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LEAD CONCENTRATION IN MEAT AND MEAT PRODUCTS OF DIFFERENT ORIGIN

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ABSTRACT

Meat is very rich and convenient source of nutrients including also a large extent of microelements. Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain. The lead concentrations depend on the environmental conditions and the food production methods. Ingestion of contaminants, especially heavy metals, by animals causes deposition of residues in meat. The aim of this study was to determine the levels of lead in the Malokarpatska and Lovecka salami during the technological processing with comparison to the raw materials originating from domestic and foreign production. Lead content was determined by atomic absorption spectrometry. The starting materials in the Malokarpatska salami were found to contain the highest level of lead in the beef of foreign production (7.58 ppb), followed pork from foreign production (3.43 ppb), beef from domestic production (3.27 ppb), pork bacon from foreign production (2.41 ppb), pork from domestic production (1.63 ppb) and pork bacon from domestic production (1.57 ppb). The average concentration of lead was higher in homogenized samples with addition of additives and spices and ranged between 6.49 to 7.56 ppb. The lead concentration in final product Malokarpatska salami was in the range from 8.57 to 8.89 ppb. The highest mean Pb concentrations in the Lovecka salami in the starting materials were beef from foreign production, beef from domestic production, pork from foreign production, pork bacon from foreign production, pork from domestic production and pork bacon from domestic production (7.31, 3.77, 3.21, 2.40, 2.03, 1.97 ppb, respectively). Increasing concentration of lead was found after the addition of additives, spices and curing compounds causing a threefold increase in the concentration of lead in final products Lovecka and Malokarpatska salami. Technological process of meat processing can create a potential source of heavy metals in final products. Improvements in the food production and processing technology are increasing the chances of food contamination with various environmental pollutants, especially heavy metals.

Keywords: lead; meat; meat products; atomic absorption spectrophotometry

INTRODUCTION

Metals are found in all living organisms where they play a variety of roles **(Nuurtamo et al., 1980)**. Metal such as Fe, Cu, Mg, Co, Zn are essential for human body but chronic metabolic disturbances may occur due to the deficiency or excess of these metals. Non-essential elements such as Pb, Cd, Cr, Ni and As are considered to be toxic and their presence in the body can cause profound biochemical and neurological changes in the body **(Schroeder, 1991)**. Heavy metal is defined as a metal, which is neither essential nor has beneficial effect, on the contrary, it displays severe toxicological symptoms at low levels and is defined as a metal with a specific weigh more than 5 $g.cm^{-3}$ **(Gonzales-Waller et al., 2006)**. Environmental pollution associated with heavy metals has been of global concern over many decades. These metals are natural components of the environment but high rate of industrialization has been responsible for their wider diffusion and dispersal in the environment **(Rajaganapathy et al., 2011)**. The sources of toxic metals in the environment are the fossil fuels, mining industries, waste disposals and municipal sewage. Farming and forestry also contribute to the metal content in the environment due to the uses of fertilizers, pesticides **(Jayasekara et al., 1992)**. With increasing industrialization, more metals are entering into the environment. These metals stay permanently because they cannot be degraded in the environment **(Baykov et al., 1996)**.

The risk associated with the exposure to heavy metals present in food products had aroused widespread concern in human health **(Reilly, 1991)**. Improvements in the food production and processing technology had increased the chances of contamination of food with various environmental pollutants, especially heavy metals. Ingestion of these contaminants by animals causes deposition of residues in meat **(Sabir et al., 2003)**. Higher level of trace metals has been recorded in beef and mutton. Presence of substantiates levels of toxic metals lead and cadmium in meat products has been recorded **(González-Weller et al., 2006)**.

The main human exposure to heavy metals usually comes from food. After continuously evaluating studies on food additives and their toxicity, the WHO has came to the conclusion that even low levels of some metals, such as lead and cadmium, can give rise to diseases in humans **(WHO 2000, WHO 2001)**. This is produced by the capacity of these metals to accumulate in living organisms.

