Mercury concentration in meat products

Anetta Lukáčová, Łukasz Binkowski, Jozef Golian

Department of Food Hygiene and Safety
Faculty of Biotechnology and Food Sciences
Slovak University of Agriculture Nitra
Nitra, Slovak Republic

Abstract

Contamination with heavy metals is a serious threat in view of their toxicity, bioaccumulation and biomagnification in the food chain. The aim of this study was to determine levels of mercury in the traditional meat products Malokarpatská and Lovecká salami during technological processing along with a comparison of raw materials originating from domestic and foreign production determined in 2011–2012. Mercury content was measured by a cold vapour atomic absorption spectrometry. The highest concentration of mercury in raw materials (beef, pork, pork bacon) was detected in beef from foreign production. Increasing concentrations of mercury were found after the addition of additives, spices and curing compounds causing a threefold increase in the concentration of mercury in final products.

Atomic absorption spectrophotometry, meat, meat products, mercury

Introduction

Mercury is a heavy metal that occurs naturally in the environment. The main sources of mercury include combustion of fossil fuels and municipal waste (Lukáč and Massányi 2011). Mercury in the form of methylmercury in aqueous environments can become part of the terrestrial environment as various species feed on aquatic animals. An environment with contaminated water increases the concentration of methylmercury in fish meat up to 10 $mg \cdot kg^{-1}$. Blood circulation carries inhaled elemental mercury vapour to the brain where it impairs normal metabolic processes. The Hg^{2+} cations harm the kidneys. The toxic effects of mercury are tragically illustrated by 111 cases of poisoning with 43 deaths in Japan between 1953 and 1960. The value of Hg recorded in marine fish at that time amounted to 5 – 20 ppm. The toxic effects of Hg manifest themselves in neurological damage and chromosomal disorders; more moderate effects include depression and psychopathological manifestations. Increased exposure to mercury in humans manifests itself by changes in behaviour, memory loss and insomnia (Nordberg et al. 2007). Adverse effects of mercury on the cardiovascular system have been confirmed in other years, more specifically mercury has been identified as an element that can generate oxidative stress (Virtanen et al. 2007). Mercury is considered the most serious contaminant of foodstuffs of animal and plant origin second only to cadmium (Massányi et al. 2003). Velíšek (2002) states that the tolerable daily intake of total mercury is 50 mg for adults, and the tolerable daily intake of methylmercury for a person of a body weight of 70 kg is 33 µg. This has prompted increased interest in monitoring the safety of produced food (Toman et al. 2000).

Meat is a rich and convenient source of nutrients that contain significant quantities of trace elements. The chemical composition of meat depends on the type and diet of the animals. Mineral requirements of animals depend on their age, physiological condition, quality of feedstuff and rearing conditions (Akan et al. 2010). Meat and meat products are an important part of human nutrition. They provide us with proteins, minerals, vitamins and trace elements, and contribute to the resolution of the global problem of a shortage of nutritionally adequate foods (Alturiqi and Albedair 2012). The risk associated with evidence of heavy metals in food products has aroused widespread concern about human health. Due to the toxic nature of heavy metals, their presence in meat is of great concern

Address for correspondence:

Prof. Ing. Jozef Golian, Ph.D.
Department of Food Hygiene and Safety
Faculty of Biotechnology and Food Sciences
Slovak University of Agriculture Nitra
Str. A. Hlinku 2, 949 01 Nitra, Slovak Republic

Phone: +421 376 414 325
E-mail: Jozef.Golian@uniag.sk
www.maso-international.cz

to human health and to food safety itself. In view of their proven toxicity, bioaccumulation and biomagnification in the food chain, heavy metals are considered a serious threat (Demirezen and Uruç 2006). In recent years, much attention has been paid to the determination of heavy metal concentrations in fish and other foods in order to monitor potential risks to human health (Moiseenko and Kudryavtseva 2001; Mansour and Sidky 2002; Farkas et al. 2003).

This study investigated mercury concentrations in traditional meat products consumed in the Slovak Republic. Specifically, mercury concentrations were determined during the course of the technological processes involved in the production of meat products that are not heat-treated, namely Lovecká and Malokarpatská salami, and raw materials from domestic and foreign production were compared.

