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CONTENT OF SELECTED ELEMENTS IN THE MUSCLE TISSUE OF PLAICE *(PLEURONECTES PLATESSA)* AND GARFISH *(BELONE BELONE)* FROM THE BALTIC SEA

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Abstract

Fish are an important component of a balanced human diet. Marine fish are more popular than freshwater fish among Polish consumers. All fish are an excellent source of minerals, which the human body cannot synthesize. Hence, they should be provided with food in right amounts and proportions. However, fish can be contaminated by heavy metals. For this reason, it is very important to determine the levels of selected trace elements in fish.

The aim of this study was to compare the content of mineral compounds in the muscle tissue of two species of fish from the Baltic Sea, i.e. plaice *(Pleuronectes platessa)* and garfish *(Belone belone)*. Wet-digested fish muscle samples were used to analyze the content of macro- (K, Na, Ca, Mg), and micronutrients (Zn, Fe, Mn, Cu) determined with flame atomic absorption spectrometry (AAS), and the levels of heavy metals (Cd, Pb) using flameless AAS.

No significant differences between the species in the concentrations of K, Mg, Ca, Cu and heavy metals appeared, while the Na, Mn, Zn and Fe concentrations were significantly different between the two fish. Higher levels of Na, Mg, Mn and heavy metals were determined in muscle tissue of European plaice, while concentrations of the other macro- and micronutrients were higher in muscles of garfish. The muscles of both species showed equal levels of Cd and Pb, below the maximum allowable limits.

Key words: garfish, plaice, muscle tissue, micronutrients, macronutrients, heavy metals.

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ZAWARTOŚĆ WYBRANYCH PIERWIASTKÓW W TKANCW MIĘŚNIOWEJ GŁADZICY *(PLEURONECTES PLATESSA)* I BELONY *(BELONE BELONE)* Z MORZA BAŁTYCKIEGO

Abstrakt

Ryby są istotnym elementem zbilansowanej diety człowieka. Polacy częściej spożywają ryby morskie niż słodkowodne. Wszystkie jednak są doskonałym źródłem związków mineralnych, które muszą być dostarczane do organizmu człowieka w odpowiedniej ilości i w odpowiednich proporcjach. Jakkolwiek ryby mogą być skażone metalami ciężkimi. Dlatego też bardzo istotne jest monitorowanie zawartości metali ciężkich.

Celem badań było porównanie zawartości związków mineralnych w mięsie dwóch gatunków ryb z Morza Bałtyckiego. Materiał badawczy stanowiła tkanka mięśniowa gładzicy *(Pleuronectes platessa)* i belony *(Belone belone)*. Pobrane próby poddano mineralizacji na mokro, a następnie oznaczono w nich zawartość makro- (Mg, Ca, Na, K) i mikroelementów (Zn, Cu, Mn, Fe) oraz metali ciężkich (Pb, Cd). Analizę mikro- i makroelementów przeprowadzono techniką płomieniowej atomowej spektrometrii absorpcyjnej (AAS), natomiast stężenie metali ciężkich oznaczono metodą bezpłomieniowej atomowej spektrometrii absorpcyjnej.

Nie wykazono istotnych różnic między badanymi gatunkami w przypadku K, Mg, Ca, Cu oraz metali ciężkich, natomiast statystycznie istotne różnice wykazano w przypadku zawartości Na, Mn, Zn oraz Fe. Wyższe stężenie Na, Mg, Mn oraz metali ciężkich stwierdzono w mięsie gładzicy, poziom pozostałych makro- i mikroelementów był wyższy w mięsie belony. Zawartość metali ciężkich w mięsie badanych gatunków ryb nie przekroczyła dopuszczalnych limitów.

Słowa kluczowe: belona, gładzica, tkanka mięśniowa, mikroelementy, makroelementy, metale ciężkie.

INTRODUCTION

People today are interested in nutrition as a way to ensure good health. Many chronic diseases, such as cardiovascular disorders, cancer or type 2 diabetes, are blamed to an unbalanced diet and lack of physical activity (ŁUCZYŃSKA et al. 2006, HONKANEN 2010). Minerals are a very important component of a diet, because they cannot be synthesized by the human body and therefore should be provided with food in the right amounts and proportions. Minerals play many crucial physiological functions and their proportions in tissues and cells condition the health of the body. Fish are an excellent source of elements, for example with respect to the mineral content some fish are superior to other types of food (POLAK-JUSZCZAK 2007). BRUCKA-JASTRZĘBSKA et al. (2010) revealed that a culture site and culture conditions exerted significant influence on the levels of macro- and micronutrients in freshwater fish. Moreover, the content of trace elements in the muscle tissue of fish can vary due to biological factors, such as the species, gender, age, feeding, living environment, or technical conditions, e.g. the method of fishing as well as transport (RYWOTYCKI 2005, ŁUCZYŃSKA et al. 2006, BRUCKA-JASTRZĘBSKA et al. 2009).

