Distribution of manganese and selenium in four different pork cuts commercially available in the Serbian market

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Abstract. This study aimed to provide information on levels of Mn and Se in four different pork cuts (loin, neck, hind leg and shoulder) commercially available on the Serbian market, with a view to providing information on dietary intakes of metals associated with the consumption of these meat cuts. In total, for 50 pork cuts, the levels of Mn and Se were determined by inductively-coupled plasma mass spectrometry (ICP-MS). The following ranges of Mn and Se were found (mg kg^{-1}) in loin 0.055-0.130 and 0.074-0.365, in neck 0.014-0.365 and 0.045-0.196, in hind leg 0.032-0.099 and 0.066-0.123, in shoulder 0.012-0.290 and 0.027-0.515, respectively. The highest mean levels were obtained for Mn (0.124 mg kg^{-1}) in shoulder and for Se (0.209 mg kg^{-1}) in loin. The Estimated Daily Intake (EDI) of essential elements through consumption of 114.1 g mammalian meat/person/day was below 1% of Adequate Intake (AI) for Mn and between 18.9% and 43.2% of Recommended Dietary Allowance (RDA) for Se.

1. Introduction

Meat and meat products are an excellent source of the major essential nutrients such as hydrophilic vitamins, high quality proteins and minerals etc. Red meat is the ideal dietary source of vitamin B12 and several minerals, while poultry supplies an important amount of niacin [1]. The levels of essential elements (e.g. Zn, Cu, Fe, Mn, Se) in meat depend on meat type [2]. These elements are critically important for life, are necessary for adequate physiological function and should be available through dietary intake. Insufficient intake of essential elements can cause improper metabolic function and can cause fatigue, poor growth, anaemia, chronic diseases and ultimately, death [3]. Essential elements act as enzyme cofactors, organic molecule stabilizers, participants in redox reactions etc [4].

The latest available data according to the UK Nutrient Databank [5], maintained by the Food Standards Agency, contains extensive information on the nutrient content of foods commonly consumed and is published by McCance and Widdowson's 'The Composition of Foods' (CoF) book series [6]. This databank contains Mn and Se levels for more than 3000 items of food and alcoholic beverages (table 1). It shows that meat and meat products are an average source of Mn and Se in the presented food sub-groups (table 1).

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Table 1. Amounts of Mn and Se in different food sub-groups (adapted from McCance and Widdowson, 2015).

Food sub-groups	Mn	Se
	Range (min-max)	
	[mg/100g]	[µg/100g]
Cereals and cereal products	0.13-1.91	3-10
Milk and milk products	0.01-0.50	1-11
Vegetables	0.10-3.10	1-21
Nuts and seeds	1.30-1.80	1-32
Fruits	0.1-0.8	1-8
Fish and fish products	0.01-0.54	12-43
Meat and meat products	0.01-0.27	2-15
Beverages	0.01-4.70	1-5
Sugars, preserves and snacks	0.01-3.30	1-4
Soups, sauces and miscellaneous foods	0.03-0.57	1-2
Alcoholic beverages	0.01-0.05	--

Meat and meat products contribute a significant part of the human diet in Serbia. Globally, pork is the most widely consumed meat (15.8 kg/capita/year), followed by poultry (13.6 kg/capita/year), beef (9.6 kg/capita/year) and finally sheep and goat meat (1.9 kg/capita/year) [7]. Meat consumption statistics vary among and within countries. The World Health Organization (WHO), through the Global Environment Monitoring System – Food Contamination Monitoring and Assessment Programme (GEMS/Food) cluster diets 2012 [8], gives data for the daily intake of 383 different food items from 183 countries. According to that data, the daily intake of meat for adult Serbian population is 114.1 g of mammalian species [8].

The main objectives of this study were to: (1) analyse and compare the levels of Mn and Se in four different pork cuts from the Serbian market; (2) determine which pork cuts contained the highest levels of each element; (3) estimate the daily intake of analysed essential elements derived from oral consumption of pork cuts.

2. Materials and Methods

2.1 Sample collection

A total of 50 different pork cuts (loin, neck, hind leg and shoulder) commercially available in Serbia were collected during one year (from September 2014 to August 2015). After collection, meats were labelled and stored in polyethylene bags and frozen at -18°C prior to analysis.

After acid mineralization of homogenized pork cuts, microwave digestion (Digestion System: Milestone, Sorisole, Italy) was used for sample preparation. Analysis of Mn and Se was performed by inductively coupled plasma mass spectrometry (ICP-MS), (iCap Q mass spectrometer, Thermo Scientific, Bremen, Germany). The most abundant isotopes were used for quantification. The accuracy of the analysis was verified by analysing the certified reference material NIST SRM 1577c (bovine liver, Gaithersburg, MD, USA).

2.2 Statistical analysis

Statistical analysis of experimental data was performed using software Statistica 10.0 (StatSoft Inc., Tulsa, OK, USA). Analysis of variance (ANOVA) and Tukey's HSD comparison of the means of results were used for analysing variations.

2.3 Estimated daily intake
The Estimated Daily Intake (EDI) of Mn and Se through consumption of analysed pork cuts was calculated. The following equation was used:

$$EDI\ (mg\ day^{-1}) = C_{elements} \times DC_{pork\ cut}$$

where $C_{elements}$ is the concentration of element (mg kg^{-1}) detected in pork cut and $DC_{pork\ cut}$ is the average per capita daily consumption of mammalian meat (114.1 g), [8].

3. Results and Discussion
The results obtained for the two elements in four different pork cuts were compared with the literature data. However, for most of the literature data, exact specifications of the samples analysed were not available. Table 2 shows grouped results for Mn and Se levels in pork cuts (SD – standard deviation, n – number of samples).

