Mercury and Nickel Contents in Fish Meat

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Abstract
The main aim of our work was to identify the content of mercury and nickel in selected fish species. Consumers today are increasingly aware of the association between diet and health, and thus in Europe consumes more and more fish. Fish is a valuable source of high quality protein, minerals and vitamins, and fatty fish are also rich in omega-3-polyunsaturated fatty acids, which are normally considered to be beneficial to health. In our work we determined content of mercury and nickel harvested fish in particular were the following species: Common goldfish (*Carassius auratus, L.)*, Common roach (*Rutilus rutilus, L.)* and Common bream (*Abramis brama, L)*. Concentrations of mercury and nickel was analyzed and results evaluated according to current standards and compared to the values established by the Codex Alimentarius of the Slovak Republic and the EU Commission Regulation no. 1881/2006, as well as in the EU Commission Regulation no. 420/2011 and no. 269/2008. In our research area we analysed 19 samples of fish muscle. Samples were taken from two water reservoirs – Golianovo and Vráble. The highest mercury content was in sample Rutilus 1 - 0.052632 mg/kg. Lowest mercury content was in sample Abramis 2 - 0.010431 mg/kg. Largest nickel content was in meat of Abramis - sample 2 - 0.78 mg/kg. Minimum content of nickel was in sample Carassius 1 - 0.11 mg/kg. We got out of the limit values specified: Codex Alimentarius SR - Mercury 0.5 mg/kg and Regulation of the EU Commission no. 1881/2006, no. 420/2011 and no. 629/2008. To optimize the protection of the population, it is necessary to continue to monitor the concentration of mercury in fish and fish products. Risk management strategy must focus on reducing potential exposure derived from consumption of fish. In particular, the definition of maximum levels for methylmercury, advising consumers and environmental activities oriented to reduce contamination.

Keywords: mercury, nickel, fish meat

1. Introduction

Fishes are one of the most consumed foods in many parts of the world. The main reason why are they consumed is their high content of protein, low content of saturated fatty acids and especially high amount of omega-3 fatty acids which are essential for people and the body can not produce it on its own. They also contain other important substances as vitamins or microelements. Well-balanced diet which included fishes contributes to the prevention of cardiovascular diseases and promotes healthy growth and development of body tissues to children. In addition of nutritionally valuable substances fishes can contain, due to environmental pollution, many contaminants such as mercury, dioxins and other substances. Mercury is one of the most toxic components of the food chain and its toxicity dependents on the occurrence. The food, especially canned food in nickel plated cans contain a high content of nickel. Increased income of nickel from food can occurs even an allergy.

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Environmental contamination by heavy metals from a number of anthropogenic activities leads to pollution of surface waters. Heavy metals can be accumulated in fish tissues and through the food chain may affect human health. It is therefore extremely important to control the content of heavy metals in fish meat and take care to its health harmless [1-3]. Common roach *(Rutilus rutilus* L.) is a very popular fish species, which is found in rivers and reservoirs across the Europe. It lives in artificial canals, slow-flowing rivers and reservoirs with stagnant water with sufficient amount of aquatic vegetation. It has been acclimatized in Australia, where it can be found in localities as Victoria and southern South Wales [4]. Common roach has a length about 20 cm, but some specimens can be about 50 cm long and their weight is about 2 kg. Red species live to the age of 18-20 years. It is a social fish forming shoals mostly the same size and age. This fish has not large environmental requirements. It is domesticated almost everywhere except mountain rivulets and cold mountain streams. But mostly it is in warmer slow- flowing water with sufficient amount of food. It reaches sexual maturity between 2-3 year and cross-breeds with chubs or Common bream [5]. It is silver coloured (back is dark blue to dark green, sides are blue, belly is white and iris is red). Common goldfish (*Carassius auratus* L.) is a cyprinid fish of medium size. It grows to a size up to 50 cm and weight about 3 kg, but mostly are species much smaller [6]. It is silvery-grey coloured, a little bit with golden tones. Opposed to the carp it does not have barbells. Nowadays it is widely spread fish predisposed to excessive population in some places, where it has larger size of its body and it is interesting for anglers [7]. *Carassius auratus* L. can reach weight up to 3 kg. After several generations and after their releasing to the nature very breaded form - gold form is changed into it's original color [4]. Food consists of animal as well as plant component. It is able to live on plankton and benthos too. It consumes the algae, some parts of higher plants and detritus. It can survive with extensive injuries because the body was protected by strong armoured by scales. Year-round hunting of this fish is allowed [8]. Common bream is a very popular fish. His head is without scales, but the body part from the hips is strongly pushed and covered with small scales with slime. The body is usually golden brown colored, pectoral and pelvic fins are black. The weight of an adult one is between 1.8 to 3.2 kg, sometimes exceeding 9 kg [4]. It prefers slow-flowing or standing water with soft muddy bottom, where is the main part of their food. It takes greater migration only for spawning. In extensive waters is it common that Common bream held during the day at depths further from shore and at night lift to the mudflats for food [9]. It reaches sexual maturity in 5 year of his life. During period from May to June has bred in mudflats with lush vegetation. It lays two hundred to three hundred thousands of eggs. It is a common fish that lives on the coast and bottoms of lakes and lower flows of larger rivers that are full of food. It also occurs in bays [10].

