Cadmium in pork and poultry liver in southern Poland

Krzysztof Kleszcz*, Wioletta Jędryka

State Higher Vocational School in Tarnow, Mickiewicza 8 st., 33-100 Tarnow, Poland

Article history:
Received 25 October 2018
Received in revised form
25 November 2018
Accepted 26 November 2018
Available online 5 December 2018

Abstract

Samples of pork and poultry livers (ten samples of each type, purchased in southern Poland) were analyzed in order to determine the cadmium concentration. Wet digestion of the samples was carried out and the concentration of cadmium was measured by means of graphite-furnace atomic absorption spectrometry (GF–AAS). The mean values for pork and poultry livers were 79.3 µg/kg and 165.3 µg/kg, respectively. In one sample of poultry liver the Cd concentration was 1043 µg/kg, which is much more than the legal limit for the European Union (500 µg/kg). Statistical analysis showed that there was no significant difference in Cd concentration between the two groups of the samples, unless the highest result (1043 µg/kg) was considered an outlier.

Keywords: Cadmium, atomic absorption, animal liver

Introduction

Cadmium is the element of environmental and health concern and thus it is essential to monitor its content in foodstuff. The risk posed by cadmium was recognized many years ago and the main route of its exposure is ingestion [1]. Natural sources of cadmium in the environment are mostly rocks weathering and volcanic emissions, but in recent decades artificial sources, like smelting industry and the use of fertilizers became more impactful [2,3].

The maximum levels of cadmium in different foodstuffs are strictly regulated. In the European Union the maximum allowed concentration of cadmium in the liver of pig and poultry is 500 µg/kg [2]. Another factor which should be borne in mind is the exposure threshold. In recent years, World Health Organization (WHO) established so-called provisional tolerable monthly intake for cadmium as 25 µg/kg body weight [3], which for 75-kg person is 62.5 µg daily. In the past years the estimations were less strict, e.g. 150 µg/day [1].

Being widely spread contaminant, cadmium can be found in the animal feed, which is an obvious source of this element for the animals [4]. Thus, together with other toxic metals, cadmium can accumulate in the animal organs, with kidney and liver being the most vulnerable. Zhuang and co-authors (2014) studied accumulation of cadmium in chicken tissues from contaminated feed and concluded that the liver seems to be primary target for Cd accumulation [5].

Though less popular than meat, pork and poultry livers are widely consumed. In Poland, according to the Statistical Yearbook of Agriculture, the annual consumption of the offal per capita was 4.1 kg [6]. Thus, toxic metals content in this foodstuff should be the subject of the constant monitoring.

The aim of the study was to evaluate the content of cadmium in pork and poultry livers in southern Poland and to estimate the possible risk related to consumption of these two metals with this type of foodstuff. Secondary goal was to examine possible differences in the content of cadmium between pork and poultry livers. The analytical method used (graphite-furnace atomic absorption spectrometry) has been widely applied for determination of cadmium in variety of samples [7–10].

Materials and Methods

Sampling

Samples were purchased in local shops and markets as well as from the small animal farms directly. Ten samples of poultry livers and ten samples of pork livers we collected, each one originating from different location in the southern Poland (the region of Malopolska). The mass of each sample purchased was approx. 100 g. Samples were frozen immediately after purchasing.

Chemicals and standards

All chemicals were of ultrapure grade. For wet digestion of the samples, ultrapure nitric acid (Fluka) was used. Standard solutions for calibration were diluted from 1000 mgL^{-1} stock solutions (Agilent Technologies). Ultrapure water (18 MΩ·cm; purification system by Polwater, Poland) was used for all operations. As a matrix modifier for cadmium determination, diammonium hydrogen phosphate (Sigma-Aldrich) was used. Certified reference material 1577c – bovine liver (NIST – National Institute of Standards and Technology, USA) was used for quality control.

*Corresponding author: k_kleszcz@pwsztar.edu.pl

Sample preparation

Approx. 2 g of each sample (wet mass) was taken for analysis and was put into a PTFE vessel. 6 mL of nitric acid (65%) was poured into the vessel and microwave-assisted wet digestion was carried out. Since the expected concentration of cadmium was unknown (and possibly very low), the volume of the samples after digestion was kept as low as possible. In order to do that, solutions obtained after wet digestion were transferred to pre-weighted PP vials. After rinsing the digestion vials with water and combining it with the dissolved sample, the final volume obtained was in a range of 20–25 mL. Mass of each solution was determined using analytical balance and with the use of the balance and the micropipette, density of each sample was determined. From these two values, the volume of each sample was calculated, which was further used for calculation of the Cd concentration (in GFAAS important is the relation between the initial mass and the final volume of the sample). Standard reference materials as well as blank samples were treated in the same way.