Table 2. Mn and Se levels (mean ± SD*) of selected pork cuts.

		Levels (mg kg^{-1})	
	n**	Mn	Se
Pork cuts			
1 Loin	10	0.088±0.026	0.209±0.109
2 Neck	14	0.089±0.056	0.120±0.051
3 Hind leg	6	0.064±0.024	0.091±0.023
4 Shoulder	20	0.124±0.078	0.150±0.126

The lowest average Mn and Se levels were found in hind leg while the highest average Mn and Se levels were observed in shoulder and loin, respectively. Post-hoc Tukey's HSD test showed that there were no statistically significant differences (at p<0.05 level) in the Mn and Se levels in various pork cuts (figure 1).

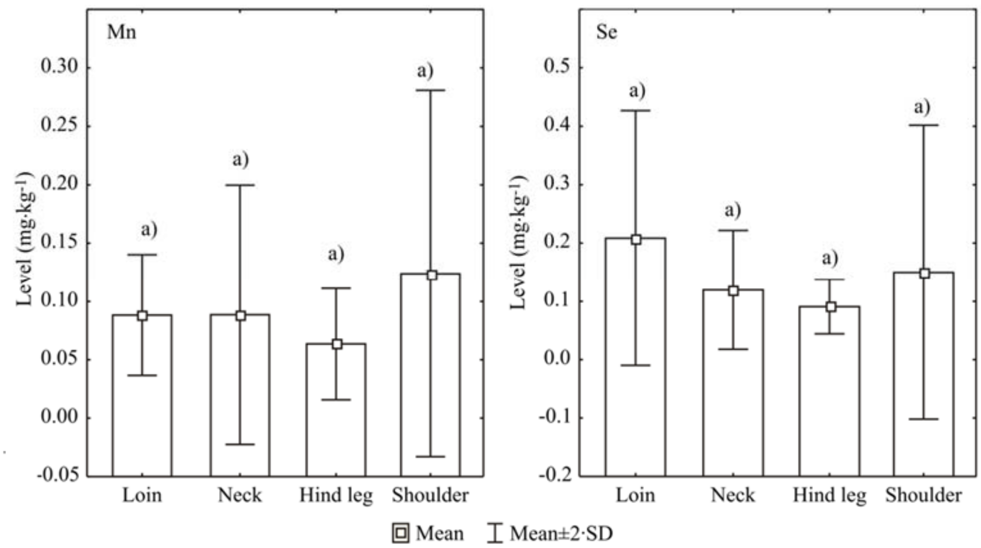

Figure 1. Levels of Mn and Se pork cuts. Data are presented as mean ± 2SD. Different letters in the bars of each element indicate significant differences of means between types of canned fish, according to Tukey's HSD test (p<0.05).

The Mn levels determined in pork cuts (0.064-0.124 mg kg^{-1}) were more than two to almost five-fold higher than those reported by Tomović et al. [9] in pigs from different genetic lines (Mn: 0.025 ± 0.004 mg/kg) but lower than levels given Batista et al. [2] in pork (0.214 mg kg^{-1}). Se levels in the analysed pork cuts (0.091-0.209 mg kg^{-1}) were higher than reported by Jablonska et al. [10] in 24 selected meat (ranging from 0.007 to 0.161 mg kg^{-1}), and Fajt et al. [11], in pork samples from different herds in Czech Republic (0.087 mg kg^{-1}). On the other hand, Se levels in pork reported by Batista et al. [2], (0.461 mg kg^{-1}) were higher than those obtained in our study.

Table 3 shows the EDI of Mn and Se, based on the average Serbian per capita consumption of mammalian meat. Estimates are for adults up to 19 years old. The results are expressed as % of the Adequate Intake (AI) and the Recommended Dietary Allowance (RDA) published by Institute of Medicine [12,13]. The results obtained showed that the contribution was dependent on the type of pork cut. Overall, pork cuts were estimated to provide between 0.32 and 0.79 % of the AI for Mn and between 18.9 and 43.2 % of the RDA for Se. The results from this study showed that estimated pork cut consumption levels (for loin, neck, hind leg and shoulder) can be considered as important dietary sources of Se. On the other hand, other food types are clearly necessary to provide adequate dietary levels of Mn for Serbian populations.

Table 3. Estimated daily intakes (EDI) of essential elements based on the average Serbian per capita consumption of mammalian species (114.1 g $person^{-1}$ day^{-1}) [8].

			EDI (expressed as % of the AI[a] or % of the RDA[b])							
Elements	Males	Females	Loin		Neck		Hind leg		Shoulder	
	AI (mg day^{-1})		M	F	M	F	M	F	M	F
Mn	2.3	1.8	0.44	0.56	0.44	0.56	0.32	0.41	0.62	0.79
	RDA (µg day^{-1})									
Se	55	55	43.2	43.2	24.9	24.9	18.9	18.9	31.1	31.1

[a]AI – Adequate intake (AI) for males (M) and females (F) up to 19 years old [12].
[b]RDA – Recommended Dietary Allowance (RDA) for males (M) and females (F) up to 19 years old [13].

4. Conclusion

This study revealed that pork cuts can be considered as important dietary sources of Se, but other food types are necessary to provide adequate dietary levels of Mn for Serbian population. The results showed there were no significant differences in the levels of Mn and Se among the analysed pork cuts. Mn was the most abundant in shoulder, while Se prevailed in loin. Periodic control of meat and meat products is necessary to provide more data on essential as well as on toxic elements to ensure the quality and safety of meat and meat products.

Acknowledgments

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