The European plaice (*Pleuronectes platessa*) is an important commercial flatfish, one of the most popular table fish in the Baltic Sea region. It is usually found on muddy seabeds from the low shore to depths exceeding 50 m. Juveniles forage on plankton and insect larvae, and adults feedn on polychaetes, molluscs, crustaceans and small fish. Similarly, the garfish (*Belone belone*) living in the pelagic zone of the Baltic Sea is fished for its tasty meat. This needlefish is a typical predator, flying in flocks near the surface and feeding on small fish and crustaceans.

Sea fish are more popular than freshwater fish in Poland, for example in 2008 the sea fish consumption was 9.4 kg per person, compared to just 3.4 kg of freshwater fish consumed per person (ŁUCZYŃSKA et al. 2011). However, low consumption of fish can be associated with an individual perception of benefits and risk associated with fish eating (VAN DIJK et al. 2011).

The pollution of seafood is both a hygienic and toxicological problem. It is extremely important to determine the levels of selected trace elements in fish. The Baltic Sea countries have monitored the content of heavy metals in fish since the 1980's (POLAK-JUSZCZAK 2009). The content of heavy metals in fish muscle tissue cannot be higher than 0.050 mg kg^{-1} for cadmium and 0.30 mg kg^{-1} for lead (European Commission 2006).

The aim of this study was to compare the concentration of selected elements in muscles of two fish species with different species-specific characteristics (coastal water vs. pelagic fish), both fished from the Baltic Sea.

MATERIAL AND METHODS

The study included two fish species from the Baltic Sea: plaice *(Pleuronectes platessa)* and garfish *(Belone belone)*. Twenty fish were analyzed, i.e. ten fish from each species, caught in the summer of 2010 from the Bay of Gdańsk, which lies in the southeastern part of the Baltic Sea (FAO Major Fishing Area 27, subarea III, division IIId, subdivision 26). Samples of the dorsal muscles of fish were wet digested in a mixture of HNO_3 and $HClO_4$ according to AOAC 986.15 standard (AOAC 2000).

The mineralized samples were used to analyze the concentration of macronutrients (potassium, sodium, calcium, magnesium), micronutrients (zinc, iron, manganese, copper), and heavy metals (cadmium and lead). Micro- and macronutrients were determined with the use of flame atomic absorption spectrometry (SOLAR 939 Unicam Spectrometer). The content of heavy metals was detected using flameless atomic absorption spectrometry (SpectrAA 880Z Varian).

Solution of lanthanum was added to all the samples and standards when determining calcium in order to eliminate the influence of phosphorus. The detection limits were 0.01 mg kg^{-1} for Na, 0.04 mg kg^{-1} for K, 0.47 mg kg^{-1}

for Mg, 0.22 mg kg^{-1} for Ca, 0.01 mg kg^{-1} for Mn, 0.01 mg kg^{-1} for Cu, 0.01 mg kg^{-1} for Zn, 0.09 mg kg^{-1} for Fe, 0.02 μg kg^{-1} for Cd, 0.24 μg kg^{-1} for Pb. The accuracy of the method was verified by means of trace metals determined in DORM-3 standard reference material. The achieved results were in good agreement with the certified values. The content of macro- and micronutrients as well as heavy metals in the muscle tissue of fish was expressed in mg kg^{-1} wet mass.

Statistical analysis was carried out using Statistica ver. 6.0 software (Statsoft 2003). The data were subjected to one-way Anova and Tukey's test was applied for comparisons of the means, considering $p < 0.05$ as significant.

RESULTS AND DISCUSSION

The concentrations of ten elements including macro-, micronutrients and heavy metals in the muscles of European plaice and garfish from the Baltic Sea are shown in Table 1. While analyzing the macronutrients, a significantly ($P \leq 0.05$) higher concentration of sodium (689.19 mg kg^{-1}) was found

Table 1

Concentration of macro- and micronutrients and heavy metals in muscle tissue of European plaice and garfish (mg kg^{-1} wet mass)

Specification	Plaice (*Pleuronectes platessa*)		Garfish (*Belone belone*)	
	$\overline{x}$	s	$\overline{x}$	s
Macronutrients (mg kg^{-1} wet mass)				
Na	689.19^{b}	176.61	480.56^{a}	53.09
K	1960.92	439.76	2014.16	335.54
Mg	333.79	53.83	258.93	37.59
Ca	1023.71	223.20	1225.55	109.05
Micronutrients (mg kg^{-1} wet mass)				
Mn	1.42^{b}	0.39	0.37^{a}	0.08
Cu	1.22	0.31	1.60	0.35
Zn	10.79^{a}	3.85	17.29^{b}	2.97
Fe	6.81a	1.58	9.34^{b}	0.97
Heavy metals (mg kg^{-1} wet mass)				
Cd	0.003	0.001	0.002	0.001
Pb	0.096	0.018	0.093	0.015

Means with different letters *a,b* differ significantly at $P \leq 0.05$

in the muscles of European plaice as compared with garfish (480.56 mg kg^{-1}). Nevertheless, the concentrations of this element found herein are within the range given by SIKORSKI (2004). Moreover, a similar content of sodium in muscles of European plaice was stated earlier by KWOCZEK (2006), who examined European flounder (692±70.5 mg kg^{-1}).