2. Materials and methods

For this study were collected samples of *Abramis brama L., Rutilus rutilus L., Carassius auratus L.* in October 2014 during pond fishing from the fish pond Vráble (Nitra district, Žitava River watershed, South-West Slovakia).

Characteristics of water dam Vráble and Golianovo:

Description: Water area of dam near Goliano and Vráble; Acreage (ha): 26 and 36; Organization: Slovak Fishing Association; Range: according to rules; Purpose: breeding; Type of permission: none; Character: carp waters.

The samples of fishes (19) had been taken in October 2014 during fish catching, when the water from dam was drained. Collected samples of fish meat were subsequently analysed by Department of Chemistry of FBFS SUA in Nitra and analysed to obtained results of Ni and Hg content by AAS and AMA method. The content of risk elements (Ni and Hg) in fish meat was carried out in extract of aqua regia. It was determined the total concentration of monitored heavy metals. The mineralization of samples was done by 10 cm^3 of aqua regia (2.5 cm^3 HNO_3 and 7.5 cm^3 HCl, Merck, Germany) using microwave digestion unit Mars X-press 5 (CEM Corp., USA) in closed PTFE vessels. Nickel determination in samples was performed by Varian AA240Z (Varian, Australia) atomic absorption spectrometer with Zeeman background correction. The graphite furnace technique was used for this determination.

The content of Hg was determined by advanced mercury analyser AMA 254. Analyser AMA 254

was used for determination of total mercury content in fish meat as well as in tissue of fish body. The total mercury concentration was determined in homogenized samples (0.005-0.01 g) using a cold-vapour AAS analyser AMA 254 (Altec, Czech Republic) with a detection limit of 0.5 ng/g. Mean difference between duplicates was up to 5%.

All statistical analyses were carried out using the statistical software Statistica 12.0 (Statsoft, USA). We used Pearson correlation coefficients at significance level of $p<0.05$ (weak statistical significance) and $p<0.001$ (very strong statistical significance) to compare the impact of monitored parameters between them. The obtained data of heavy metals contents were compared with the limit values that are defined by legislative norm of Slovak republic and EU: Codex Alimentarius SR - Mercury 0.5 mg/kg and Regulation of the EU Commission no. 1881/2006, no. 420/2011 and no. 629/2008.

3. Results and discussion

Table 1 presents the content of mercury and nickel in studied samples of fish meat from the dam Golianovo.

Table 1. The contents of nickel and mercury in samples of monitored fish muscle in mg/kg of WD Golianovo

samples	*Nickel (mg/kg)*	*Mercury (mg/kg)*
Common goldfish 1	0.27	0.019002
Common goldfish 2	0.42	0.026961
Common goldfish 3	0.44	0.023274
Common roach 1	0.59	0.058454
Common roach 2	0.36	0.041361
Common roach 3	0.39	0.044576
Common bream 1	0.62	0.013501
Common bream 2	0.78	0.010431
Common bream 3	0.50	0.012763
Average contents	**0.49**	**0.027814**
Max. contents	**0.78**	**0.058454**
Min. contents	**0.27**	**0.010431**
MAC*	**-**	**0.5**

* MAC - the maximum allowable concentration according to EU Commission Regulation No. 1881/2006

The results of mercury and nickel show that the average value of nickel content was 0.49 mg/kg and mercury 0.02 mg/kg. The minimum value of nickel content of all samples was 0.27 mg/kg (*Carassius auratus* L. No. 1). The maximum value of nickel from all samples was 0.78 mg/kg (*Abramis brama* L. No. 2).

The average value of nickel content in samples of selected fish species was 0.49 mg/kg. The highest content of nickel was detected in muscle of *Abramis brama* L. with an average value of 0.63 mg/kg and the smallest content of nickel was in muscle of *Carassius auratus* L. with an average of 0.37 mg/kg. The content of mercury in fish muscle was compared with the limit value (MAC- maximum allowable concentration of Hg by EU Commission Regulation No. 1881/2006) in mg/kg. The average value of mercury content in samples of selected fish species was 0.02 mg/kg, which represents only 4% of the MAC. It shows that the consumption of these fish species do not pose any risk of mercury entry into the human body. The highest content of mercury was in *Rutilus rutilus* L. meat with an average value of 0.04 mg/kg and smallest content was in *Abramis brama* L. muscle with an average value of 0.01 mg/kg.

