ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 18, No. 8 2011

Monika KOWALSKA-GÓRALSKA[1] and Magdalena SENZE[1]

SELENIUM CONCENTRATION IN VARIOUS CARP (*Cyprinus carpio* L.) ORGANS

ZRÓŻNICOWANIE ZAWARTOŚCI SELENU W NARZĄDACH KARPI (*Cyprinus carpio* L.)

Abstract: In 2007 samples taken from carps (*Cyprinus carpio* L.) aged between one and two years with an average weight of 430 g were tested for selenium concentration. The fish was obtained from a 5 ha pond owned by the MILICZ Fish Breeding Farm, located in the Barycz River catchment. The following organs were taken from each 15 fishes: muscles, trunk kidneys, hepatopancrea, gills, intestine and spleen. Selenium concentrations were determined using the hydride vapour generation method. The highest selenium content was found in spleen (on average 0.848 mg Se · kg^{-1}), intestine (on average 0.651 mg Se · kg^{-1}) and kidney (on average 0.603 mg Se · kg^{-1}). The medium concentration, at 0.37 mg Se · kg^{-1}, was measured in hepatopancrea. Selenium was at its lowest concentration in gills and muscles.

Keywords: selenium, carp, tissues

Microelements are involved in important processes occurring inside the organism. Their presence is necessary for the proper functioning of the body and their lack may lead to various disorders. Selenium (Se) is one of such microelements. Its role was underestimated for a time; it attracted more attention when it was discovered that its deficiency brings about serious disorders, such as the Keshan or Kasin-Beck diseases [1]. Se deficiency has been found to be responsible for a number of ailments connected with various organs, tissues or systems, eg it weakens the immune system, causes necrosis, bone diseases, thyroid malfunctions, may lead to hypertension or cancer [2].

People in Poland consume insufficient amounts of Se [3]. The environment in most regions of country is poor in this element. A low Se concentration in soil reflected its poor amount in plants and herbivorous animals. The average person in Poland is estimated to eat about 40 μg Se per day, while the requirement is twice as high [3]. The amount of Se in the body depends on its uptake with food; in the case of fish – absorption from water through gills. Poland's inland waters contain on average 0.05 μg

[1] Section of Limnology and Fishery, Wroclaw University of Environmental and Life Sciences, ul. Chełmońskiego 38C, 51–630 Wrocław, Poland, phone: +48 71 320 58 70, fax: +48 71 320 58 76, email: monika.kowalska-goralska@up.wroc.pl

Se · dm^{-3} (0.01–0.08). In the region of Lower Silesia, near the Milicz town, there operates the biggest Cyprinidae production facility in Europe. Nowadays about 10 % of eaten carps stock is produced there. The milickie ponds receive water from local rivers. Se concentrations in this water are recognized – in accordance with the USEPA standards – as low [4].

Studies involving carps of various ages have proved that the carp's organs are capable of accumulating Se [5]. In this study the highest amounts were found in the kidneys only of two-year-old carps (K_2). Consequently it influenced the aim of our examination. It is interesting to find out whether it is a normal tendency to accumulate Se in two-year-old carps kidneys or it was caused by individual variety.

Low fish consumption is a typical tendency both in Poland and in the rest of the world, although this trend could be changed by popularization of health benefits of fish consumption. In beef, pork or poultry Se concentrations are lower [6, 7]. Considerably more Se was found in various fishes – striped Snake-head fish (on average 335 μg Se · kg^{-1} of wet mass), batrachian walking catfish (on average 473 μg Se · kg^{-1} of wet mass) [6]. People with microelement deficiency are commonly recommended to eat fish.

Studies regarding Se content have been conducted in respect of the liver, kidneys, heart, diaphragm, pancreas of various animals [8] but nothing is known about carp intestine or spleen.

The aim of work was determination of total Se concentration (II, IV, VI oxidation state) in the K_2 carp organs (*Cyprinus carpio* L.): muscles, gills, hepatopancreas, kidneys including intestine and spleen, and comparison of this microelement content between them.

Material and methods

Fresh fish were bought from the MILICZ Fish Breeding Farm. They were caught by means of fishing nets. The fishing nets were cast three times on three successive days in order to obtain a sample containing 15 carps (*Cyprinus carpio* L.) aged one-two years. Three water samples were taken from the pond to determine the basic physico-chemical parameters of the water. The following parameters were checked: reaction (204 pH-meter); electrolytic conductivity PN-EN 27888:1999; hardness – the Versenate method PN-ISO 6059; alkalinity PN-90/C-04540.03; calcium – the Versenate method PN-ISO 6058; magnesium PN-ISO 6059; copper, zinc – atomic absorption spectrometry with flame atomization PN-ISO 8288:2002 by means of a VARIAN 220FS atomic absorption spectrometer; sulfates – the ionite titration method; nitrates(III) – particle absorption spectrometry PN-EN 26777; nitrates(V) – particle absorption spectrometry PN-82/C-04576.08; ammonia – the direct Nessler method PN-C-04576-4; phosphates PN-EN 1189.

