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SHORT COMMUNICATION

# The content of cadmium and lead in canned fish available in the Polish market

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**Abstract** The study aimed to verify whether canned fish available in Poland were safe in terms of Cd and Pb content. The content of Cd and Pb was examined in 25 products using Graphite Furnace Atomic Absorption Spectrometry (GFAAS). The examined canned fish contained from nearly 0.2 to 1.7 μg Cd and from ca. 0.02 μg to ca. 7.9 μg per 100 g of the product. The content of both Cd and Pb was found to be higher in canned salmon and tuna. It was found that consumption of canned fish acute posed no hazard to adult men. Consuming 1 canned fish a week will result in an intake of Cd amounting to a maximum of 0.8 % TWI, and of Pb amounting to a maximum of 3.5 % $BMDL_{10}$ and 1.23 % $BMDL_{01}$. The levels of Cd and Pb in canned fish do not exceed safe levels for men.

**Keywords** Canned fish · Cadmium · Lead · Safety · TWI · BMDL

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## 1 Introduction

Aqueous environment is particularly exposed to pollution, since water reservoirs are often a direct destination for the discharge of process effluents, municipal wastewater sewage and pollutants from farming activity. Fish are one of the last cells within the trophic network of aqueous ecosystems so significant amounts of toxic metals can accumulate in their tissues. The content of metals in organisms is determined by: amount of exposure (dose), route of absorption, rate of excretion, and eating habits. Cadmium (Cd) and lead (Pb) are characterised by an ability to accumulate in tissues and a long half-life. Cadmium can cause kidneys damage whereas lead has been associated with kidneys diseases and with the central nervous system damage (EFSA 2012a, b). These metals show a mutagenic, genotoxic, carcinogenic and teratogenic effect on humans and animals.

Despite potential hazards related to consumption of fish by humans, fish meat is recommended as an excellent source of complete protein, polyunsaturated fatty acids, minerals and vitamins (Usydus et al. 2009). According to rational nutrition guidelines, meals comprising 200–300 g of various fish species should be consumed 2–3 times a week. The presented study was to verify whether canned fish available in Poland were safe in terms of Cd and Pb content. This group of fish products was selected with regard to the fact that canned fish is very convenient to eat, microbiologically safe and is a frequent choice among consumers in Poland—canned fish accounts for as much as 60 % of all fish products (Usydus et al. 2009).

## 2 Materials and methods

### 2.1 Materials

Canned fish (n = 25) were purchased in grocery shops in Lublin from May to July 2012. The cans contained tuna (n = 6), mackerel (n = 5), herring (n = 6), sprat (n = 4) and salmon (n = 4) (Table 1). Prior to sampling the contents were thoroughly mixed using a homogenizer to make the mixture uniform throughout. Afterwards, three samples of ca. 3 g were taken from each product.

### 2.2 Determination of the content of Cd and Pb

The samples were dried at a temperature of 105 °C and then ashed at a temperature of 450 °C (Winiarska-Mieczan 2014). The content of Cd and Pb was determined by Graphite Furnace Atomic Absorption Spectrometry (GFAAS) in a Zeeman Varian Spectr AA 880, using the following parameters:

Cd: $\lambda = 228.8$ nm; LOQ 0.004 mg/kg; LOD 0.001 mg/kg

Pb: $\lambda = 217.0$ nm; LOQ 0.03 mg/kg; LOD 0.011 mg/kg.

More than 94 % Cd and Pb was recovered from the reference material with about 5 % replicability of results. The results were verified against a blank sample (1 M $HNO_3$) and CRM DORM-3. Standard Cd and Pb solutions were purchased from Merck (Germany). A detailed description of methods for determining Cd and Pb is provided in another work (Winiarska-Mieczan 2014).

### 2.3 Survey

The survey was carried out in October and November 2013 involving 350 men aged 19–24 from the student community of Lublin. The objective of the survey was to collect information about the popularity and amount of weekly intake of canned fish as well as about the respondents' preferred choices.