Materials and Methods

Our sampling design ensured that representative samples of average composition and product properties were collected. In 2011 and 2012, total mercury concentrations were determined in 180 samples of raw materials and finished products that were differentiated with respect to the domestic or foreign origin of the raw materials. The following sampling schemes were used:

Malokarpatská salami – the raw materials were beef, pork and pork bacon, homogenised meat batter with additives (salt, pepper and seasoning extracts, dextrose, sodium nitrite as a stabiliser, *Lactobacillus* starter culture, flavour enhancer) – ready product.

Lovecká salami – the raw materials were beef, pork, pork bacon, homogenised meat batter with additives (salt, ground black pepper, sugar, garlic, ground cloves, erythorbic acid as an antioxidant and sodium ascorbate, starter culture and collagen casings) – ready product.

Sample preparation

The collected samples of meat and meat products weighing 30 – 50 mg were packed in plastic bags and frozen to -20 °C. The material was not mineralised prior to measurement and analyses were performed on the wet weight of the material. The samples were supplemented with standardising components, namely the M component (Wako Pure Chemicals Industries Ltd., NIC 286-61845) and the B component (Wako Pure Chemicals Industries Ltd., 282- 98 6266 5) in order to minimise any measurement interference. The accuracy of the method was verified by certified reference samples (BCR-463). All concentrations are expressed in parts per million ($\mu g \cdot g^{-1}$).

Sample analysis

Mercury concentrations in samples were measured by cold vapour atomic absorption spectrometry (Nippon Instrument Corporation MA-2).

Statistical analysis

The data obtained were statistically evaluated for the basic parameters of descriptive statistics (mean, standard deviation, coefficient of variation, standard error of the mean). Significance at the level of α = 99.99% was calculated by one-way analysis of variance using Dunnett's test.

Results and Discussion

On the basis of the results of measurements and statistical analyses, we found that the mean mercury concentrations in the input raw materials (beef, pork and pork bacon) for the production of the Malokarpatská salami fell within a range of 0.0006 ppm – 0.0036 ppm, with the highest mean mercury concentration found in beef imported from abroad (0.0036 ppm). Using univariate analysis, we found a significant difference at the $P < 0.05$ level of significance in mercury concentrations between beef imported from abroad and beef from farms in the Slovak Republic. Alturiqi and Albedair (2012) detected mercury concentrations in beef from 0.0009 to 0.087 ppm. In their results, Park et al. (2005) reported mercury concentrations in samples of cattle in South Korea of 0.68 ppm, which they explained as the impact of environmental pollution. Mercury concentrations in pork and pork fat were significantly lower, compared to mercury concentrations in beef (from 0.0006 to 0.0019 ppm). These values were markedly lower, compared with the data published by Vos et al. (1986) who reported a mean mercury concentration of

0.00523 ppm in pork from the Netherlands. A comparison between mercury concentrations determined in pork from domestic and foreign production showed insignificant differences at the level of significance $P < 0.05$. A comparison of mercury concentrations in pork bacon from domestic and foreign farms showed significant differences at the $\alpha < 99.9$ ($P < 0.01$) level of significance.

Mercury concentrations in the homogenised meat batter after the addition of additives averaged 0.0061 to 0.0071 ppm. Higher mercury concentrations were found in the batter made from meat of foreign provenance. These higher mercury concentrations were significantly higher ($P < 0.05$) than mercury concentrations in the batter from raw materials from domestic production.

Table 1. Basic statistical variance characteristics of mercury concentrations in Malokarpatská salami

	Beef		Pork		Pork bacon		Homogenised batter		Final product	
	D	I	D	I	D	I	D	I	D	I
X	0.0027	0.0036	0.0015	0.0018	0.0019	0.0006	0.0061	0.0071	0.009	0.009
SD	0.0011	0.0006	0.0005	0.0004	0.0005	0.0002	0.00153	0.00168	0.0023	0.003
SEM	0.0003	0.0002	0.0002	0.0001	0.00015	0.0005	0.00048	0.00025	0.0007	0.001
CV	39.82	17.55	34.17	22.31	24.00	24.85	15.57	9.64	25.47	12.89
P	0.0368 (P < 0.05)		0.1107 (NS)		0.0023 (P < 0.01)		0.0485 (P < 0.05)		0.2386 (NS)	

D - products made from domestic raw materials, I - products made from foreign raw materials; $\bar{x}$ - mean, SD - standard deviation, SEM - standard error of the mean, CV (%) - coefficient of variation, P - value

An interesting finding with respect to mercury concentrations was the fact that values of mercury concentrations in the final Malokarpatská salami were identical irrespective of whether the meat in the finished salami originated from foreign farms or domestic farms (0.009 ppm) (Table 1).

