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THE NUTRITIONAL VALUE OF SELECTED SPECIES OF FISH FROM LAKE AND FISH FARM OF NORTH-EASTERN POLAND

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K e y w o r d s: fish, chemical composition, fatty acids.

A b s t r a c t

The objective of this study has been to determine the chemical composition of fish which are used to make traditional dishes in Warmia and Mazury. The material for our analyses consisted of lake fish (roach, tench, pike, vendace, burbot) and cultured fish (carp) from north-eastern Poland. The highest protein content was found in muscles of vendace (19.2 ÷ 21.9%) and roach (20.5%), and the lowest one – in fillets from the carp reared in cooling water (15.7 ÷ 16.6%). The content of fat in meat of the carp from cooling waters was typical for fish (9.3 ÷ 12.4%). In contrast, lake fish (roach, tench, pike, vendace and burbot) were classified as lean fish.

The results showed the highest content of unsaturated fatty acids in muscles of burbot (82.8%) and the lowest one – in roach fillets (71.7%). Burbot meat was characterized by the highest share of n-3 PUFA acids (25.0%), including eicosapentaenoic (7.9%) and docosahexaenoic (11.5%) acids.

Our investigations have verified the assumption that the nutritional value of fish is affected by species-specific traits, environmental conditions and aquaculture techniques.

WARTOŚĆ ODŻYWCZA WYBRANYCH GATUNKÓW RYB Z PÓŁNOCNO-WSCHODNIEJ POLSKI

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K e y w o r d s: ryby, skład chemiczny, kwasy tłuszczowe.

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Abstrakt

Celem badań było określenie składu biochemicznego ryb, z których przyrządzane potrawy należą do tradycyjnych produktów regionalnych Warmii i Mazur. Materiał badawczy stanowiły ryby jeziorowe (płoć, lin, szczupak, sielawa, miętus) oraz ryby hodowlane (karp) z terenu północno-wschodniej Polski. Najwyższą zawartość białka stwierdzono w mięśniach sielawy (19,2 ÷ 21,9%) i płoci (20,5%), a najniższą w filetach karpia z wód pochłodniczych (15,7 ÷ 16,6%). Zawartość tłuszczu w mięsie karpia z wód pochłodniczych była charakterystyczna dla ryb tłustych (9,3–12,4%). Natomiast ryby jeziorowe (płoć, lin, szczupak, sielawa, miętus) zaliczono do ryb chudych.

Uzyskane wyniki badań wskazały najwyższą zawartość kwasów tłuszczowych nienasyconych w mięśniach miętusa (82,8%), a najniższą w filetach płoci (71,7%). Mięso miętusa charakteryzowało się najwyższym udziałem kwasów PUFA n-3 (25,0%), w tym kwasów eikozapentaenowego (7,9%) i dokozaheksaenowego (11,5%).

W przeprowadzonych badaniach potwierdzono tezę, że na wartość odżywczą ryb wpływają m.in. cechy gatunkowe, środowiskowe oraz technika chowu.

Introduction

Since prehistoric times, water bodies, both marine and inland (lakes and rivers) have been one of the basic sources of food for people (CIOS 2007, MAKOWIECKI 2003). North-eastern Poland is no exception and its residents used to eat large amounts of fish from Masurian lakes and rivers, from Vistula Lagoon and from the Baltic Sea (OSTOJSKI and WOLSKI 2006). Today, increasingly more often, people look for products typical of a given region.

Development of regional products is listed as one of the aims in development strategies of different European regions (RADZYMIŃSKA 2007). Taking advantage of regional products, including fish dishes (GĄTARSKA at al. 2009, RADZYMIŃSKA et al. 2009), is also becoming important for the growth of tourism in Warmia and Mazury. Fish are not just a regional product but also a true 'treasure trove' of valuable nutrients, because fish meat is a source of value-rich and easily digestible protein, which is 90% assimilable in the human digestive tract (BRZOZOWSKA 1998, SIKORSKI 1997a).

