

CONCENTRATION OF CADMIUM IN MEAT AND SELECTED MEATS PRODUCTS

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ABSTRACT

The cadmium concentrations depend on the environmental conditions and food production methods. The monitoring of cadmium concentration in meat is important for human health. The concentrations of cadmium in meat and meat products collected from central Slovakia, in the central Europe region and from different countries of West Europe were assessed using by AA spectrometer with graphite furnace (PerkinElmer AAnalyst 80, MA, USA). Within starting materials we detected the highest values of cadmium in beef from foreign production (0.1101 ppm), followed by pork from foreign production (0.0901 ppm) in Lovecka salama and pork thigh (0.0523 ppm) in selected ham. In Lovecka salami we were found the highest concentration of cadmium in final samples from foreign starting materials, followed by homogenized samples from foreign starting materials, final samples from domestic starting materials and homogenized samples from domestic starting materials (0.3728, 0.3549, 0.2387, 0.2112 ppm, respectively). The highest concentration of cadmium in selected ham were found in final products from foreign starting materials, homogenized samples from foreign starting materials, final products from domestic starting materials and homogenized samples from domestic starting materials (0.1453, 0.1382, 0.0810, 0.0734 ppm, respectively). The obtained results suggested that the concentrations of cadmium are higher in homogenized samples and final products in Lovecka salami and selected ham in comparison with to starting materials. Technological process of meat processing can create a potential source of heavy metals in final products.

Keywords: Cadmium, beef, pork, pork thigh, pork bacon, meat products, atomic absorption spectrophotometry

INTRODUCTION

Meat is very rich and convenient source of nutrients, also to large extent microelements. Meat represents the main source of protein in the diet (Beneddouché *et al.*, 2014). The chemical composition of meat depends on both kind and degree of the feeding animal (Munoz-Olives and Camara, 2001). The need for mineral compounds depends on the age, physiological state and feed intake as well as on living conditions. 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 (Baykov *et al.*, 1996).

The main human exposure to heavy metals usually comes from food. After continuously evaluating studies on food additives and their toxicity, the WHO has come to the conclusion that even low levels of some metals, such as cadmium and lead, can give rise to diseases in humans (WHO 2000, WHO 2001). 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/cm³ (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. These metals stay permanently because they cannot be degraded in the environment. They enter into the food material and from there they ultimately make their passage into the tissue (Jayasekara *et al.*, 1992). Heavy metals pollutants can contaminate the products during processing (through the raw material, spices, water and packaging) by inhalation of air and penetration through the skin's surface (Raikwar *et al.*, 2008).

Cadmium is an environmental contaminant unique among metals because of its non-biodegradable nature, long environmental persistence, diverse toxic effects, extremely protracted biological half-life, low rate of excretion from the body and predominant storage in soft tissue, although its toxic effects extend to other organs as the lungs, prostate and the bladder (Lukáč and Massányi, 2011). Cadmium has a long residence time in human tissues (10-40 years), especially in the kidneys (Rubio *et al.*, 2006). The toxic effects of cadmium are noticeable in various ways. It can interfere with some of the organism's enzymatic reactions, substituting zinc and other metals, manifesting its action in several pathological processes such as renal dysfunctions, hypertension, arteriosclerosis, inhibition of growth, damages in the nervous system, bone demineralisation and endocrine

disruption (Lafuente *et al.*, 2004). Cadmium is suspected to be an etiological factor in various pathological processes as higher blood pressure, arteriosclerosis, growth inhibition, alterations in central nervous system, hepatic dysfunction, bronchitis and teratogenic effects (Oishi *et al.*, 2000). Cadmium can, also, stimulate or inhibit the immune activity according to the dose. Doses of 5 and 10 mg/kg of cadmium inhibit the humeral and cellular immune response in rats, whereas doses of 25, 50 and 100 mg/kg produce opposite effects (Massányi *et al.*, 2007).

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

MATERIAL AND METHODS

Sample collection

To reach representative samples, average composition and characteristics of the goods were analysed. The concentration of cadmium 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, 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 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). 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 (HNO₃ 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 (PerkinElmer AAnalyst 800; MA, USA) to determine cadmium of concentration (Binkowski, et al., 2013). Final results were given in ppm (mg.kg⁻¹) for meat and other samples.

