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Lead in Meat and Meat Products Consumed by the Population in Slovakia

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Abstract: The presence of heavy metals in food is the consequence of atmosphere contamination of polluted soil, waters and results in contaminated feed with heavy metals. The lead concentrations depend on the environmental conditions and the food production methods. The monitoring of lead concentration in meat is important for human health. 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 was carried out to determine the levels of lead in Lovecka salami and selected Ham products during the technological processing. The raw materials originating from domestic and foreign production were compared. Lead concentrations were measured by the method of AA spectrometry with the graphite furnace (Perkin Elmer A Analyst 800; MA, USA). Mean concentration of lead in the starting materials in Lovecka salami for the pork of foreign production had the highest mean lead level (0.607 ppm), followed by beef from foreign production (0.518 ppm), pork from domestic production (0.377 ppm), pork bacon from foreign production (0.173 ppm), beef from domestic production (0.142 ppm) and pork bacon from domestic production (0.106 ppm). The highest concentrations of lead were found in the homogenized samples with addition of additives and spices (salt, sodium ascorbate, erythorbic acid, ground black pepper, sugar, garlic, starter culture) from foreign starting materials and final samples from foreign and domestic production in Lovecka salami (0.769; 0.811 and 0.676 ppm, respectively). The highest concentrations of lead in the selected Ham product were found in final sample from foreign production (0.813 ppm), followed by final sample from domestic production (0.740 ppm), homogenized sample with additives (salt, Sodium Nitrite, Sodium Pyrophosphate, Sodium Tripolyphosphate and Ascorbic acid) from foreign starting material and domestic starting material (0.791 and 0.697 ppm, respectively). The lowest mean Pb concentration in selected Ham was found in the starting materials (pork thigh) from domestic and foreign production (0.344 and 0.397 ppm, respectively). In the present study, samples of lead were higher than the maximum lead levels allowed by Commission Regulations (EC) No1881/2006. The allowable level for lead is 0.1 mg kg^{-1}. Technological process of meat processing can create a potential source of heavy metals risk 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. 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 (Chowdhury *et al*., 2011). A 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). 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 fertilizer, pesticide and herbicides (Jayasekara *et al*., 1992). These metals stay permanently because they cannot be degraded in the environment (Baykov *et al*., 1996). They enter into the food material and from there they ultimately make their passage into the tissue (Munoz-Olives and Camara, 2001).

Meat is a very important human food; therefore, it may potentially accumulate toxic minerals and represents one of the sources of heavy metals for humans. Meat represents the main source of protein in the diet (Bendeddouche *et al*., 2014). Meat is also a very rich and convenient source of nutrient, including microelements. The chemical composition of meat depends on both the kind and degree of the feeding animal tissue (Munoz-Olives and Camara, 2001).

Metals in general can be classified as toxic (cadmium, lead and mercury) and essential (cobalt, copper, zinc, iron). Toxic elements can be very harmful even at low concentration when ingested over a long time period due to their ability to accumulate in human and animal body (Ray, 1994).

Lead is toxic heavy metals with widespread industrial use, but no known nutritional benefits. Chronic exposure at relatively low levels can result to damage to kidneys and liver and to immune, reproductive, cardiovascular, nervous and gastrointestinal systems (Okoye and Ugwu, 2010). Lead, for example, bio-accumulates in plants and animals. Its concentration is generally magnified in the food chain (Halliwel *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 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 salami and selected Hamproducts during the technological processing. The raw materials originating from domestic and foreign production were compared.

Materials and Methodology

Sample Collection

To reach representative samples, average composition and characteristics of the goods were analyzed. The concentration of lead was determined in total 160 samples during the year 2013 from raw materials and final product, respectively. Raw materials from domestic production were collected in central Slovakia, in the central Europe region. Raw material from foreign was collected from different countries of West Europe. The collection of samples during the manufacturing process was carried out under the following scheme:

> *"Lovecka salami"*-basic raw material (beef, pork and pork bacon) was collected; than samples of homogenized meat with additives (salt, sodium ascorbate, e*rythorbic 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 incimates with a w = 0.95 was analyze

> *"Selected ham"* was collected basic raw (pork thigh), than samples of homogenized meat with additives (salt, Sodium Nitrite, *sodium pyrophosphate, sodium tripolyphosphate,* Ascorbic acid) and finish product after heat treatment

Sample Preparation

Collected samples were placed to plastic bags and frozen (-18°C). About 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 analyzed by the AA spectrometer with the graphite furnace (Perkin Elmer A Analyst 800; MA, USA) to determine lead concentration (Binkowski, 2012). Final results were given in ppm (mg/kg) for meat and other samples.

