao i u mišićima LTL između pet čistih rasa svinja nisu bile značajne (P>0,05). Tip mišića nema značajan (P>0,05) uticaj na sadržaj makrominerala, osim na sadržaj P (P=0,011) kod svinja rase Landras i na sadržaj K (P=0,026) i Mg (P=0,019) kod svinja rase Velika Bela. Svinjsko meso proizvedeno u Vojvodini pokazuje nešto veći sadržaj Ca i nešto manji sadržaj K u poređenju sa sadržajima utvrđenim u drugim zemljama.

***Ključne reči**: svinje, makrominerali, M. semimembranosus, M. longissimus thoracis et lumborum.*

INTRODUCTION

Meat quality is the sum of all sensoric, nutritive, hygienic-toxicological and technological factors of meat. The nutritive factors of meat quality include proteins and their composition, fats and their composition, vitamins, minerals, utilisation, digestibility and biological value (*Hofmann, 1990; Honikel, 1999; Olsson, and Pickova, 2005; Tomović et al., 2014a*). Red meat (pork) contains high biological value protein and important micronutrients, including zinc, iron and vitamin B_{12}, all of which are essential for good health throughout life (*Higgs, 2000; Lombardi-Boccia et al., 2005; Williamson et al., 2005; Biliaderis, 2008; McAfee et al., 2010; Tomović et at., 2011*).

Minerals are the inorganic elements, other than carbon, hydrogen, oxygen and nitrogen, which remain behind in the ash when food is incinerated. They are usually divided into two groups – macrominerals (calcium, magnesium, phosphorus, potassium, sodium, sulphur) and microminerals (chromium, cobalt, copper, iodine, iron, manganese, molybdenum, selenium, zinc). The minerals are classified as either essential or non-essential, depending on whether or not they are required for human nutrition and have metabolic roles in the body (*Reilly, 2002*).

The Autonomous Province of Vojvodina (the northern part of the Republic of Serbia) is a region where the number of animals of the porcine species and the production of pork meat

are of high economic importance. Five purebred pigs (Large White, Landrace, Duroc, Hampshire and Pietrain) and their crosses are used for commercial pork production in Vojvodina. In (cross) breeding programme Large White and Landrace are used as female lines and Duroc, Hampshire and Pietrain are used as male lines (*Tomović et at., 2011, Jokanović et al., 2012*).

The continuous innovations in the breeding systems, rearing practices, feeds composition, changes in slaughtering method and ageing, largely contribute to induced changes in the concentration of some of micronutrients (*Lombardi-Boccia et al., 2005; Greenfield et al., 2009*). According to *Hermida et al. (2006)*, the average macrominerals and microminerals concentrations in tissues depend, in part, on the type of cuts, the age of the animals, and various other factors. However, the existing information in the scientific literature related to the influence of the mentioned factors on the mineral content in pork meat are very scarce (*Edmonds et al., 2001; Pettigrew and Esnaola, 2001; Tomović et at., 2010*).

The *M. semimembranosus* and *M. longissimus thoracis et lumborum* are two economically most important muscles in the pork carcass (*Tomović et at., 2014b)*.

Having in mind that pork is an important component of the diet of the population in Vojvodina and Serbia the objectives of the present investigation, was to determine the content of phosphorus, potassium, sodium, magnesium and calcium in two muscles (*M. semimembranosus* and *M. longissimus thoracis et lumborum*), obtained from five purebred pigs (Large White, Landrace, Duroc, Hampshire and Pietrain) used nowadays in Vojvodina for pork production.

MATERIAL AND METHOD

Animals, diet, sampling and preparing. In this study five purebred pigs (castrates males and females) were used: Large White (n=8), Landrace (n=7), Duroc (n=6), Hampshire (n=7) and Pietrain (n=7). The pigs were fattened at the production farms in the northern part of the Republic of Serbia (Autonomous Province of Vojvodina). The pig fattening involved the following phases: starting period (from 15 to 25 kg), growing period (from 25 to 60 kg) and finishing period (from 60 to 110 kg). The diets were based on locally produced corn and soybean meals, and were formulated to meet the nutrient requirements for the different growth phases (*NRC, 1998; Tomović et al., 2011*). The finishers were housed in pens with fully slatted floor and 0.80 m^2 space allocation per pig. Each pen contained 10 animals. The environmental temperature in the building was 22 °C. All pigs had ad libitum access to a diet and water.

The pigs were randomly selected at an individual live weight between 95 and 110 kg, and were about 6 months old. The pigs were slaughtered in the two biggest Vojvodian slaughterhouses according to routine procedure. Carcasses were conventionally chilled for 24 h in a chiller at 2–4 °C. After chilling, *M. semimembranosus* (SM) and *M. longissimus thoracis et lumborum* (LTL) were removed from the each right half-carcases. SM and LTL muscles were taken from the same half-carcases. Samples for chemical analysis (approximately 250 g) were taken after the homogenisation of the SM and LTL muscles, vacuum packaged in polyethylene bags and stored at –40 °C until analysis.