Lead is toxic heavy metal with widespread industrial use, but no known nutritional benefits. Chronic exposure at relatively low levels can result in damage to kidneys and liver and to immune, reproductive, cardiovascular, nervous and gastrointestinal systems **(Okoye et al., 2010)**. Lead, for example, bio-accumulates in plants and animals. Its concentration is generally magnified in the food chain **(Halliwell et al., 2000)**. Lead is metabolic poison and neurotoxin that binds to essential enzymes and several other cellular components and inactivates them **(Cunningham and Saigo, 1997)**. The main toxic effect of lead is nervous system dysfunction of the foetus and infants. In adults, it causes adverse blood effects, reproductive dysfunctions, damage to the gastrointestinal tract, nephropathies, damage to the central as well as the peripheral nervous system and interferences in the enzymatic systems **(Rubio et al., 2005)**. The health risks caused by lead and cadmium are well known and the levels in food as well as the migration of these metals from food containers are regulated **(Tahvonen and Kumpulainen, 1994)**. However, cases of accidental exposure to higher levels of lead and cadmium are often reported within the EU. For example, in Sweden in 2004, a man was poisoned by lead after using ceramics bought from another EU country, which had not been properly fabricated **(National Food Administraton in Sweden, 2004)**.

The risk of heavy metal contamination in meat is of great concern for both food safety and human health because of the toxic nature of these metals at relatively minute concentrations **(Santhi et al., 2008)**.

The aim of this study was to determine the level of lead in the traditional and popular meat products consumed in Slovak republic. This study is carried out to determine the levels of lead in Lovecka and Malokarpatska salami during the technological processing. The raw materials originating from domestic and foreign production were compared.

MATERIAL AND METHODOLOGY

Sample collection: To reach representative samples, average composition and characteristics of the goods were analysed. The concentration of lead was determined in 180 samples of raw materials and final products, respectively. The samples came from Slovakia Western Slovakia region and directly imported samples from European and American holdings. The collection of samples during the manufacturing process was carried out under the following scheme:

"*Malokarpatska salami*" - basic raw material (beef, pork and pork bacon) was collected; then samples of homogenized meat with additives (salt, spice extracts, sodium nitrite, highlighter flavour, *Lactobacillus*) and finally the actual sample of the final product after heat treatment was analysed;

"Lovecka salami" - basic raw material (beef, pork and pork bacon) was collected; than samples of homogenized meat with additives (salt, sodium ascorbate, erythorbic acid, ground black pepper, sugar, garlic, starter culture) and finally, the actual sample of the final product after heat treatment, cooling to 25 °C and drying in climates with aw = 0.95 was analyzed.

Sample preparation: Collected samples were packet to plastic bags, and frozen (-18 °C). Amount 30 - 50 mg of meat or homogenized meat samples and final products were used in the protocol.

The samples were dried at 105 °C in order to obtain dry mass of meat samples. All the samples were mineralized in the hot nitric acid (HNO_3 65% Ultranal®, POCH, Poland) at the temperature of 90 °C until complete dissolution of tissues using VELP Scientifica DK 20 (VELP Scientifica, Italy) mineralizator. Later the samples were thinned with spectrally pure water to cubic capacity of 10 mL. The mineralized samples were analysed by the AA spectrometer with the graphite furnace (PerkinElmer AAnalyst 800; MA, USA) to determine lead concentration. Final results were given in ppb ($\mu g.kg^{-1}$) for meat and other samples.

Statistical analyses: Data collected were presented as mean, standard deviation, coefficient of variation and standard error of mean. The results were subjected to statistical analysis using the Graph Pad Prism (ver. 6.0 for Windows; GraphPad Software, Inc.; USA) involving ANOVA tests and post hoc Tuckey analysis.