RESULTS AND DISCUSSION

In this study we determined the content of cadmium in Selected ham samples in: pork thigh, homogenized samples with additives (salt, Sodium Nitrite, sodium pyrophosphate, sodium tripolyphosphate, Ascorbic acid) and finish product after heat treatment and Lovecka salami specifically in: beef, pork, pork bacon, homogenized samples with additives (salt, sodium ascorbate, erythorbic acid, ground black pepper, sugar, garlic, starter culture and final samples) was determined. Also the raw materials originating from domestic and foreign production were compared. The concentration of cadmium in the studied in Lovecka salami are given in table 1. The level of cadmium in beef from domestic production (0.0321±0.0106 ppm) was lower than in beef from foreign production (0.1101±0.0313 ppm). Cd content in the beef samples from foreign production was significantly higher (P<0.05) compared to those from domestic production. The obtained results are in agreement with the obtained by Koréneková et al. (2002), their results ranged from 0.070 to 0.387 ppm in biological samples of cattle from three regions (Haniska, Cestice and Perín) in Slovakia. The average values for cadmium in our study were higher than the corresponding values for cadmium in meat from cattle produced in Algeria (0.0076±0.03 ppm) (Beneddouche et al. 2014) who they further state that Cd concentrations in

meat depend on the concentration of Cd in the animal feed. The hazardous effect was more visible at higher bioaccumulation of heavy metals during vegetative growth stage. However higher average concentration of Cd were observed in in beef products in Saudi Kingdom during 2011 – 2012 (3.06±0.16 ppm) and residue levels in the liver (0.0097 ppm) and muscle (0.001 ppm) of cattle from Galicia (Spain) (Alturiqi et al. 2012, Lopez-Alonso et al., 2000) in comparison to our results. The level of cadmium in pork from foreign production was higher (0.0901±0.0178 ppm) than in pork from domestic production (0.0435±0.0142 ppm). Cadmium data showed noticeable insignificant difference between Cd content in pork from domestic production and pork from foreign production. Gonzales –Waller et al. (2006) reported that average amount of cadmium in pork and pork meat products in Tenerife Island, Spain ranged between 0.00549 ppm for pork and 0.00650 ppm for pork meat products. Iwegbue et al. (2008) reported mean levels of Cd in Turkey meat collected from Ughelli zone in Southern Nigeria 1.29±0.22 ppm. Cadmium concentrations in meat increase with the age of the animal and depend on the concentrations of Cd in the feed (Hecht, 1983). Vos et al. (1987) stated that cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage and reproductive deficiencies. Mean contents of cadmium in pork bacon from foreign production (0.0379±0.0174 ppm) was higher than in pork bacon from domestic production (0.0189±0.0101 ppm). Cadmium data showed noticeable insignificant difference between Cd content in pork bacon from domestic production and pork bacon from foreign production. The highest level of cadmium in bacon was observed in pork products in Chennai (India) (Santhi et al., 2008) in mean 0.220±0.031 ppm. Their results indicated that contamination of meat products with cadmium might occur in three ways, on from animal grazing on lands spread with sewage sludge or phosphate fertilizers and another from animal grazing on lands contaminated with industrial cadmium effluent. Secondary cadmium contamination of food occurs as a result of its use in food processing (Zurera-Cosano, 1993). Muller et al. (1996) that reported that sausages had higher cadmium content than the raw meat. The addition of spices during production of homogenized samples might be the main reason since spices could contain cadmium concentrations up to 200mg/g (Santhi et al., 2008). The data is consistent with our following results.

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

Cd	beef		pork		pork bacon		homogenized samples		final sample	
	D	F	D	F	D	F	D	F	D	F
–	0.0321	0.1101	0.0435	0.0901	0.0189	0.0379	0.2112	0.3549	0.2387	0.3728
X										
Min	0.0213	0.0657	0.0243	0.0567	0.0013	0.0124	0.1253	0.2100	0.1587	0.2400
Med	0.0307	0.1056	0.0439	0.0915	0.0186	0.0351	0.2166	0.3600	0.2457	0.3349
Max	0.0487	0.1647	0.0653	0.1253	0.0324	0.0653	0.2984	0.4900	0.3583	0.5400
SD	0.0106	0.0313	0.0142	0.0178	0.0101	0.0174	0.0486	0.1007	0.0574	0.1127
SEM	0.0033	0.0099	0.0045	0.0056	0.0032	0.0055	0.0154	0.0319	0.0182	0.0357
CV	32.25	28.00	32.60	19.69	51.80	45.68	22.75	28.40	24.04	30.25
P	0.0204 (P<0.05)		0.4739 (NS)		(NS)		P<0.001		P<0.001	

Legend: X – mean, SD – standard deviation, Med (x) – Median, CV (%) – coefficient of variation, D – domestic and F – foreign production, NS – non significant, Cd – cadmium