The following were obtained from the fish: gill arches from the left-hand side, entire hepatopancreas, muscles, intestine and spleen. After being rinsed in distilled water the organs were placed in a freezer at –18 ^{o}C; next they were wet mineralized with nitrac(III) acid [9] under a high-pressure, closed CEM MARS-5 microwave oven (USA). The pond water samples were also wet mineralized with nitrac(III) acid [9].

Se concentrations were determined using hydride generation atomic absorption spectrophotometry (HG AAS) by means of a VARIAN Spectra 220 FS. The methodology used followed that described by Diaz-Alarcon [10], in a closed system. The results were verified against DORM-2 reference material. The reference Se concentration in DORM-2 amounted to 1.40 ± 0.09 mg kg^{-1}, and in the applied analytic procedure: 1.32 ± 0.1 mg Se · kg^{-1}. Se concentrations were quoted in μg Se · kg^{-1} of wet mass – for carp organs. Correlations between the concentration of Se in individual organs were calculated and the significance of the differences was determined while studying fish from breeding ponds.

The results were presented by means of a box and whiskey plot. The centrally placed rectangle covers 50 % of the results, while the sides of the box are the lower and upper quartiles. The horizontal line in the rectangle stands for the median, with the whiskers extending from the minimum to the maximum data values.

The results were verified statistically (calculation of average values, standard deviations, significance of differences) using Statistica ver. 8.0.

Results and discussion

The Se concentrations in the water samples did not exceed 0.001 mg Se · dm^{-3}. The values must be regarded as low, as they fall within the standards prescribed for surface waters. The average values of the determined water parameters: water reaction – 7.4; electrolytic conductivity – 428 μS · dm^{-3}; hardness – 185.64 mg $CaCO_3$ · dm^{-3}; alkalinity – 140 mg $CaCO_3$ · dm^{-3}; calcium – 55 mg Ca · dm^{-3}; magnesium – 7.3 mg Mg · dm^{-3}; copper – 0.002 mg Cu · dm^{-3}, zinc – 0.003 mg Zn · dm^{-3}; sulfates – 43 mg SO_4 · dm^{-3}; nitrate(V) nitrogen – 0.04 mg N-NO_3 · dm^{-3}; nitrate(III) nitrogen – 0.05 mg N-NO_2 · dm^{-3}; ammonia nitrogen – 0.14 mg N-NH_4 · dm^{-3}; phosphates – 0.04 mg PO_4 · dm^{-3}.

In terms of the growing mean Se concentration, the organs can be ordered as follows:

gills < muscles < hepatopancreas < kidney < intestine < spleen [Table 1, Fig. 1]

High Se concentrations in the spleen may be connected with its impact of the activity of cytotoxic NT cells, which are produced in this organ [11] or its presence in the form of selenoprotein W [7].

Se is removed from the body via the kidneys in urine or via the intestine in faeces. The intestine is also involved in absorbing Se and transporting it to lipoproteids and albumines [7]; for this reason the amount of Se accumulated in its walls may be the resultant of absorption and secretion of the element.

Table 1

Selenium concentration [μg · kg^{-1}] in various carp organs

	Gills	Muscle	Hepatopancreas	Kidney	Intestine	Spleen
Max	331.50	668.66	781.85	1265.69	857.06	1291.97
Min	52.73	88.52	163.17	195.34	391.75	429.13
Medium	159.26	200.71	370.00	602.97	651.52	848.53
SD	85.39	146.55	181.70	312.25	156.48	198.84

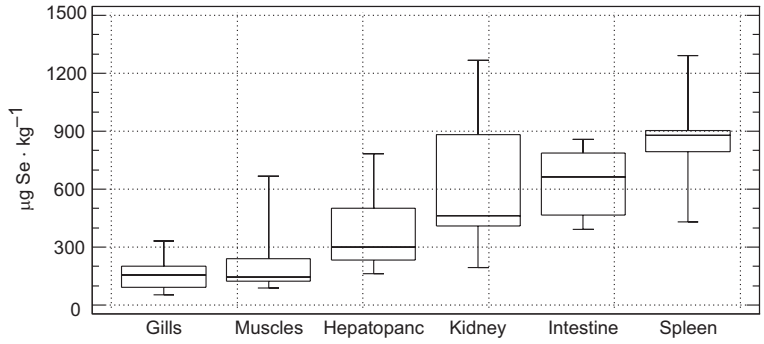

Fig. 1. Selenium concentration in various carp organs

Se was concentrated more in the kidneys than in the hepatopancreas. This tendency seems to occur in other animals as well. Research into Se concentration in the liver and kidneys of lambs indicated that the mean Se content was higher in the kidneys than in the liver [12]. Most probably the element is present in kidneys in the form of extracellular glutathione peroxidase or deiodinase [7] and, similarly to Se in the intestine, its amount may be linked to the secreting processes. Se concentration in the kidney was most strictly correlated with the amount of Se in muscles (0.84), gills (0.54) and hepatopancreas (0.47). The ratio of the kidney medium Se concentration to the hepatopancreas one was calculated as 1.6. This value was lower for 2-years carps than in the previous Author's research (2,7) [5] and was close to that of adult carps (1,4) [5]. It suggests a large individual differentiation of Se concentration in carp organs. Because of low Se concentration in water the amount of this element in gills is the lowest.