Analytical methods and quality control. The total phosphorous (P) content was determined according to the ISO method *(ISO 13730, 1996)*. The contents of potassium (K), sodium (Na), magnesium (Mg) and calcium (Ca) were determined as described in detail by *Tomović et al.* (*2011*). All analyses were performed in duplicate.

A strict analytical quality control programme was employed during the study. The quality control of the analytical measurements was performed using the following standard reference materials (SRM): SMRD 2000 (Matrix meat reference material, National Food Administration, Uppsala, Sweden) for P, K, Na and Ca. For the determination of the Mg content, the SRM samples were spiked with three different concentrations of this element. The results of the analytical quality control programme are presented in Table 1. In every series of samples, two blanks and two samples of standard reference material were included.

Table 1. The results of the analytical quality control programme (n = 8) used in the determination of the macrominerals in SM and LTL muscles

	P	K	Na	Mg	Ca
Certified concentration (mg/kg)	1080 ± 110	1860 ± 100	8500 ± 800		70±23
Recovery (%)	98.1	97.8	106.2	98.2	95.5
Limit of detection (mg/100 g)		50	20	5	5
Limit of quantitation (mg/100 g)		75	30	7	7

Statistical analysis. All data are presented as average (X), standard deviation (Sd) and range. Independent t-test and analysis of variance (one-way ANOVA) were used to test the hypothesis about differences between two or more mean values. The software package STATISTICA 12.0 (*StatSoft, 2012*) was used for analysis.

RESULTS AND DISCUSSION

The average content, the standard deviation and range for the phosphorus, potassium, sodium, magnesium and calcium in the investigated samples of the *semimembranosus and longissimus thoracis et lumborum* muscle tissues of five different purebred pig breeds (Large White, Landrace, Duroc, Hampshire and Pietrain), are presented in Table 1.

The order of the macrominerals in the SM and LTL muscles samples (Table 2) was the same, and it was: K > P > Na > Mg > Ca. Average content of K, as the most abundant macromineral in the muscles was in the range from 280 mg/100 g (Pietrain) to 294 mg/100 g (Large White) in SM muscles, while the lowest content of K in LTL was for Large White (265 mg/100 g) and the highest was for Pietrain (290 mg/100 g). The differences in the content of K in the SM muscles, as well as in the LTL muscles among the five purebreds were not significant (P>0.05). The content of K in all the SM muscles (n=35) was in the range: 220–331 mg/100g (average 285 mg/100 g), and in the all LTL (n=35) was in the range: 213–331 mg/100 g (average 280 mg/100 g). Regarding results for all analysed muscles there was no significant (P>0.05) difference in the K content between SM and LTL muscles, but significant (P=0.026) difference was

determined between K content in SM and LTL muscles for Large White purebred.

The second most abundant macromineral was P. The lowest average content of P was determined for Pietrain, both in SM and in the LTL muscle (217 mg/100 g), and the highest for Landrase in SM muscles (238 mg/100 g) and for the Hampshire in LTL muscles (227 mg/100 g). The purebred had no significant effect (P>0.05) on P content. The content of P in all the SM muscles (n=35) was in the range: 202–248 mg/100 g (average 227 mg/100 g), and in the all LTL (n=35) was in the range: 201–251 mg/100 g (average 222 mg/100 g), with no significant (P>0.05) difference between muscles. Significant (P=0.011) difference between muscles in P content was determined only for Landrace.Hampshire was the lowest in Na content, both in SM (58.0 mg/100 g) and in the LTL (55.8 mg/100 g) muscles, while Landrace was the highest in both muscle (69.1 and 62.2 mg/100 g, for SM and LTL respectively). The purebred and the type of muscle had no significant effect (P>0.05) on Na content. Content of Na in all analysed muscles samples was in the range: 39.0–82.7 mg/100 g (average 62.2 mg/100 g) in SM muscles, and was in the range 49.7–73.4 mg/100 g (average 59.1 mg/100 g) in LTL muscles. The lowest content of Mg in SM muscles was determined for Hampshire (26.4 mg/100 g).

Both the highest Mg content in SM (27.6 mg/100 g) and the lowest in LTL (25.7 mg/100 g) was determined for Large White, and this difference was significant (P=0.019).The highest Mg content in LTL (26.8 mg/100 g) was determined for Hampshire and Pietrain. Purebred did not significantly (P>0.05) affect Mg content in SM or LTL muscles.The content of Mg in all the SM muscles (n=35) was in the range: 24.9–29.4 mg/100 g (average 26.9 mg/100 g), and in the LTL was in the range: 24.2–29.5 mg/100 g (average 26.4 mg/100 g).