Results and Discussion

In this study the content of lead in Lovecka salami specifically in: Beef, pork, pork bacon, homogenized samples with additives (salt, sodium ascorbate, e*rythorbic acid, ground black pepper,* sugar, garlic, starter culture) and final samples and selected hamsamples in: Pork thigh, homogenized samples with additives additives (salt, Sodium Nitrite, *sodium* *pyrophosphate, sodium tripolyphosphate,* Ascorbic acid) and finish product after heat treatmentwas determined. Also the raw materials originating from domestic and foreign productionwere compared.The concentration of lead in the studied in Lovecka salami are given in Table 1. The level of lead in beef from domestic production (0.142±0.008 ppm) was lower than in beef from foreign production (0.518±0.134 ppm). Pb content in the beef samples from foreign production was significantly higher ($p<0.0001$) compared to those from domestic production. These results were higher than previously reported Gonzales-Waller *et al*. (2006). They have shown mean concentration of lead in the beef meat samples from 0.0191 to 0.090 ppm. Our results are in accordance with thosedescribed by Oskarsson *et al*. (1992) reporting lead concentration in the range of 0.412-0.568 ppm in beef after accidental exposure to lead. Vreman *et al*. (1988) found higher concentration of lead in the muscle of dairy cows raised on pasture than in the muscle of dairy cows kept indoors. Koréneková *et al*. (2002) assessed that the values exceeding limit Pb in muscle were recorded in three Slovak regions: Haniska, Cestice and Perin (0.416, 0.671 and 2.324 ppm, respectively). From their result obtained concerning heavy metals in the area of observation, we can conclude that lead is of particular ecological importance. They consider necessary to implement ecological measures in the area of observation with respect to human consumption of beef. Humphreys (1991) reviewed the effects of lead in animals and reported that due to its low rate of elimination and harmful levels,lead could accumulate in tissues after prolonged exposure toeven low quantities. Lead is known to induce reduced cognitive development and intellectual performance in children and increase blood pressure and cardiovascular diseases in adults WHO (2007). Bendeddouche *et al*. (2014) stated that the average amount of this metal was between 7.76-8.43 ppm of beef slaughtered in Algeria. This study also reported high concentration of lead than those described in our study. Similar results were obtained by Akan *et al*. (2010) who determined lead concentrations in beef samples from Kasawan Shanu, Maiduguri Metropolis, Nigeria (0.25 ppm).

The level of lead in pork from foreign production was higher (0.607±0.173 ppm) than in pork from domestic production (0.377±0.033 ppm). There was a significant variation ($p<0.0001$) 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). Bendeddouche *et al*. (2014) reported that the average concentration of lead in fresh meat from four animals: Beef, sheep, chicken and camel produced in Algeria ranged from 8.80 ppm dry weight (chicken), 3.49 ppm dry weight (sheep) to 2.01 ppm dry weight (camel). Lead concentrations in our pork samples were similar to those recorded by Demirezen and Uruc (2006), who corresponding values for lead in meat (0.18-0.28 ppm). Mean contents of lead in pork bacon from foreign production (0.173±0.067 ppm) was higher than in pork bacon from domestic production (0.106±0.005 ppm). 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 pork of foreign production had the highest mean lead level (0.607 ppm), followed by beef from foreign production (0.518 ppm), pork from domestic production (0.377 ppm), pork bacon from foreign production (0.173 ppm), beef from domestic production (0.142 ppm) and pork bacon from domestic production (0.106 ppm).

The average concentration of lead was higher in homogenized samples with addition of additives and spices. The level of lead in the homogenized samples from foreign starting materials was 0.769±0.100 ppm. The average lead concentration was 0.601±0.049 ppm in homogenized samples from domestic starting materials. Ulrich *et al*. (2001) review that secondary contamination of food may occur due to processing an addition of spices and 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).

In final product Lovecka salami from domestic production the lead concentration (0.676±0.068 ppm) was lower than in final product Lovecka salami from foreign production (0.811±0.115 ppm). Pb content in the final sample from foreign production was significantly higher ($p<0.01$) compared to those from final product from domestic production.

Bolger *et al*. (1996) reported that infants and children are more susceptible to lead toxicity than adults because they consume more food per unit of body mass, with the lead getting absorbed more readily.

