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HEAVY METALS CONTAMINATION LEVELS IN PROCESSED MEAT MARKETED IN ROMANIA

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Abstract

Atomic absorption spectrophotometry (AAS) technique was applied in order to identify the occurrence of certain heavy metals in samples of pork products, such as bacon, ham, sausage and salami, taken from four commercial centers in Romania. Lead levels in samples varied from 0.58 to 0.96 mg/kg, Cadmium values from 0.11 to 0.21 mg/ kg, Copper from 0.73 to 1.32 mg/kg, while Zinc levels were detected between 32.19 and 42.12 mg/kg. Lead, Copper and Zinc found in samples were lower than the maximum levels recommended by the Food and Agriculture Organization (FAO) and the European Commission (EC), while Cadmium was quantified with values higher than the upper admitted threshold, of 0.1 mg/kg, as stated by the same authorities. From total of examined samples, sausage and salami contained the highest levels of heavy metals. The presence of heavy metals in pork product, even in small quantities, demonstrated the need for such determinations to ensure safe products for human consumption.

Key words: Atomic Absorption Spectrophotometry, heavy metals, pork product

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1. Introduction

Among the pollutants generated by industry and urbanization, heavy metals and various pathogenic bacteria are the most dangerous, because they can cause serious health problems to human population. As a consequence of natural and anthropogenic activities, heavy metals are present in the environment, so that people come into contact with them especially through the consumption of foods.(Hărmănescu et. al., 2011). The main sources of heavy metal contamination are growing and are represented, especially, by pesticides, fertilizers, industrial processes and exhaust gases from automobiles (Albu, 2010).

The main threats to human health are contamination with heavy metals, especially lead, cadmium and mercury. Heavy metals become toxic when they are not metabolized by the body and accumulate in tissues (WHO, 2011). Heavy metals are dangerous because they tend to accumulate in living organisms. Some heavy metals are deposited as residues in food, during processing (WHO, 2000). Chronic exposure to these products leads, on long term, to undesirable effects for consumers' health and organic resistance. Normally, the exposure is kept at low, controlled level, due to quality standards imposed for water and feed (EC 178, 2002).

In general, lead accumulates in the plants and animals, while its concentration is magnified in the food chain (Halliwell et al., 2000). Cadmium has a long remanence in the human body (between 10-40 years), especially in the kidneys (Rubio et al., 2006). In some cases, high concentrations of Cu and Zn in feeds for pigs and poultry lead to contamination of produced manure. If this is applied to agricultural land, as fertilizer, it might lead to pollution of land with these metals resulting in a pollution risk for

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other animals that are fed with the plants issued from that field (Poulsen, 1998).

During last decades, human population has faced changes in life and food style, which have led to an increase in demand for processed foods. The rise of food production and development of processing technology have increased the chances of food contamination with various environmental pollutants, especially heavy metals. The occurrence of heavy metals, particularly lead and cadmium in meat products have been shown by numerous studies (Gonzalez-Weller et al., 2006; Hărmănescu et. al., 2011; Santhi et al. 2008). If residual levels exceed the prescribed standards, due to the cumulative effect in the human body consecutive to repetitive and persistent ingestion, they will induce negative effects on human health, hence the duty of all farmers and meat processors to minimize the possibilities and probabilities of contamination.

Pork products are the most consumed meat in the world in the form of fresh or processed forms. Given the growing interest of consumers for food safety and pork products we considered necessary to assess the contents of heavy metals of pork products, in order to provide information on consumer exposure to a possible risk of toxicity.

2. Materials and methods

The study was carried out during 2012. The aim was to identify and quantify the content of heavy metals (Lead, Cadmium, Cooper and Zinc) in four types of pork products: ham, bacon, sausages and salami. All samples were fresh and purchased, in the same day, from four commercial centers in Iasi city, Romania. The pork products analyzed were produced by six slaughterhouses.

A total of 36 meat samples (bacon, ham, sausage and salami) was used for the study and examined for the presence of heavy metals. The samples for chemical analysis (approximately 200 g) were homogenized for each product separately. Once the samples were homogenized, they were stored at -18ºC in clean polyethylene recipients. This was carried out between November and December 2012.