Instruments and analysis

The analyses were performed using Agilent 240Z AA atomic absorption spectrometer with graphite furnace atomizer and Zeeman background correction. As an inert gas, high-purity argon (99.998%) was used. Cadmium was determined at 228.8 nm with diammonium hydrogen phosphate as a matrix modifier, allowing for higher ashing temperature.

Data handling

Data were the subject of statistical analysis with the use of Statistica software (StatSoft Inc.). Relevant statistical tests were used in order to find possible correlations between the two groups of the samples. Uncertainties were calculated according to the NIST guide for uncertainty expression [11].

Method validation

Accuracy of the measurements has been proven by analysis of two samples of standard reference material (SRM 1577c). The certified concentration of cadmium in this material is 97.0±1.4 μg/kg. Details of these results, including recovery, are given in Table 1.

Limit of detection (LOD) and limit of quantification (LOQ) were determined using blank samples, measured in 10 replicates. Two blanks were prepared and measured during the analyses; for the LOD and LOQ calculations the higher result was taken. LOD is expressed as the result for blank increased with 3 standard deviation (SD) while for LOQ the blank result is increased with 10 SD.

The calibration range used was 0–5 μg/L. The precision of the measurements was very good (for the samples: below 3.5% – Table 2). The applied method is well known for its specificity and robustness due to the Zeeman background correction.

Table 1. Quality control results based on the standard reference material and blank samples

Quality parameter	Cd [ug/kg]
SRM – 1st sample:	
Measured value	96.2 ± 4.0
RSD	1.6%
Recovery	99.2%
SRM - 2nd sample:	
Measured value	102.9 ± 2.4
RSD	0.9%
Recovery	106.1%
LOD	0.70
LOQ	1.35

Results and discussion

The results (mean values from three replicates) and the expanded uncertainties (k=2) are shown in Table 2. The precision is expressed as a relative standard deviation (RSD).

The results show noticeable content of cadmium in the samples measured, although in only one sample (WD02; C=1043±63 μg/kg) the level of cadmium exceeded legal regulations (500 μg/kg). In another sample, the concentration was close to the legal threshold (WD03; C=403±11 μg/kg). Both were poultry livers, while none of the pork livers exceeded 200 μg/kg.

Since data in poultry livers group were not normally distributed, results comparison couldn't have been done with simple t-test. Thus, Mann-Whitney test had been applied and showed no significant difference between the two groups (p=0.096). However, if the highest result from the poultry group was considered an outlier (WD02; C=1043±63 μg/kg), Mann-Whitney test would show a significant difference in Cd content between pork and poultry livers (p=0.02).

Similar research of cattle of different age from Poland [12] showed that the Cd in livers was in a range of 60–487 μg/kg for young cattle and 81–672 for old cattle. In the present study, the age of the animals was not known but still the results are very similar. Another studies of Polish cattle [8] showed that among 100 liver samples, in four the permissible level (500 μg/kg) was exceeded. The study covered five groups of the samples and the mean values for Cd concentrations were in a range of 159–200 μg/kg, which is comparable with the mean value for poultry liver from this study.

Tabela 2. Concentration of cadmium in pork and poultry livers

	Sample code	Cd [μg/kg]	Expanded uncertainty (k=2) [μg/kg]	RSD [%]
Pork Cd [μg/kg]: Mean: 79 SD: 46 median: 63	WW01	25.2	1.3	2.0
	WW02	135	3.5	1.0
	WW03	41.7	3.1	2.8
	WW04	60.8	0.95	0.6
	WW05	75.8	5.2	2.6
	WW06	51.5	0.81	0.6
	WW07	44.2	0.12	0.1
	WW08	140	3.6	1.0
	WW09	155	4.0	1.0
	WW10	65.1	0.17	0.1
Poultry Cd [μg/kg]: Mean: 165 SD: 330 median: 23	WD01	56.0	0.29	0.2
	WD02	1043	63	2.3
	WD03	403	11	1.0
	WD04	11.9	0.81	2.6
	WD05	12.2	1.1	3.4
	WD06	47.6	1.7	1.4
	WD07	27.6	0.22	0.3
	WD08	16.4	0.73	1.7
	WD09	18.3	0.53	1.1
	WD10	17.1	0.67	1.5

According to the other research [13], concentration of cadmium in the livers of cow and pig from Ghana was up to 1500 and 1700 μg/kg, respectively, with the lower level being below limit of detection of the method used (200 μg/kg). The results are clearly higher than obtained in our study. On the other hand, Dong-Gyu with co-authors [14] studied Cd level in animal tissue and found that the mean concentration of cadmium ± standard deviation in the livers of pig was 34.2±50.6 while for chicken liver it was 21.4±49.4. Unlike the previously mentioned, these results are much lower and show very little contamination of the animal liver with cadmium. This comparison points out that the results for animals from different locations may vary a lot. One of the reasons for that can be different levels of the contamination of the local environment with cadmium.