**Table 1** The characteristics of canned fish and the content of Cd and Pb

| | Type of packaging | Percent of fish (%) | Weight of can | Content of | |
|---|---|---|---|---|---|
| | | | | Cd (μg/100 g) | Pb (μg/100 g) |
| Tuna in olive oil | Metal can | 65 | 170 | 1.705 | 1.191 |
| Tuna in oil | Metal can | 70 | 170 | 1.326 | 1.959 |
| Tuna in water | Metal can | 70 | 170 | 1.656 | 1.584 |
| Tuna in thousand islands dressing | Metal can | 45 | 185 | 1.021 | 6.798 |
| Tuna in sweet–sour sauce | Metal can | 26 | 185 | 1.026 | 5.959 |
| Tuna with vegetables in tomato sauce | Metal can | 38 | 185 | 1.466 | 7.894 |
| Mackerel in spicy sauce | Metal can | 40 | 180 | 0.872 | 1.097 |
| Mackerel in tomato sauce-1 | Metal can | 50 | 170 | 0.653 | 5.982 |
| Mackerel in tomato sauce-2 | Metal can | 50 | 170 | 0.441 | 4.332 |
| Mackerel in oil | Metal can | 59 | 170 | 0.085 | 2.223 |
| Mackerel in Mexican sauce | Metal can | 40 | 170 | 0.112 | 1.891 |
| Herring in oil | Metal can | 60 | 180 | 0.178 | 0.171 |
| Fried herring in tomato sauce with pepper | Metal can | 50 | 180 | 0.156 | 0.021 |
| Herring in Greek sauce | Metal can | 30 | 170 | 0.029 | 0.044 |
| Herring in vinegar | Glass container | 50 | 200 | 0.033 | 0.226 |
| Herring in tomato sauce | Metal can | 50 | 170 | 0.301 | 0.194 |
| Herring in tomato sauce with pepper | Metal can | 50 | 175 | 0.141 | 0.025 |
| Sprat in tomato sauce | Metal can | 50 | 170 | 0.019 | 0.012 |
| Sprat in oil | Metal can | 59 | 170 | 0.087 | 0.116 |
| Smoked sprat in oil-1 | Metal can | 59 | 110 | 0.084 | 0.127 |
| Smoked sprat in oil-2 | Glass container | 60 | 250 | 0.211 | 0.158 |
| Royal salmon | Metal can | 55 | 150 | 1.393 | 7.842 |
| Salmon in oil | Metal can | 60 | 150 | 1.424 | 6.212 |
| Salmon in water | Metal can | 60 | 150 | 1.192 | 6.054 |
| Salmon salad in Mexican sauce | Metal can | 46 | 170 | 1.502 | 7.534 |

### 2.4 Calculations

The content of Cd and Pb was calculated as per fresh weight of the product. The weekly supply of Cd and Pb from canned fish was calculated assuming that an adult man weighing 70 kg consumes 1 can of fish/week. Information concerning the intake of canned fish was obtained by survey. This enabled calculating the actual intake of Cd and Pb from canned products. The standard values proposed by EFSA (European Food Safety Authority) were adopted: TWI (Tolerable Weekly Intake) for Cd—2.5 μg/kg of body weight/week and two BMDL (Benchmark Dose Lower Confidence Limit) values for Pb: $BMDL_{10}$—4.4 μg/kg of body weight/week and $BMDL_{01}$—10.5 μg/kg of body weight/week for nephrotoxicity and cardiovascular effects (EFSA 2012a, b).

## 3 Results

### 3.1 Popularity of canned fish

The survey showed that nearly all respondents (96.4 %) consumed canned fish, out of which 27.9 % of surveyed men ate such products once a week, 4.5 % a few times a week and 67.6 % sporadically. As many as 58.3 % of respondents reported that they preferred the taste of canned fish to that of fresh fish and could successfully replace them. The respondents' most frequent choice was tuna and mackerel (ca. 50 % indications each). Their favourite addition was oil (more than 80 % indications), followed by tomato sauce (ca. 70 % indications) (Fig. 1a, b). Regardless of the frequency of fish consumption all respondents claimed they ate 1 can of fish at a time.

### 3.2 Content of Cd and Pb in canned fish

The examined canned fish contained from nearly 0.2 μg (sprat in tomato sauce) to 1.7 μg (tuna in olive oil) Cd per 100 g of the product (Table 1). The content of Pb per 100 g ranged from ca. 0.02 μg (herring in tomato sauce with pepper and fried herring in tomato sauce with pepper) to ca. 7.9 μg (tuna with vegetables in tomato sauce and royal salmon). The content of both Cd and Pb was found to be higher in canned salmon and tuna.