Fish meat is characterized by differentiated fat content, which ranges – depending on a fish species – from 0.2 to 40% (SIKORSKI 1997b, KOŁAKOWSKA and KOŁAKOWSKI 2001). This fat contains long-chain, polyunsaturated omega-3 fatty acids, valuable for human health, and especially eicosapentaenoic and docosahexaenoic acids, practically speaking available to people only in fish. These acids produce a variety of beneficial effects on the human body, e.g. they alleviate symptoms of inflammatory diseases, are essential for the good development of the brain and help maintain proper functions of the brain and the organ of vision (UAUY and DANGOUR 2006).

One of the most significant effects produced by omega-3 fatty acids concerns the development and functions of the nervous system (BURDGE 1998). Omega-3 acids support learning processes, improve concentration and relieve

aggression in children and are extremely important in prevention of cardiovascular diseases (NESS et al. 2002, KOLANOWSKI 2007, KOLANOWSKI and POWIERŻA 2008). Moreover, they reduce the risk of contracting cancer (CARROL 1996).

According to American Heart Association (Lichtenstein at al. 2006) and The America Dietetic of Canada (KRIS-ETHERTON at al. 2007) daily consumption of EPA and DHA should be between 0.5 to 1.0 g.

For nutrition, it is extremely important that fish contain fat-soluble vitamins, especially A and D as well as group B vitamins (GAWĘDZKI and HRYNIEWIECKI 2005).

Fish meat is certainly a better source of such elements as phosphorus, potassium or magnesium than slaughter animal meat. With respect to micronutrients, such elements as iron, copper, iodine, selenium, chromium and fluoride, by being present in considerable amounts in fish meat, attract special attention (BORUCKA and WIECZOREK 2003, POLAK-JUSZCZAK 2005).

The nutritional value of fish is shaped by several factors, e.g. the fish species and size, environmental conditions, type of ingested food (by wild fish) and aquaculture techniques (cultured fish).

The purpose of this study has been to determine the biochemical composition of selected fish species, which are used to make traditional fish dishes in the region of Warmia and Mazury in Poland.

Material and Methods

The material consisted of lake fish (roach, tench, pike, vendace, burbot), found in catches on open waters, and cultured fish (carp) from north-eastern Poland. Vendace was captured in Wigry Lake; roach, vendace, tench and pike were caught in Hańcza Lake; cultured carp originated from the fish farms in Bartołty Wielkie and cage placed in cooling water in Ostrołęka. The carp from the Fish Farm in Bartołty Wielkie received wheat as supplementary fed, and in the Fish Farm in Ostrołęka, the carp were fed granulated feed. Fish were caught in September.

The content of the basic chemical components (dry matter, total protein, crude fat, crude ash) in muscles of the examined fish was determined with the Weende method (AOAC 1996). Dry matter was determined by drying in an oven at 105°C for 24 h. Crude protein was determined by Kjeldahl's method and crude fat by Soxhlet's method. Crude fat content was extracted from the sample in anhydrous ethyl ether, crude ash by combustion at 550°C in a muffle furnace for 24 h. The determinations of the crude protein and fat, moisture and crude ash, were carried out at the Laboratory of Department of Nutrition Animals and Feed Science.

Quantitative and qualitative analyses of fatty acids were performed after muscle fat was cold-extracted (FOLCH et al. 1957). Seperation of fatty acids was conducted with the gas chromatography method using Hewlett Packard 6890 with a flame – ionising detector (FID), on a 30 m 0.32 mm internal diameter capillary column (Chair of Commodity Science and Food Analysis University of Warmia and Mazury in Olsztyn).

Results

The content of the basic chemical components in muscles of the examined fish was varied and depended on the fish species and size, and on the habitat in which they lived (Table 1). The highest total protein content was found in muscles of vendace (19.2 ÷ 21.9%) and roach (20.5%). Muscles of tench and pike were characterized by a lower protein content (19.1 and 18.6%, respectively), and the lowest level of this component was found in fillets of the carp cultured in cooling water (15.7 ÷ 16.6%).