The average concentration of cadmium was higher in homogenized samples with additives and spices in comparison the starting materials. The level of cadmium in the homogenized samples from foreign starting materials was 0.3549±0.1007 ppm. The average cadmium concentration was 0.2112±0.0486 ppm in homogenized samples from domestic starting materials. The mean level of cadmium in the homogenized samples from foreign production was higher (P<0.001) than in homogenized samples from domestic production. In final product Lovecka salami from domestic production (0.2387±0.0574 ppm) was lower than in final product Lovecka salami from foreign production (0.3728±0.1127 ppm). Cd content in the final sample from foreign production was significantly higher (P<0.001) compared to those from final product from domestic production. Santhi et al. (2008) in their study reported that sausages and salami had the highest concentration of cadmium among the products analysed could be due to the processes involved during canning. The biological half-life of cadmium in the human kidney is long and has been estimated to be 10 to 30 years (Nordberg, 1999). The levels of cadmium in pork and beef meat

from foreign production, homogenized samples and final product are above guideline of 0.050 mg/kg (Commission regulation 488/2014 2014). The concentrations of cadmium in the selected ham are presented in Table 2. The mean Cd concentrations in pork thigh ranged between 0.0179 to 0.0782 ppm. The concentration of cadmium in pork thigh from foreign production (0.0523±0.0151 ppm) was higher than in pork thigh from domestic production (0.0204±0.0028 ppm). Data showed noticeable insignificant difference between Cd content in pork thigh from domestic production and pork thigh from foreign production. The cadmium concentrations obtained from this study were lower than those recorded Demirezen-Uruc (2006). Their levels of cadmium in pork samples collected in Kayseri (Turkey) ranged from 0.77 to 1.04 ppm. The mean level of Cd in the homogenized samples from foreign production was higher (0.1303±0.0460 ppm) than concentration of cadmium detected in the homogenized samples from domestic production (0.0705±0.0201 ppm).

Table 2 Basic variation statistical characteristics of lead concentration in the raw materials and final product „Selected ham“

Cd	pork thigh		homogenized samples		smoked homogenized samples		final sample	
	D	F	D	F	D	F	D	F
—	0.0204	0.0523	0.0705	0.1303	0.0734	0.1382	0.0810	0.1453
X	0.0179	0.0345	0.0356	0.0654	0.0422	0.0953	0.0382	0.0654
Min	0.0197	0.0564	0.0752	0.1307	0.0782	0.1354	0.0812	0.1516
Med	0.0254	0.0782	0.0952	0.1987	0.0952	0.1984	0.1254	0.1987
Max	0.0028	0.0151	0.0201	0.0460	0.0184	0.0355	0.0238	0.0451
SD	0.0009	0.0048	0.0064	0.0146	0.0059	0.0113	0.0076	0.0143
SEM	14.04	29.15	28.61	35.31	25.20	25.73	29.50	31.12
CV	0.0752(NS)		P<0.001		P<0.001		P<0.001	

Legend: X – mean, SD – standard deviation, Med (x) – Median, CV (%) – coefficient of variation, D – domestic and F – foreign production, NS – non significant, Cd – cadmium

In final product selected ham from foreign production higher concentration of cadmium (0.1453±0.0451 ppm) than in final product Selected ham from domestic production (0.0810±0.0238 ppm) were found. Our results were lower than obtained by **Alturiqi – Albedair (2012)**. They have shown mean concentration of cadmium in sausage is 3.33±0.17 ppm. **Santhi et al. (2008)** stated that average amount of this metal in salami was 0.296±0.036 ppm. However, the obtained result of cadmium in the samples with the exception of samples pork thigh from domestic production exceeds the permissible levels 0.050 mg/kg (**Commission regulation 488/2014 2014**).

CONCLUSION

The levels of cadmium in meat and meat products consumed by the population in Slovakia were determined. The cadmium levels in pork and beef meat from foreign production, homogenized samples, final product in Lovecka salami and pork thigh from foreign production, homogenized samples and final products in Selected ham analysed in this study were exceeds the permissible levels. The cadmium levels in beef, pork from domestic production and pork bacon from domestic and foreign production in Lovecka salami and pork thigh in Selected ham from domestic production were below the legal limits by the current EU legislation. The obtained results suggested that the concentrations of cadmium are higher in homogenized samples and final products in Lovecka salami and selected ham in compared starting materials. Technological treatments are important for levels of trace elements in meat products. Improvements in the food production and processing technology are food contamination with various environmental pollutants and heavy metals.

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