The presence of residues of heavy metals (Lead, Cadmium, Copper and Zinc) in samples were assessed through atomic absorption spectrometry method (AAS), using an atomic absorption spectrometer GBC-AVANTA type. The principle of the method consists in calcinating samples, dissolving the ash in hydrochloric acid and evaporation of the solution obtained to dryness. Final residue was re-dissolved in 0.1 mol/L nitric acid and the assessment of heavy metal content was performed by atomic absorption method according to SR EN 14082 (2003). After complete calcination of the samples, 5mL of hydrochloric acid (6 mol/L) were added. The resulting mixture was subjected to evaporation on marine-bath and subsequent dissolution in a defined volume of nitric acid (0.1 mol/L). Crucible and the resulting solution were subjected to 2 hours rest and then transferred into a plastic container. The solutions prepared as mentioned before were analyzed using AAS system. Construction of calibration curve initially assumed the achievement of optimal operating parameters, listed in the device manual. This step was followed by measuring the absorbance of each successive standard solution. The measurement of absorbance and analysis of results were similar to those described by Radu Rusu et al. (2013). The achieved data were processed statistically and presented as mean ± standard error. For the significance of differences for each comparison, the unifactorial ANOVA algorithm was applied, using SPSS software, followed by post-hoc detailing, the methodology being similar to that described by Radu Rusu et al. (2013).

3. Results and discussions

The mean content, standard deviation and range for the total Lead found in the investigated samples of the bacon, ham, sausage and salami are presented in Table 1.

Table 1. Mean lead levels (mg/kg) in various pork products

Type of examined samples	***Observed value***			
	No. of examined samples	***Mean± SE***	***Minimum***	***Maximum***
Bacon	6	0.58 ±0.009	0.42	0.78
Ham	6	0.65 ± 0.005	0.35	0.86
Sausage	12	0.82 ± 0.006	0.72	0.97
Salami	12	0.96 ± 0.004	0.72	1.06

SE – standard error

The highest concentration of Lead was found in salami (0.96 mg/kg), followed by the concentration in sausage (0.82 mg/kg), concentration in ham (0.65 mg/kg), and concentration in bacon (0.58 mg/kg). The lead levels were significantly closer to the pork product recommended by Food and Agricultural Organisation (FAO, 2002) and European Commission (EC 1881, 2006) (1mg/kg) in sausage and salami, while ham and bacon had significantly lower ($p<0.05$) levels. The Lead levels determined in this study were lower than those found by Brito et al. (1990) and Santhi et al. (2008).

The main sources of pork products contamination are mineral components of commercial feeds in animal nutrition and spices added to processed pork. Excepting bacon and ham, pepper which contains higher levels of Cadmium and Lead (>2.5 ppm) (Larkin et al., 1954) had been added invariably to almost all types of pork products. Muller and Anke (1995) also indicated that the Lead levels are higher in the sausage compared with the raw meat used in their manufacture. They suggested the spices used to make sausages as a possible cause for this excess. Researches carried out by Tuormaa (1995) demonstrated that high Lead concentrations causing adverse effects to humans. The high levels of Lead in adults body can generate heart diseases, cancer and infertility. For children, the diseases caused by Lead can lead to antisocial behavior, low intelligence or hyperactivity.

Cadmium is a toxic element to every animal species and for humans, as well. It is almost absent in the human and animal body at birth, however it accumulates with age. Statistical estimators of Cadmium concentration values in bacon, ham, sausage and salami samples (Table 2) have defined a broad dispersion of data, related to average, with higher limits of the coefficient of variation.

Table 2. Mean Cadmium levels (mg/ kg) in pork product

Samples	*Observed value*			
	No. samples	*Mean± SE*	*Minimum*	*Maximum*
Bacon	6	0.11 ±0.003	0.04	0.16
Ham	6	0.13 ±0.006	0.09	0.16
Sausage	12	0.16 ±0.008	0.08	0.19
Salami	12	0.21 ±0.005	0.09	0.24

SE – standard error

In the present study, the obtained results revealed that the mean Cadmium concentrations in bacon, ham, sausage and salami samples were 0.11, 0.13, 0.16 and 0.21 mg/kg. The highest concentration of Cadmium was found in salami and sausage, followed by bacon and ham. The explanation for these results is that sausages and salami were highly spiced; they were found highly contaminated with Cadmium. Muller et al. (1992) reported that sausages had higher Cadmium content than the raw meat. The addition of spices during production of sausages might be the main reason since spices could contain cadmium concentrations up to 200 ng g^{-1}.