Table 1

Chemical composition of muscle selected species of fish from north-eastern Poland

Species of fish	Components [%]			
	dry matter	crude protein	crude fat	crude ash
Vendace H	25.8	21.9	2.6	1.2
Vendace W	21.8	19.2	1.4	1.0
Burbot	19.6	17,9	0.4	1.1
Roach	22.8	20.5	0,9	1.2
Tench	21.1	19.1	0.6	1.2
Pike	21.0	18.6	0.8	1.4
Carp O	27.9	16.60	9.3	1.8
Carp O1	30.2	15.7	12.4	1.9
Carp B	26.5	17.78	6.8	1.7
Carp B1	26.7	18.0	6.9	1.6

vendace H – fish caught in Hańcza Lake; vendace W – fish caught in Wigry Lake; carp O – fish (body weight 1000–1500 g) from cooling water in Ostrołęka; carp O1 – fish (body weight 1500–2000 g) from cooling water in Ostrołęka; carp B – fish(body weight 1000–1500 g) from Fish Farm in Bartołty Wielkie; carp B1 – fish (body weight 1500–2000 g) from Fish Farm in Bartołty Wielkie

The highest fat content was determined in muscles of the carp from cooling water (9.3 ÷ 12.4%), much less- in the carp from Fish Farm in Bartołty Wielkie (6.8 ÷ 6.9%). The percentage of fat did not exceed 1% in muscles of roach, tench and pike (Table 1). The lowest fat content was found in burbot meat (0.4%).

The content of crude ash in muscles of the analyzed fish ranged from 1.0 to 1.9% The highest content of this component was determined in muscles of the carp from cooling water (1.8 ÷ 1.9%), slightly less – in the carp cultured in an earthen fish pond. The lowest content of crude ash, from 1.0 to 1.4%, was detected in muscles of the fish captured in natural habitats.

The share of particular fatty acids was differentiated depending on the fish species and habitat (Figures 1–3). Our analysis of the profile of fatty acids showed that the highest percentage of mono- and polyunsaturated acids occurred in muscles of burbot (82.8%), and the lowest – in muscles of roach (71.7%). A much higher percentage of unsaturated acids was determined in fat of vendace (74.0 ÷ 77.6%), pike (75.6%) and tench (73.4%). In muscles of the carp kept in cooling waters contained a higher percentage (75.2 ÷ 75.7%) of unsaturated acids relative to the carp reared in earthen fish ponds (73.2 ÷ 73.3%).

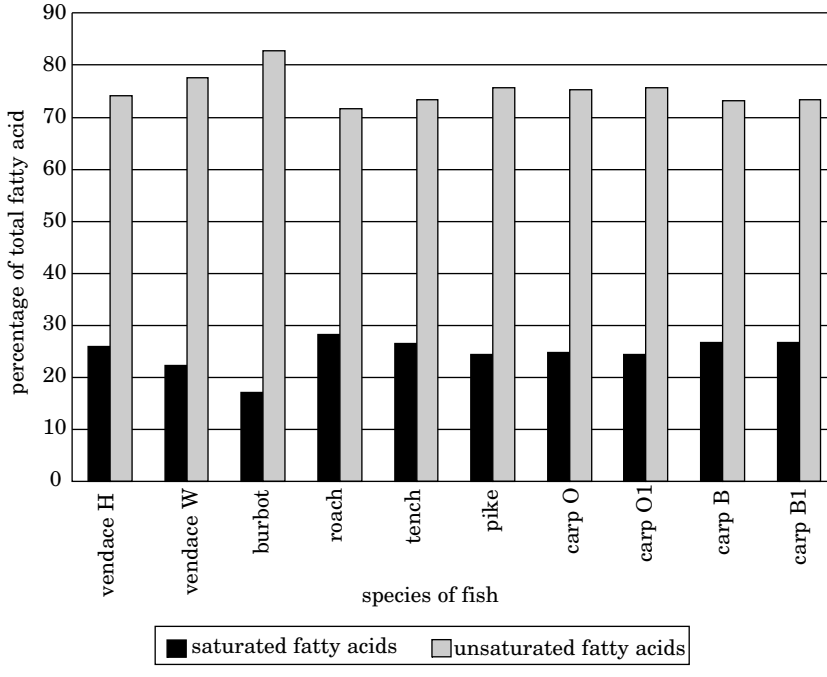

Fig. 1. Fatty acids composition [%] of muscle selected species of fish from north-eastern Poland