This fact can be explained by the use of additives that may contain higher concentrations of mercury in the production of the Malokarpatská salami. FAO (2009) studies point to various uses of spices, but there is a little information available on the safety of spices in relation to concentrations of heavy metals. Plants, vegetables, fruits and canned foods can be contaminated with heavy metals through air, water and soil, though also during their industrial processing and packaging. In their study, Nkansah and Amoako (2010) highlighted increased concentrations of mercury in black pepper, garlic, onion,

Table 2. Basic statistical variance characteristics of mercury concentrations in Lovecká salami

	Beef		Pork		Pork bacon		Homogenised batter		Final product	
	D	I	D	I	D	I	D	I	D	I
X	0.0025	0.0037	0.0013	0.0014	0.0017	0.0011	0.0084	0.0061	0.0094	0.0067
SD	0.0011	0.0003	0.00048	0.0001	0.0004	0.0001	0.0027	0.0005	0.0022	0.0006
SEM	0.00034	0.0001	0.00015	0.0001	0.0001	0.0001	0.0008	0.0001	0.0007	0.0002
CV	42.58	8.65	37.07	5.46	23.43	4.47	32.91	8.15	23.08	998
P	0.0027 (P < 0.01)		0.2324 (NS)		P < 0.0001		0.0145 (P < 0.05)		0.001 (P < 0.01)	

D - products made from domestic raw materials, I - products made from foreign raw materials; $\bar{x}$ - mean, SD - standard deviation, SEM - standard error of the mean, CV (%) - coefficient of variation, P - value white pepper, rosemary and anise (0.002, 0.0019, 0.00123, 0.0042, 0.0035 and 0.0013 ppm, respectively). Takácsová and Príbela (1996) highlight the chemicals detected in food that can be considered natural contaminants in the environment, but many of them are considered secondary contaminants that enter foodstuffs during processing or are intentionally added to foodstuffs to adjust their biological value, shape, consistency or aroma or to extend their shelf life.

The lowest mercury concentrations in samples of raw materials, i.e. beef, pork and pork bacon, in the manufacture of Lovecká salami were 0.0017 ppm and 0.0011 ppm in pork bacon of domestic and foreign origin, respectively (Table 2). Significant differences in mercury concentrations between pork bacon of domestic and foreign origin were at a level of significance of $P < 0.0001$. The highest mercury concentrations were found in beef imported to Slovakia from foreign farms (0.0037 ppm). This concentration is higher than the 0.001 ppm found in beef by Akan et al. (2010) or the 0.00023 ppm found by Alturiqi and Albedair (2012). Aranha (1994) reports significantly higher amounts of mercury in the muscle of cattle from areas with refineries (4.223 ppb). Šalgovičová (2005) point out, that average mercury concentrations determined in beef by coordinated targeted monitoring of the consumer basket in the years 1991–2005 ranged from 0.0005 to 0.0025 $mg \cdot kg^{-1}$ (ppm). This, in view of the standard in force in 2004 stipulating the limit values of mercury concentrations in meat and meat products at 0.05 $mg \cdot kg^{-1}$, represented a low level of contamination (Decree No. 608/3/2004-100 Coll.).

As in the case of Malokarpatská salami, significantly increased mercury concentrations were found in the homogenised batter for Lovecká salami (0.0061 to 0.0084 ppm) and also in the finished product (0.0067 to 0.0094 ppm). Of the 180 samples, mercury concentrations were below the permitted limit of 0.5 or 1.0 $mg \cdot kg^{-1}$ (Commision Regulation (EC) No. 1881/2006) which are the concentration limits stipulated for fish muscle and fishery products. The legislation does not stipulate any maximum permitted mercury concentrations in other types of meat and meat products.

Conclusions

In this study, we monitored mercury concentrations in meat products, namely Lovecká and Malokarpatská salami. A comparison of raw materials from domestic and foreign production showed that the highest mercury concentrations were found in beef from foreign farms in both Malokarpatská and Lovecká salami. The lowest mercury concentrations in raw materials were found in pork bacon. Markedly higher mercury concentrations, which were three times higher than those in raw materials, were found in homogenised meat batter and, subsequently, in the ready Lovecká and Malokarpatská salami.

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