The lower levels in bacon and ham could be due to the fact that, in bacon and ham, fewer spices were introduced. The results obtained indicate that mean values of the individual products and were significantly ($p<0.05$) higher than maximum (0.1 mg/kg for pork product) recommended by the Food and Agricultural Organization (FAO) and European Commission (EC).

The Cadmium levels assessed in this study were equal or lower than those found by Coleman et al.,(1992) (0.1 to 0.2 mg/kg), Kirkpatrick and Coffin (1973) (0.01 to 0.42 mg/kg), and Santhi et al. (2008) (0.22 to 0.32 mg/kg) respectively.

Chronic exposure to Cadmium could cause nephrotoxicity in humans, mainly due to abnormalities of tubular re-absorption (Nordberg, 1999). The biological half life of Cadmium in the human kidney is long and has been estimated to be 10 to 30 years (Fox Spivey, 1987).

Although is an essential element of life Copper causes adverse effects on health by acute or chronic intoxications or even death of animals, when is introduced in excess in the body, on fodder or water. Primary statistical estimators calculated for the Copper are shown in Table 3.

Table 3. Mean Copper levels in pork product (mg/kg)

Samples	*Observed value*			
	No. of samples	*Mean± SE*	*Minimum*	*Maximum*
Bacon	6	1.02 ±0.19	0.82	1.12
Ham	6	0.73 ±0.08	0.65	0.92
Sausage	12	0.84 ±0.12	0.71	0.96
Salami	12	1.32 ±0.27	1.12	1.55

SE – standard error

None of the samples in this study had Copper content exceeding the maximum level (3 mg/kg) prescribed FAO and EC in meat products (EC 178, 2002; FAO, 2002). The highest level of Copper (1.32 mg/kg) was observed in salami samples. Bacon (1.02 mg/kg), ham (0.73 mg/kg) and sausage products (0.84 mg/kg) had lower Copper content. Statistical analysis implied that the observed mean values of all the products were significantly lower ($p<0.01$) than maximum (3 mg/kg for pork product) recommended by the FAO and EC (EC 1881, 2006, 2002; FAO, 2002). Our results were in accordance with the results shown by Larkin et al. (1954), Brito et al. (1990) and Santhi et al. (2008).

Zinc is an essential element in animal and human diet. Too little Zinc can cause problems; however, too much Zinc is harmful to human health (nausea and vomiting, epigastric pain, abdominal cramps, and diarrhea) (Plum et al., 2010).

Table 4. Mean zinc levels in pork product (mg/kg)

Samples	*Observed value*			
	No. ofsamples	*Mean ± SE*	*Iinimum*	*Maximum*
Bacon	6	42.1 ±3.54	93.3	52.7
Ham	6	33.5±2.68	24.6	62.1
Sausage	12	38.4 ±1.03	23.1	45.7
Salami	12	32.19±1.13	26.8	55.9

SE – standard error

The highest Zinc concentration was found in the bacon samples (42.1 mg/kg) and the least value was observed in the sausage (32.19 mg/kg). The Zinc concentration in the bacon, ham, sausage and salami was below the upper allowed limit of 50 mg/kg (FAO, 2002). In all studied pork products the mean Zinc levels were significantly ($p>0.05$), approaching the maximum level.

Deficiency of Copper and Zinc in human nutrition can cause clinical symptoms, while high levels of Lead accumulated in certain organs, such as liver and kidney can generate toxic effects (Cherian and Nordberg, 1983).

4. Conclusions

Heavy metals are considered particularly dangerous to human health because, in the preparation of food, they do not decompose; on the contrary, their concentration tends to bioaccumulate. Of the four products analyzed, the highest contents of Lead, considered to be highly toxic metal, were found in samples of salami (0.96 mg/kg) and sausage (0.82 mg/kg). For the other two products analyzed, the concentration of Lead had lower values, of 0.65mg/kg in ham, and 0.58mg/kg in bacon. All samples contain Cadmium above the maximum levels admitted by FAO and EC. The highest value was 0.21mg/kg, found in salami, while the lowest one, of 0.11mg/kg, in ham sample. Zinc and Copper levels were below the limits allowed by law, in all samples.

The results of this study demonstrate the presence of heavy metals in pork products sold in commercial centers in Romania. Even if there were in small amounts, the presence of these heavy metals can generate worries due to their cumulative effect in the consumers' organism.

More future studies are required, because food contamination with heavy metals from various activities is expected to affect the health of many people. The most endangered category are poor people from underdeveloped countries, which consumes, usually, the cheapest food.

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