The percentage of n-3 PUFA acids was the highest in burbot meat (25.0%), including eicosapentaenoic acid (7.9%) and docosahexaenoic acid (11.5%). Much less of omega 3 acids was found in fat of vendance (17.3 ÷ 18.4%), roach (14.2%), tench (11.9%) and pike (11.4%).

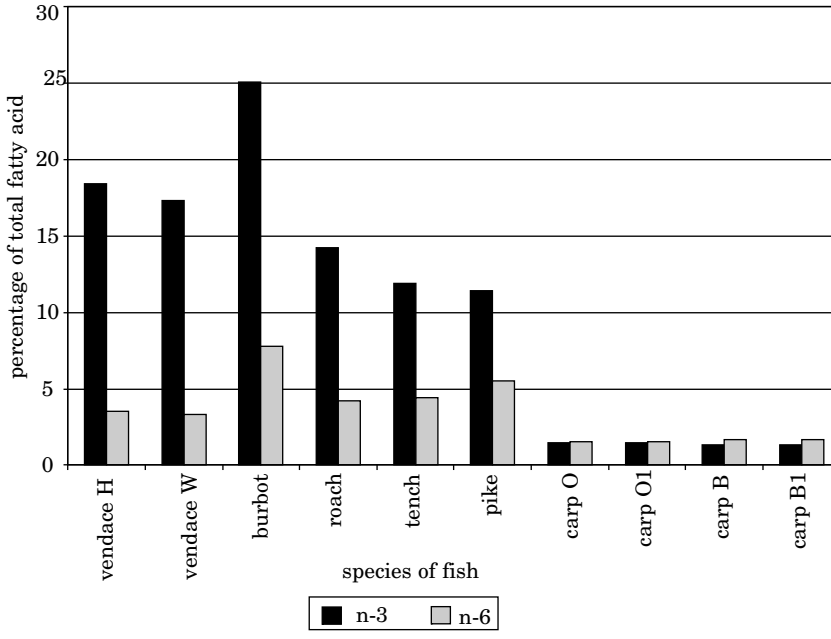

Fig. 2. Percentage share of essential polyunsaturated fatty acids n-3 and n-6 in muscle of selected species of fish from north-eastern Poland