Average Ca content in SM ranged from 11.6 mg/100g (Landrace) to 12.7 mg/100 g (Large White) and in LTL from 10.9 mg/100 g (Pietrain) to 12.2 mg/100 g (Duroc). Purebred or the type of the muscle didn't significantly affect Ca content (P>0.05). Regarding all the analysed muscle samples content of Ca in SM (n=35) ranged from 9.6–15.5 mg/100 g (average 12.0 mg/100 g) and in LTL (n=35) ranged from 9.6–13.8 mg/100 g (average 11.6 mg/100 g).

The SM and LTL muscles, investigated in the present study showed slightly higher Ca content and slightly lower K content compared to the data presented in the food composition tables of other countries *(Romans et al., 1994; Greenfield et al., 2009, The Norwegian Food Safety Authority, 2006; INRAN, 2007; National Food Institute Denmark, 2009; National Institute for Health and Welfare, Fineli, 2009)*.

Table 2. Macromineral content (P, K, Na, Mg i Ca) of M. semimembranosus (SM) *and M. longissimusthoracis et lumborum (LTL) of five purebred pigs*

Macromin.	Muscle		Pig purebred					*P* value[1]	All animals
			Large White	Landrace	Duroc	Hampshire	Pietrain		
P (mg/100 g)	SM	X±Sd	227±17	238±5	225±13	226±9	217±12	0.108	227±13
		Interval	202–248	232–243	212–243	211–236	204–239		202–248
	LTL	X±Sd	222±14	223±10	219±10	227±19	217±15	0.775	222±14
		Interval	201–238	211–239	207–236	202–251	204–239		201–251
		P vrednost[2]	0.569	0.011	0.457	0.910	0.968		0.162
K (mg/100 g)	SM	X±Sd	294±24	281±39	284±22	287±27	280±33	0.784	285±28
		Interval	259–325	220–313	255–317	261–326	231–331		220–331
	LTL	X±Sd	265±24	274±43	283±19	289±19	290±22	0.454	280±27
		Interval	227–299	213–331	259–305	266–315	257–322		213–331
		P vrednost	0.026	0.779	0.934	0.877	0.549		0.433
Na (mg/100 g)	SM	X±Sd	59.8±14.1	69.1±13.1	60.8±8.5	58.0±3.9	63.6±9.7	0.402	62.2±10.5
		Interval	39.0–76.7	50.9–82.7	51.6–72.0	53.9–63.8	56.7–78.6		39.0–82.7
	LTL	X±Sd	57.4±4.0	62.2±6.5	58.6±6.7	55.8±4.3	61.4±9.7	0.431	59.1±6.5
		Interval	52.7–62.1	57.0–73.0	53.5–71.0	50.4–59.7	49.7–73.4		49.7–73.4
		P vrednost	0.859	0.275	0.619	0.388	0.701		0.189
Mg (mg/100 g)	SM	X±Sd	27.6±1.5	27.3±1.4	26.6±0.3	26.4±1.0	26.9±0.9	0.211	26.9±1.1
		Interval	25.7–29.4	24.9–29.0	26.4–27.0	25.1–28.1	25.3–27.7		24.9–29.4
	LTL	X±Sd	25.7±1.0	26.4±2.0	26.6±0.8	26.8±0.8	26.8±1.0	0.534	26.4±1.2
		Interval	24.4–27.3	24.2–29.5	25.5–27.6	25.6–27.7	25.3–28.0		24.2–29.5
		P vrednost	0.019	0.382	0.872	0.452	0.880		0.088
Ca (mg/100 g)	SM	X±Sd	12.7±2.1	11.6±1.1	11.8±1.3	11.7±1.3	12.0±0.6	0.271	12.0±1.3
		Interval	10.2–15.5	9.9–13.2	9.6–13.3	10.1–13.4	11.3–13.1		9.6–15.5
	LTL	X±Sd	11.9±1.2	11.9±1.4	12.2±0.9	11.0±0.6	10.9±1.4	0.204	11.6±1.2
		Interval	10.5–13.7	10.0–13.8	10.7–13.4	9.8–11.5	9.6–12.8		9.6–13.8
		P vrednost	0.187	0.688	0.494	0.239	0.118		0.178

[1]*indicates significant difference between purebred within raw*
[2]*indicates significant difference between SM and LTL muscles within column*

CONCLUSION

The results of the present investigation show that the content of macrominerals determined in the *M. semimembranosus* (SM) and *M. longissimus thoracis et lumborum* of pigs produced in Vojvodina was not influenced by the purebred. The type of the muscles had no significant effect (P>0.05) on the macromineral content, except on P (P=0.011) content for Landrace, and on K (P=0.026) and Mg (P=0.019) content for Large White.

Compared with the data presented in the food composition tables of other countries the Ca content in muscles of the pigs produced in Vojvodina was slightly higher and K content was slightly lower.

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