### 3.3 Safety of canned fish for consumption

A single can of salmon on average contained 2.14 μg Cd and 10.7 μg Pb, tuna—2.41 μg Cd and 7.71 μg Pb, while a can of mackerel—0.75 μg Cd and 5.3 μg Pb (Fig. 2a). The level of Cd in a can of herring and in that of sprat did not exceed 0.25 μg, and that of Pb—0.21 μg per can. Consuming 1 can of fish a week will result in an intake of Cd not exceeding 1 % TWI, and that of Pb lower than 3.5 % $BMDL_{10}$ and 1.3 % $BMDL_{01}$ (Fig. 2a). Tuna and salmon had the highest share in the supply of Cd and Pb (ca. 0.8 % TWI, 2.5–3.5 % $BMDL_{10}$, 1–1.2 % $BMDL_{01}$).

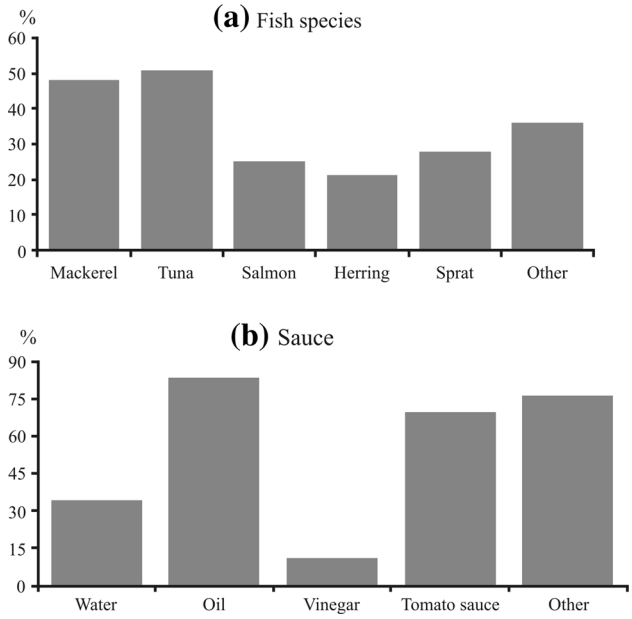


**Fig. 1** Preferred choices of canned fish among the respondents

## 4 Discussion

Canned fish are among the favourite fish products for Poles (Usydus et al. 2009). These authors' survey has shown that nearly 100 % of the audited population of young men ate canned fish.

The presented studies indicated that fish products available in the Lublin market were safe for adult male consumers in terms of Cd and Pb content. The highest content of the metals was found in canned tuna and salmon, which is not surprising considering these are predatory fish. The level of toxic metals increases at subsequent levels of the food chain as these metals tend to accumulate in tissues (Squadrone et al. 2013). Studies by other authors also revealed the presence of Cd and Pb in canned foods. Most available data refers to tuna as this species of fish is particularly popular among consumers around the world (Boadi et al. 2011), which was also supported by the present authors' own studies.