The concentrations of other macronutrients (K, Mg, and Ca) did not differ significantly between the compared species. Considerably lower concentrations of these elements in muscles of European flounder were reported by KWOCZEK (2006): K – 340, Mg – 88.5, and Ca – 413 mg kg^{-1}, respectively, in comparison with the muscles of plaice analzyed in the present study. The differences may stem from the fact that the cited study investigated European flounder, while the present results concern muscles of European plaice. However, both species belong to the same family (*Pleuronectidae*) living in the Baltic Sea.

While analyzing micronutrients, a significantly ($P \leq 0.05$) higher concentration of manganese (1.42 mg kg^{-1}) was found in muscles of European plaice than in garfish (0.37 mg kg^{-1}). However, the mean concentration of copper in muscles of the compared species did not differ significantly, and ranged from 1.22 mg kg^{-1} in plaice to 1.60 mg kg^{-1} in garfish.

Regional differences in Mn and Cu concentrations in muscles of garfish from Turkish waters were examined by TÜRKMEN et al. (2009). The authors obtained concentrations ranging from 0.25 to 1.33 mg kg^{-1} for manganese, and from 0.21 to 5.89 mg kg^{-1} for copper. However, considerably lower concentrations of these metals were reported by KWOCZEK (2006), i.e. 0.1 Mn and 0.3 mg Cu kg^{-1} for manganese and copper.

The species correlated significantly ($P \leq 0.05$) to the concentrations of zinc and iron in muscles of the examined fish. Higher levels of Zn and Fe were determined in the muscles of garfish (17.29 and 9.34 mg kg^{-1} for Zn and Fe, respectively) than in plaice (10.79 and 6.81 mg kg^{-1} for Zn and Fe, respectively).

TÜRKMEN et al. (2009) determined lower concentrations of zinc in the muscles of garfish, that is 8.1 to 15.0 mg kg^{-1}. Also, KWOCZEK (2006) reported a lower content of zinc (averaged 5.7 mg kg^{-1}) in the muscles of flounder than found in plaice in the present study. The above differences may be caused to the different living environments (the coastal waters of Turkey vs. the coastal waters of Poland). With respect to plaice, KWOCZEK (2006) analzyed fish of another species which belonged to the same family.

Our values of iron concentrations were in agreement with literature (SIKORSKI 2004). Also, a similar Fe content (averaged 9.99 mg kg^{-1}) was found by TÜRKMEN et al. (2009) in the meat of garfish from the Sea of Marmara. However, the same authors reported a higher Fe level for garfish meat from the Black Sea, ranging from 16.5 to 43.3 mg kg^{-1}. According to KWOCZEK (2006), the concentration of iron in flounder muscles averaged 5.4 mg kg^{-1}, and was lower than in plaice muscles analyzed in the present study.

Numerous factors, both biological (species and feeding type) and environmental ones, affect the degree of contamination of fish muscle tissue with heavy metals, mainly lead, mercury and cadmium. Fish absorb heavy metal through the intestinal tract from ingested food, and through the gills and skin from ambient waters (POLAK-JUSZCZAK 2009). Trace element levels are known to vary in fish depending on various factors such as the habitat, feeding behavior and migration, even in the same area (TÜRKMEN et al. 2009).

No differences between the investigated species in terms of the heavy metal concentration were found in the present study. It is noteworthy that the Pb and Cd concentrations in all the samples were found to be lower than the threshold proposed for human consumption by the European Commission (2006). However, a considerably higher concentration of both elements were determined by TÜRKMEN et al. (2009) in garfish muscles from Turkish waters. The concentrations of the heavy metals from 0.01 to 0.07 mg kg^{-1} for cadmium and from 0.19 to 0.81 mg kg^{-1} for lead.

Finally, POLAK-JUSZCZAK (2009), who analyzed temporal trends in the bioaccumulation of trace metals in fish from the southern Baltic Sea in 1994-2003, indicates that the most likely cause of decreasing trends in concentrations of cadmium, lead and mercury in the herring, sprats and cod is the lowering accumulation of these metals in the Baltic waters.

CONCLUSION

Out of the two species from the Baltic Sea analyzed in this study, the European plaice was a coastal water fish and garfish was a pelagic fish. These species-specific characteristics may be responsible for differences in the accumulation of individual elements accumulation between the two fish speices from the Baltic waters.

No significant differences between the species in the concentrations of potassium, magnesium, calcium, copper and heavy metals were determined. However, significant differences were observed in the sodium, manganese, zinc and iron concentration. Higher levels of sodium, magnesium, manganese and heavy metals were determined in muscles of European plaice, while the concentrations of the other macro- and micronutrients were higher in muscles of garfish. The muscles of both species showed equal levels of cadmium and lead.

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