Table 2 shows the content of mercury and nickel in samples of monitored fish muscle from water dam in Vráble. The results of mercury and nickel show that the average value of nickel content was 0.42 mg/kg and mercury 0.03 mg/kg. The minimum value of nickel content of analysed samples was 0.11 mg/kg (*Carassius auratus* L. No. 1). The maximum value of nickel content of analysed samples was 0.73 mg/kg (*Abramis brama* L. No. 3). The average value of nickel content in samples of monitored fish species was 0.42 mg/kg. The highest content of nickel was in *Abramis brama* L. muscle with an average value of 0.65 mg/kg and the smallest in *Carassius auratus* L. muscle with an average value of 0.17 mg/kg. The content of mercury in fish muscle was compared with the limit value (MAC- maximum allowable concentration of Hg by EU Commission Regulation No. 1881/2006) in mg/kg. The average value of mercury content in samples of selected fish species was 0.03 mg/kg, which represents only 6% of the MAC. It shows that the consumption of these fish species do not pose any risk of mercury entry into the human body. The highest content of mercury was in *Rutilus rutilus*

L. meat with an average value of 0.04 mg/kg and smallest content was in *Abramis brama* L. muscle with an average value of 0.01 mg/kg. Based on obtained results can be concluded that by comparing the average value of nickel content in fish muscle between WD Golianovo with value of 0.49 mg/kg and WD Vráble with an average value of 0.42 mg/kg there is no significant difference. Muscle meat of *Abramis brama* L. has a higher content of nickel from WD Vráble and in the case of *Carassius auratus* L. and *Rutilus rutilus* L. is content of nickel higher from WD Golianovo.

Table 2. The contents of nickel and mercury in samples of monitored fish muscle in mg.kg of WD Vráble

samples	*Nickel (mg/kg)*	*Mercury (mg/kg)*
Common goldfish 1	0.11	0.043056
Common goldfish 2	0.22	0.034577
Common goldfish 3	0.19	0.026307
Common roach 1	0.59	0.030413
Common roach 2	0.26	0.040845
Common roach 3	0.29	0.052632
Common bream 1	0.69	0.016250
Common bream 2	0.62	0.020022
Common bream 3	0.73	0.016813
Common bream 4	0.54	0.019437
Average contents	**0.42**	**0.030035**
Max. contents	**0.73**	**0.052632**
Min. contents	**0.11**	**0.016250**
MAC*		**0.5**

* MAC - the maximum allowable concentration according to EU Commission Regulation No. 1881/2006

Comparing the mercury content mg/kg from WD Golianovo and WD Vráble were obtained results that point to the fact that in all monitored parameters of mercury content in muscle samples of selected fish species is higher from WD Vráble than from WD Golianovo.In terms of evaluation and comparison with the legislation set values for mercury content in fish muscle it can be concluded that compared with MAC all analyzed samples from Vrable and WD Vráble and WD Golianovo do not exceed hygiene limits for mercury content and are suitable for consumption.

The health risk of mercury in water consists primarily from biotransformation of inorganic mercury to methylmercury, which is very toxic. It indicates that in this form mercury especially in fish, which are from these waters, can be a risk factor for humans, productive animals and birds, which are feed by these fishes.

The results of determination of total mercury concentration in fishes based on our findings do not exceeded the limit value of 0.5 mg/kg. The main aim of this work was to identify and assess the content of mercury and nickel in selected fish species. Consumers are nowadays more and more aware the association between diet and health, and thus in Europe it is consumed a lot of fishes. Fishes are valuable source of high quality protein, minerals and vitamins, and fatty acids and especially high amount of omega-3 fatty acids, which are normally considered to be beneficial to health. Recently, based on reports about the risks associated with contaminants coming from the environment, for example mercury and nickel, which are known that, are accumulated in fishes, to break the consuming public trust.

4. Conclusions

In our work we determined mercury and nickel content of collected fish species: Common goldfish (*Carassius auratus* L.), Common roach (*Rutilus rutilus* L.) and Common bream (*Abramis brama* L).

Mercury and nickel concentrations were analysed and results were evaluated according to current standards and compared to the values established by Food Codex of the Slovak Republic and the EU Commission Regulation No. 1881/2006, as well as by EU Commission Regulation No. 420/2011 and No. 269/2008. In our research were analysed 19 samples of fish muscle. Samples were taken from two water dams and consisted of three selected fish species. The highest mercury content has *Rutilus rutilus* L. No. 1 (WD Golianovo) with average value of 0.052632 mg/kg. The smallest mercury content has *Abramis brama* L. No. 2 (WD Golianovo) with average value of 0.010431 mg/kg. The highest nickel content has *Abramis brama* L. No. 2 (WD Golianovo) with average value of 0.78 mg/kg. The smallest nickel content has *Carassius auratus* L. No. 1 (WD Vráble) with average value of 0.11 mg/kg. We evaluated our obtained results compared to limit values that

were specified by: Food Codex of SR - mercury 0.5 mg/kg and it is not specified for nickel. EU Commission Regulation No. 1881/2006, No. 420/2011 and No. 629/2008 - Mercury $mg.kg^{-1}$ for a nickel. To optimize the protection of the population, it is necessary to continuing monitor the concentration of mercury content in fishes and fish products. Risk management strategy must be focused on reducing potential of exposure from consumption of fishes. In particular, it should be the definition of maximum levels for methylmercury, advising consumers and environmental activities oriented to reduce real contamination in the environment.

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