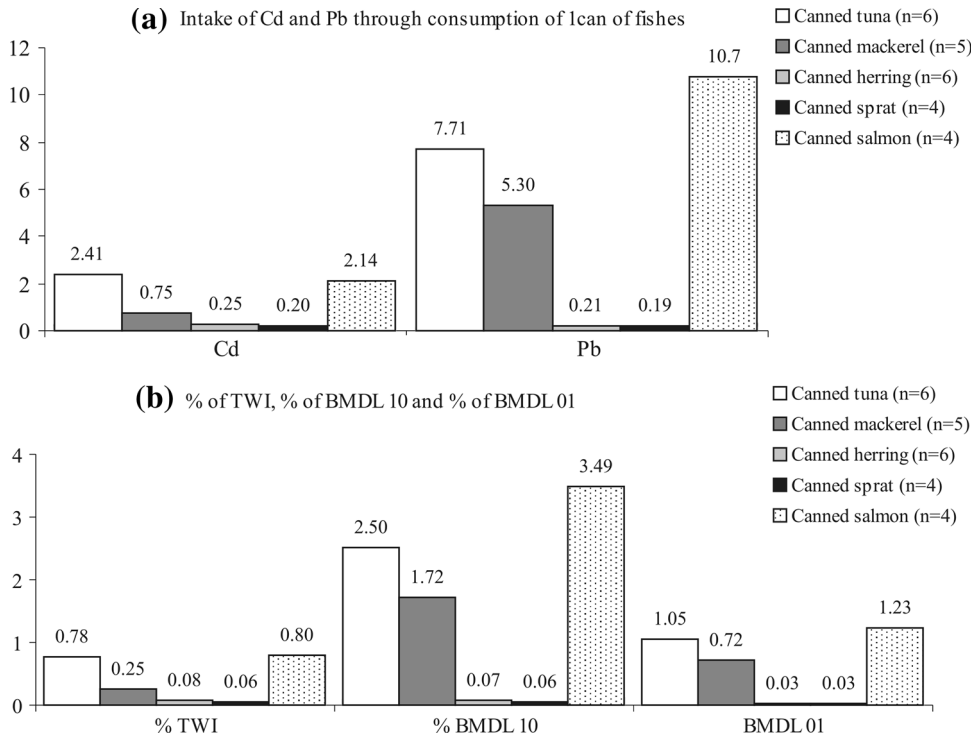


**Fig. 2** Estimated weekly intake of Cd and Pb with canned fish (**a**) safety of canned fish for consumption (**b**)

The presented studies revealed that canned tuna contained 1.02–1.705 μg Cd and 1.19–7.89 μg Pb per 100 g. The content measured by other authors, based on research carried out in various countries (Ikem and Egeibor 2005; Boadi et al. 2011) was similar to that determined by the present authors; however, some authors obtained lower results (Mahalakshmi et al. 2012). In turn, results referring to the content of Cd and Pb in canned salmon and mackerel, available in literature (Ikem and Egeibor 2005), are lower compared to those obtained in these authors' own studies. In own studies the lowest content of Cd and Pb was recorded in canned herring and sprats. These are fish from a lower level of the food chain, thus they accumulate less Cd and Pb.

The concentration of toxic metals in fish meat is primarily due to the pollution of the environment in which the fish live (geographical region), duration of exposure to the toxic agent and their diet (Squadrone et al. 2013). In addition, the material from which the can was made could be a source of contamination, although now a special varnish coat is often used inside the can to prevent metals from penetrating into the contents of the can (Tahán et al. 1995). Suppin et al. (2005) demonstrated that the level of Pb in the meat of canned versus fresh fish differs to a slight degree only. In turn, in their studies involving 30 types of food, Al-Thagafi et al. (2014) found that the content of toxic metals in canned food was significantly higher than in the respective fresh food.

Results of these authors' own studies indicate that weekly consumption of one can of salmon and tuna (that are most contaminated by Cd and Pb) does not add considerably to the amount of Cd and Pb taken up daily to the surveyed group of consumers as it will result in the supply of about 2.14–2.4 μg Cd and 7.7–10.7 μg Pb/day. On average, the supply of these metals from all the examined products does not exceed 0.16 μg Cd (0.39 % TWI) and 0.69 μg Pb (ca. 1.6 % BMDL) per day. This figure results from both the small content of metals in the products and low consumption of fish in Poland. Even if the above-mentioned canned fish are consumed at the recommended level (300 g/week), the risk of excessive intake of Cd and Pb seems negligible. Studies carried out in Spain showed that on average fish supply about 1.1 μg Cd and 2 μg Pd per day to adult men (Falcó et al. 2006). Studies in Lebanon demonstrated that fish eaten by adult residents in the amount of 17.9 g/day (of which 6.7 g was canned tuna) provided on average 0.1 μg of both Cd and Pb per day (Nasreddine et al. 2006). According to studies carried out among adult men from China, fish and seafood supply as much as 10.2 % Cd (He et al. 2013).

## 5 Conclusions

To sum up, results obtained by the present authors allow stating that the levels of toxic metals in canned

fish do not exceed levels considered safe for the adults male population. Consumption of fish, also canned fish, should be promoted since fish are not very eagerly consumed in Poland. At the same time, due to the scarcity of data related to the content of toxic metals in canned foods in Poland, the impact of this method of food preservation on the content of Cd and Pb must be investigated.



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