RESULTS AND DISCUSSION

The mean values, standard deviations, standard error of mean, coefficient of variation of lead concentration in Malokarpatska salami are listed in Table 1. The level of lead in beef from domestic production (3.27 ±0.827 ppb) was lower than in beef from foreign production (7.58 ±1.214). Pb content in the beef samples from foreign production was significantly higher ($p < 0.0001$) compared to those from domestic production. The lead concentrations in beef are similar to those reported by **Gonzales-Waller et al. (2006)** but lower than those described by **Akan et al. (2010)** in beef meat (25 ppb). **Oskarsson et al. (1992)** reported high concentrations of lead in the muscle of dairy cows raised on pasture than in the muscle of dairy cows kept indoors. Lead was present in pork from domestic and foreign production in the range from 1.63 to 3.43 ppb. There was a significant variation ($p < 0.05$) between Pb content in collected pork samples from domestic and foreign production. The most hazardous heavy metal monitored on the swine farms in the district of Hodonin, Czech republic in 1994-1999 was lead, the major source of which being paint coats (containing more than 0.6 g lead per kg), mineral components of commercial feeds, scrap lead batteries put away in barns and lead coated guide bars of electric lines **(Ulrich et al., 2001)**. Mean contents of lead in pork bacon from foreign production (3.43 ±1.147 ppb) was higher than in pork bacon from domestic production (1.63 ±0.276 ppb). Lead data showed noticeable insignificant difference between Pb content in pork bacon from domestic production and pork bacon from foreign production. The starting materials for the beef of foreign production had the highest mean lead level (7.58 ppb), followed by pork from foreign production (3.43 ppb), beef from domestic production (3.27 ppb), pork bacon from foreign production (2.41 ppb), pork from domestic production (1.63 ppb) and pork bacon from domestic production (1.57 ppb).

The average concentration of lead was higher in homogenized samples with addition of additives and spices. The levels of lead in the homogenized samples from foreign starting materials ranged from 4.320 to 11.02 ppb. The average lead concentration 6.49 ppb was found in homogenized samples from domestic starting materials. **Larkin et al. (1954)** reported that pepper contains higher levels of lead (>2.5 ppm) as is added invariably to almost all types of meat products. **Nkansah and Amoako (2010)** reported that high value of Pb was registered for black and white pepper (0.965 and 0.978 $mg.kg^{-1}$, respectively).

Final product Malokarpatska salami was in the range from 8.57 to 8.89 ppb. The lead concentrations detected in Malokarpatska salami in this study are similar to those of **Gonzales-Waller et al. (2006)** who reported the mean concentration of lead in the pork meat products samples 6.72 ppb and in the beef products samples 9.12 ppb. **Santhi et al. (2008)** found lower concentration of lead in the salami (2.231 ±0.432 ppb). **Muller and Anke (1995)** reported that lead content in sausage was higher than that in the meat used for its production, presumably due to the spices used in sausage production. **Demirezen and Uruc (2006)** reported that the highest average lead concentrations were obtained from pastirma, meat and sausage (0.126, 0.115, 0.135 ppb, respectively). The values are lower in comparison to our outgoing products.

The concentrations of lead observed in the Lovecka salami are presented in Table 2. The mean Pb concentrations in beef ranged between 3.77 ppb from domestic production to 7.31 ppb from foreign production.

The mean level of Pb in the beef from foreign production was higher ($p < 0.0001$) than in beef from domestic production. **Oskarsson et al. (1992)** reported a high lead concentration (500 $\mu g.kg^{-1}$) in beef after accidental exposure to lead. **Humphreys (1991)** reviewed the effects of lead in animals and reported that due to its slow rate of elimination lead could accumulate in tissues after prolonged exposure to even low quantities of lead. Pork meat of the foreign production (3.21 ppb) appeared to accumulate more Pb than pork meat in the domestic production (2.03 ppb). Content of lead in the pork samples from foreign production was significantly ($p < 0.05$) higher than in pork samples from domestic production. Regarding lead concentrations in pork, our values are lower compared to data published by **Demirezen and Uruc (2006)**, but higher than reported by **Chowdhury et al. (2011).** Lead concentrations were significantly increased after the addition of additives to the homogenized samples. The concentration of lead detected in the homogenized samples

Table 1 Basic variation statistical characteristics of lead concentration in the raw materials and final product “Malokarpatska” salami