The half-life of lead in blood, soft tissues, spongy bones (pelvis, ribs and skull) and cortical bones (mid tibia and mid femur) is 35, 40 days, 3-5 and 30 years, respectively (Pueschel *et al*., 1996). Tuormaa (1995) reported that an excessive lead accumulation in children is known to cause hyperactivity, reduced intelligence and antisocial behavior. Lead could cause adverse effects on the renal and nervous systems and cross the placental barrier, having potential toxic effects on the fetus (WHO, 2003). The concentrations of lead in the "selected Ham" are presented in Table 2.

Table 1. Basic variation statistical characteristics of lead con-centration in the raw materials and final product "Lovecka" salami

Pb		$\overline{x}$	SD	Med (x)	CV	P
Beef	D	0.142	0.008	0.139	5.45	p<0.0001
	F	0.518	0.134	0.479	25.93	
Pork	D	0.377	0.033	0.389	8.65	p<0.0001
	F	0.607	0.173	0.601	28.52	
Pork bacon	D	0.106	0.005	0.104	4.45	0.6523 (NS)
	F	0.173	0.067	0.163	38.64	
HS	D	0.601	0.049	0.620	8.14	p<0.0001
	F	0.769	0.100	0.792	13.02	
Final sample	D	0.676	0.068	0.698	10.01	p<0.01
	F	0.811	0.115	0.818	14.19	

Table 2. Basic variation statistical characteristics of lead con-centration in the raw materials and final product "Selected ham"

Pb		$\overline{x}$	SD	Med (x)	CV	P
Pork thigh	D	0.344	0.032	0.353	9.29	0.5087 (NS)
	F	0.397	0.039	0.406	9.78	
HS	D	0.697	0.106	0.661	15.16	p<0.05
	F	0.791	0.087	0.808	11.12	
Final sample	D	0.740	0.072	0.725	9.72	0.1499 (NS)
	F	0.813	0.039	0.826	4.75	

The mean Pb concentrations in pork thigh ranged between 0.344 from domestic production to 0.397 ppm from foreign production. Lead data showed noticeable insignificant difference between Pb content in pork from domestic production and pork from foreign production. Regarding lead concentrations in pork, our values are lower compared to data published by Demirezen and Uruc (2006), but higher 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 from foreign products (0.791±0.087 ppm) was higher than concentration of lead in homogenized samples from domestic products (0.697±0.106 ppm). The mean level of Pb in the homogenized samples from foreign production were higher ($p<0.05$) than in homogenized samples from domestic production. Nkansah and Amoako (2010) attention that process of preparation spices and handling can make them a source of food poisoning. Lead may reach and contaminate plants, vegetables and fruits. Monitoring the levels of heavy metal toxicity in spices would help ascertain the health impact of taking spices. 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 lead to different health problems. Ozkutlu *et al*. (2006) reported highest concentration of lead in the samples of garlic (0.999 mg kg^{-1}). In final product "Selected ham" from foreign production higher concentration of lead (0.813±0.039 ppm) than in final product "Selected ham" from domestic production (0.740±0.072 ppm) was found. Santhi *et al*. (2008) reported relatively higher lead content in bacon (1.641±0.406 ppm), ham (1.966±0.463 ppm), sausage (1.352±0.257 ppm), salami (3.250±1.525 ppm) and luncheon meat (2.231±0.432 ppm) obtained from retail outlets of Chennai city. Akan *et al*. (2010) showed the highest concentration of lead in caprine (1.34 ppm) and the lowest concentration of lead in mutton and chicken (0.76, 0.65 ppm, respectively) from Nigeria. Akan *et al*. (2010) also reported that significantly higher amounts of lead in liver and kidneys were found in cattle sampled around the refineries than those cattle in the rural area.

In the present study, samples of lead were higher than the maximum lead level allowed Commission Regulations (EC) No 1881/2006. The allowable level for lead is 0.1 mg kg^{-1}.

Conclusion

The levels of lead in meat and meat products consumed by the population in Slovakia were determined. The present study depicts that the lead levels in meat and meat products were higher than the maximum lead level allowed the legal limits established by the current EU legislation. The obtained results suggested that the concentrations of lead are higher in the starting materials for the pork and beef in "Lovecka salami". Generally, beef and pork meat were found to have the highest significant levels of lead samples after homogenization in "Lovecká salami"; "Selected ham".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.

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Author's Contributions

All authors equally contributed in this work.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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