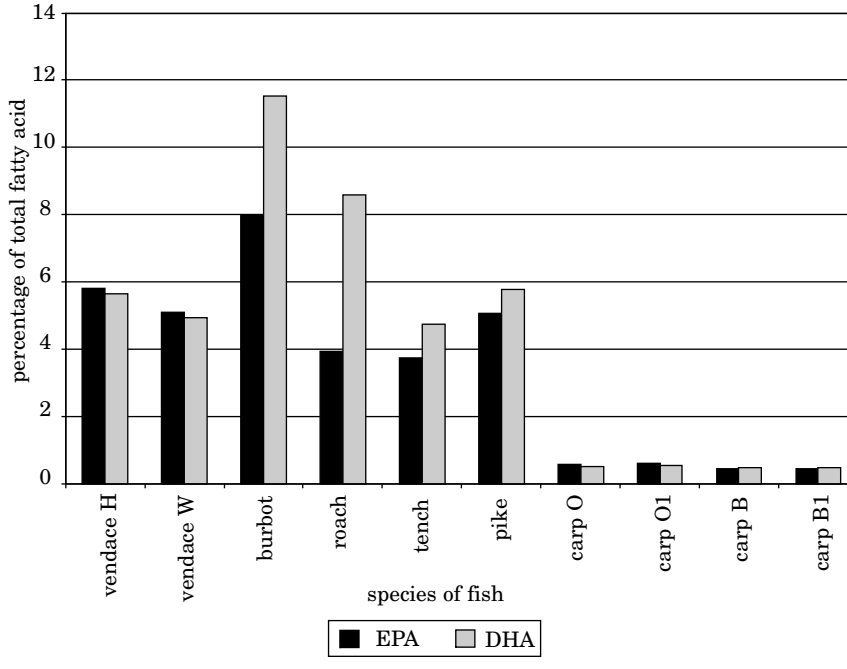

Fig. 3. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) content in muscle of selected species of fish from north-eastern Poland

Fat in the muscles of carp was characterized by the lowest percentage of these acids (1.3 ÷ 1.4%). It is noteworthy that also the level of EPA and DHA acids was the lowest in carp fat (0.5 ÷ 0.6%).

The highest percentage of omega-6 polyunsaturated fatty acids was found in burbot muscles (7.8%); a much lower percentage of this acid occurred in the muscle fat of pike (5.5%), tench (4.4%) and roach (4.2%). The fat from carp, irrespective of where the fish were reared, had the lowest content of omega-6 acids (1.3 ÷ 1.5%) – Figure 2.

The nutritional value of fish also depends on the n-3 to n-6 acid ratio. The determined values of this ratio are shown in Figure 4. The highest ratio of these two groups of acids was found in fat of the vendance from Wigry Lake (1:5.3); it was slightly lower in fat of the whitefish captured from Hańcza Lake. The lowest ratio was detected in fat of cultured carp (from 1:0.8 to 1:1).

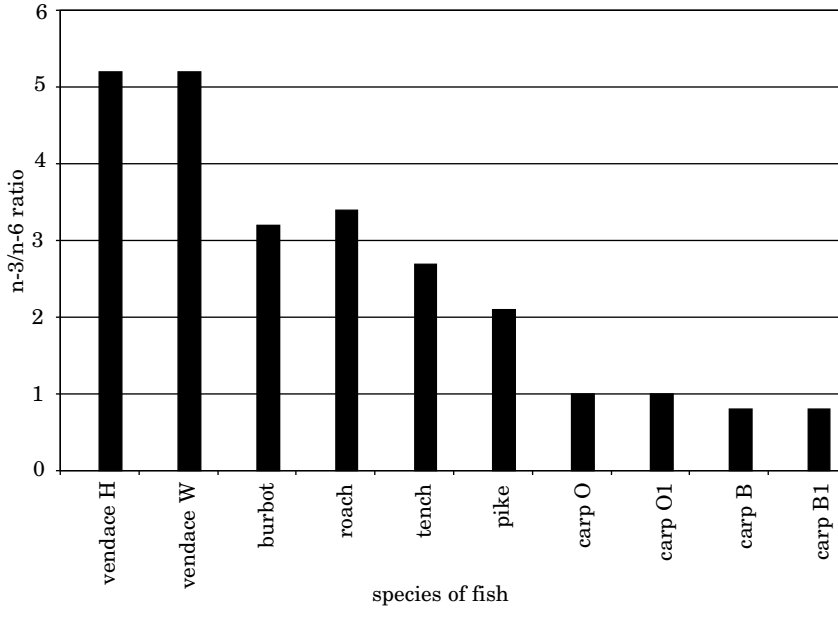

Fig. 4. Polyunsaturated acids n-3/n-6 ratio in muscle of selected species of fish from north-eastern Poland

Discussion

The results of our analyses, as presented above, reveal high variation in the content of particular nutrients in fish meat (Table 1, Figures 1–3). In meat of the vendace from Hańcza Lake, the level of total protein was higher than in meat of the vendace from Wigry Lake. Likewise, the content of crude fat and crude ash in the vendace from Hańcza Lake was higher than in the vendace

from Wigry Lake. It can be suspected that these differences were a result of the different trophic status of both lakes. Our data are different from the information reported by ZIĘCIK and ZAMOJSKI (1964), who examined vendace captured from Wydryńskie Lake, and found 17.8% of crude protein and 1.4 ÷ 1.5 of crude fat.