	Beef/Pb		Pork/Pb		Pork bacon/Pb		Homogenized samples/Pb		Final product/Pb	
	D	*F*	*D*	*F*	*D*	*F*	*D*	*F*	*D*	*F*
$\bar{x}$	3.27	7.58	1.63	3.43	1.57	2.41	6.49	7.56	8.89	8.57
SD	0.827	1.214	0.276	1.147	0.368	1.096	1.715	1.696	2.243	1.739
Min.	1.980	5.330	1.110	1.980	1.150	0.420	4.320	5.210	4.210	6.120
Max.	4.420	9.330	1.920	4.990	2.320	4.120	9.920	11.02	11.65	12.89
Med.	3.260	8.110	1.600	3.120	1.570	2.420	6.480	6.970	8.700	8.560
SEM	0.249	0.366	0.083	0.346	0.111	0.331	0.517	0.511	0.676	0.524
CV	25.30	16.03	16.93	33.48	23.40	45.54	26.43	22.43	25.23	20.29
p	p <0.0001		0.014 (p <0.05)		0.622 (NS)		0.328 (NS)		0.994 (NS)	

Legend: $\bar{x}$ – mean, SD – standard deviation, CV(%) – coefficient of variation, SEM – standard error of mean, Min. – minimum, Max. – maximum, Med. – median, D – domestic and F – foreign production, NS - non significant, Pb – lead

Table 2 Basic variation statistical characteristics of lead concentration in the raw materials and final product “Lovecka” salami

	Beef/Pb		Pork/Pb		Pork bacon/Pb		homogenized samples/Pb		final product/Pb	
	D	*F*	*D*	*F*	*D*	*F*	*D*	*F*	*D*	*F*
$\bar{x}$	3.77	7.31	2.03	3.21	1.97	2.40	6.41	6.61	7.62	7.88
SD	0.927	0.882	0.584	1.014	0.629	0.701	0.843	1.103	1.147	1.014
Min.	2.280	5.980	1.220	1.210	1.120	1.150	5.200	4.120	5.700	5.760
Max.	5.720	8.330	2.870	4.980	2.950	3.460	7.900	8.650	9.600	9.730
Med.	3.770	7.540	1.880	3.280	1.880	2.210	6.400	6.870	7.600	8.110
SEM	0.279	0.266	0.176	0.306	0.189	0.211	0.254	0.332	0.346	0.306
CV	24.62	12.07	28.79	31.55	31.95	29.26	13.15	16.68	15.06	12.86
p	p < 0.0001		0.028 (p <0.05)		0.883 (NS)		0.998 (NS)		0.988 (NS)	

Legend: $\bar{x}$ – mean, SD – standard deviation, CV (%) – coefficient of variation, SEM – standard error of mean, Min. – minimum, Max. – maximum, Med. – median D – domestic and F – foreign production, NS - non significant, Pb – lead from foreign products (6.61 ±1.103 ppb) was higher than concentration of lead in homogenized samples from domestic products (6.41 ±0.843 ppb).

Al-Eed et al. (1997) pointed on the addition of spices that may be contaminated with trace and heavy metals to food as a habit may result in accumulation of these metals in human organs and can cause different health problems. **Nkansah and Amoako (2010)** warn that process of spices preparation and handling can make them a source of food poisoning. Lead may reach and contaminate plants, vegetables and fruits. Monitoring of the levels of heavy metals in spices would help ascertain the health impact of taking spices. **Ozkutlu et al. (2006)** reported highest concentration of lead in the samples of garlic (0.999 $mg.kg^{-1}$). In the case of our homogenized samples, they were mixed with additives (salt, sodium ascorbate, erythorbic acid, ground black pepper, sugar, garlic, starter culture).

In final product Lovecka salami from foreign production higher concentration of lead (7.88 ±1.014 ppb) than in final product Lovecka salami from domestic production (7.62 ±1.147 ppb) was found. The maximum lead, which is allowed in meat from different animals, is regulated by the **Commission Regulations (EC) No 466/2001**. The allowable level for lead is 0.1 $mg.kg^{-1}$. The concentrations of these metals measured in this work are all within the accepted limits. There is also an absolute need for good manufacturing practices - Hazard Analysis and Critical Control points to monitor and curtail the contaminants in meat and meat products.

CONCLUSION

The lead levels in meat and meat products analysed in this study were below the legal limits established by the current EU legislation. The obtained results suggested that the concentrations of lead are higher in meat product samples (final products) after homogenization than in raw materials. Technological process of meat processing can create a potential source of heavy metals in final products. Improvements in the food production and processing technology are increasing the chances of food contamination with various environmental pollutants, especially heavy metals. Steps have to be taken to control the environmental contaminants, as a primary and effective food safety control.

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