In muscles Se most probably forms part of the protein – selenomethionine W [7]. In the carps under study the content of Se in muscles was statistically much lower than in all of the studied organs except for gills. Similar results were obtained for the organs of chickens [13]. No differences were discovered in the order of organs accumulating highest Se concentrations. The organs were ordered as follows:

$$\text{muscles } (190 \pm 26\ \mu g\ Se \cdot kg^{-1}) < \text{pancreas } (240 \pm 35\ \mu g\ Se \cdot kg^{-1}) < \text{liver } (340 \pm 41\ \mu g\ Se \cdot kg^{-1}) < \text{kidney } (360 \pm 30\ \mu g\ Se \cdot kg^{-1})\ [13]$$

Although the lowest Se concentration was found in the muscles of the studied carps, it was similar to that determined for carps caught in Slovakia (243 µg Se · kg^{-1}), higher than that in Slovakian trouts (196 µg Se · kg^{-1}) [14], and similar to other fishes, eg the sea bass (*Dicentrarchus labrax*) – 250 µg Se · kg^{-1} of wet weight, in the case of which no Se supplementation was used [15], while by an order higher than Se concentration in lamb meat, which only confirms the opinion that fish should be eaten if Se deficiency is diagnosed.

Conclusions

The fact that the lowest concentration of selenium is to have been found in gills indicates that water is not the most important intake path of the element. Althought the selenium concentration in water is low, fish meet is able to accumulate significant amounts of selenium. The Se concentration in carp organs is almost the lowest in muscles but it is on a higher level than in other animals' meat.

References

[1] Kabata-Pendias A. and Pendias H.: Biogeochemia pierwiastków śladowych. PWN, Warszawa 1999.
[2] The Directive 76/464/EEC of 4 May 1976 (codified as 2006/11/EC) on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community.
[3] Floriańczyk B.: Nowiny Lekarskie 1999, **68**, 244–253.
[4] USEPA (U.S. Environmental Protection Agency): Ambient Water Quality Criteria for Selenium. Publication EPA-440/5-87-006, USEPA, Office of Water Regulations and Standards, Washington DC 1987.
[5] Kowalska-Góralska M., Dobicki W. and Pokorny P.: Zesz. Nauk. AR Wroclaw, 2004, **51**, 125–130.
[6] Sirichakwal P.P., Puwastien P., Polngam J. and Kongkachuichai R.: J. Food Anal. 2005, **18**, 47–59.
[7] Kuczyńska J. and Biziuk M.: Ecol. Chem. Eng., 2007, **14**(1), 47–65.
[8] Daun Ch. and Akesson B.: Meat Sci. 2004, **66**, 801–807.
[9] Korczyński F., Pliszka B. and Borkowski A.: Instrumentalna chemia analityczna z ćwiczeniami. Wyd. Art., Bydgoszcz 1995.
[10] Diaz-Alaron J.P., Nawarro-Alarcon M, de la Serrana L.-G. and Lopez-Martinez M.C.: J. Agric. Food Chem. 1994, **42**, 2848–2851.
[11] Rogala B. Szczerbowski M. and Żegleń S.: Alergia Astma Immunologia 1999, **4**(4), 239–243.
[12] Chałabis-Mazurek A. and Wałkuska G.: Med. Wet. 2008, **64**(11), 1324–1326.
[13] Wang Y-B. and Xu B-H.: Anim. Feed Sci. Technol., 2008, **144**, 306–314.
[14] Kadrobova J., Madaric A. and Ginter E.: Food Chem. 1997, **58**, 29–32.
[15] Satovic V. and Beker D.: Eur. Ford. Technol. 2004, **218**, 111–113.

ZRÓŻNICOWANIE ZAWARTOŚCI SELENU W NARZĄDACH KARPI (*Cyprinus carpio* L.)

Zakład Hydrobiologii i Akwakultury
Uniwersytet Przyrodniczy we Wrocławiu

Abstrakt: W 2007 roku zbadano próbki pochodzące od kroczków karpia (*Cyprinus carpio* L.) o średniej masie 430 g. Ryby pozyskano z 5 ha stawu Gospodarstwa Rybackiego MILICZ, położonego w zlewni rzeki Baryczy. Z każdej z 15 ryb pobrano następujące narządy: mięśnie, nerkę tułowiową, wątrobotrzustkę, skrzela, jelito i śledzionę. Określono zawartość selenu metodą generacji par wodorków (HG AAS). W wyniku przeprowadzonych badań stwierdzono najwyższą zawartość selenu w śledzionie (średnio 0,848 mg Se · kg^{-1}), jelicie (średnio 0,651 mg Se · kg^{-1}) oraz nerce (średnio 0,603 mg Se · kg^{-1}). Średnią koncentracją selenu na poziomie 0,37 mg Se · kg^{-1} charakteryzowała się wątrobotrzustka. Najmniej selenu stwierdzono w skrzelach i mięśniach ryb.

Słowa kluczowe: selen, karpie, tkanki