Wild animals have been the subject of the similar studies as well. Kramárová and co-authors (2005) determined Cd in the livers of a few wild species, including hare, mouse and deer. In mouse livers, Cd was below 100 μg/kg while for hare and deer it was close to 1000 μg/kg [15]. One can carefully conclude that the difference between wild and domestic animals is not that significant, which would also mean that the feed for domestic animals is not the main source of cadmium in their diet.

Conclusions

The results show that contamination of the animal livers with cadmium can pose a risk for humans, as among the studied samples there are ones exceeding or being close to the legal thresholds (both: EU regulations and WHO provisional daily intake). Although the offal is not as popular as meat, it should be subjected to the constant monitoring of the content of contaminants.

References

1. Hutton M. Human Health Concerns of Lead, Mercury, Cadmium and Arsenic. In: Lead, Mercury, Cadmium and Arsenic in the Environment. 1987, 53–68.
2. European Commission. Commission Regulation (EC) no 1881/2006: setting maximum levels for certain contaminants in foodstuffs. Off J Eur Union. 2006; (1881):5–24.
3. WHO – World Health Organization. Evaluation of certain food additive and contaminants. World Health Organ Tech Rep Ser. 2011; 960:162–77.
4. Bampidis VA, Nistor E, Nitas D. Arsenic, Cadmium, Lead and Mercury as Undesirable Substances in Animal Feeds. Anim Sci Biotechnol. 2013; 46(1):17–22.
5. Ping Zhuang, Bi Zou, Huanping Lu ZL. Heavy Metal Concentrations in Five Tissues of Chickens from a Mining Area. Pol J Environ Stud. 2014; 23(6):2375–9.
6. Central Statistical Office P. Statistical Yearbook of Agriculture. 2016.
7. Costa RG, Bah HAF, Bandeira MJ, Oliveira SSP, Menezes--Filho JA. Lead and cadmium in mangrove root crab (*Goniopsis cruentata)*, in natura and at food processing stages. Food Addit Contam Part B. 2017; 10(3):216–21.
8. Rudy M. Correlation of lead, cadmium and mercury levels in tissue and liver samples with age in cattle. Food Addit Contam – Part A Chem Anal Control Expo Risk Assess. 2009; 26(6):847–53.
9. Serpe FP, Russo R, Simone A de, Florio S, Esposito M, Severino L. Levels of heavy metals in liver and kidney of dogs from urban environment. Open Vet J. 2012; 2:15–8.
10. Tahvonen R, Kumpulainen J. Lead and cadmium contents in pork, beef and chicken, and in pig and cow liver in Finland during 1991. Food Addit Contam. 1994; 11(4):415–426.
11. Taylor BN, Kuyatt CE. Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results. Vol. 1297, NIST Technical Note. 1994.
12. Zasadowski A, Barski D, Markiewicz K, Zasadowski Z, Spodniewska A, Terlecka A. Levels of Cadmium Contamination of Domestic Animals (Cattle) in the Region of Warmia and Masuria. Polish J Environ Stud. 1999; 8(6):443–6.
13. Adei E, Forson-Adaboh K. Toxic (Pb, Cd, Hg) and essential (Fe, Cu, Zn, Mn) metal content of liver tissue of some dome-

stic and bush animals in ghana. Food Addit Contam Part B Surveill. 2008; 1(2):100–5.
14. Kim D-G, Kim M, Shin JY, Son S-W. Cadmium and lead in animal tissue (muscle, liver and kidney), cow milk and dairy products in Korea. Food Addit Contam Part B. 2016; 9(1):33–7.
15. Kramárová M, Massányi P, Slamecka J, Tataruch F, Jancová A, Gasparik J, et al. Distribution of cadmium and lead in liver and kidney of some wild animals in Slovakia. J Environ Sci Heal – Part A Toxic/Hazardous Subst Environ Eng. 2005; 40(3):593–600.