In the analysed meat of tench, the total protein content (19.1%) was similar and that of crude fat (0.6%) lower than in meat of tench captured from Legińskie Lake (ZIĘCIK and SŁAWIŃSKI 1965). On the other hand, the meat of burbot contained four-fold less fat (0.4%) than in burbot the Rogalica River, in north-western Poland (KOŁAKOWSKA at al. 2000).

Muscles of the carp from the earthen fish pond in Bartołty Wielkie were characterized by a higher total protein and lower crude fat content than found in carp from the cage fish farm located in cooling water in Ostrołęka (Table 1). The differences in total protein in the muscles of carp B and carp B1 could have been an effect of very good feeding conditions in the earthen ponds. In turn, the higher fat content in carp O and carp O1 (9.3 ÷ 12.4%) was most probably due to the feeding of carp with granulated feed and a higher water temperature, which stimulated higher feed intake and led to fat accumulation in muscles. The results obtained in our study were close to the ones reported by WIELOPOLSKA at al. (2003), i.e. 9.3 ÷ 14.4%. It should be emphasized that larger carp, weighing 1.5 ÷ 2 kg, had more fat than smaller ones (1.0 ÷ 1.5 kg).

The results achieved during our research enable us to conclude that fish originating from Polish lakes can be classified as lean ones (*Ryby i przetwory rybne*... PN-A-86770: 1999). It has also been proven that meat of wild fish contains much less lipids than meat of cultured fish (Table 1).

Crude fat content of muscle for vendace, burbot, roach, tench, pike and carp was lower in comparison with results obtained by BIENKIEWICZ at al. (2008). Presumbly, such significant differences were methodology dependent for crude fat content estimation, especially for common using Soxhlet's metod (in this work) and Bligh and Dyer's method applied by BIENKIEWICZ at al. (2008).

Nonetheless, the health-promoting value of fish meat depends primarily on the presence of polyunsaturated fatty acids, and especially eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids. Our analysis of the profile of fatty acids revealed that the highest percentage of polyunsaturated fatty acids appeared in fat of burbot (Figure 1). In addition, the composition of omega-3 acids in this fish had the highest per cent share of EPA and DHA (Figure 3). Our comparison of the content of fatty acids in muscles of roach and burbot with the results obtained by KOŁAKOWSKA at al. (2000) enabled us to conclude that the fish caught in Hańcza Lake were characterized by a higher content of PUFA acids than fish from other lakes in north-eastern Poland. The level of

unsaturated fatty acids in fat of anlysed fishes was significantly different in comparison to values described by BIENKIEWICZ at al. (2008). Only in case of carp, originated from aftercooling water farming, values were similar and ca 2% lower than values obtained for carp farmed in classical pond system.

Fishes such as vendace, tench, roach, burbot and pike originated from north-east lakes of Poland revealed higher nutritive value in relation to n-3 PUFA content in comparison with popular and marketing preferable fishes in Poland such as: oilfish, nile perch and pangasiid catfish (POLAK-JUSZCZAK 2007).

Conclusions

The results indicate that fish (vendace, tench, roach, burbot, pike) from lakes in north-eastern Poland, compared to fish from fish farms, are characterized by a higher content of protein and a much lower level of fat. The profile of fatty acids clearly demonstrates that burbot, vendace, roach and tench contained much more of the dietary valuable polyunsaturated fatty acids than the analysed carp. Fish caught in lakes contained large quantities of EPA and DHA, which are an essential component of human diet.

The present study confirmed the assumption that the nutritional value of fish is affected by such factors as the fish species and size, the habitat and aquaculture techniques.

Wild fish in Warmia and Mazury, caught from lakes in north-eastern Poland, are a valuable element of our diet and should be promoted as regional products. In the context of the nutritional value of fish and the culinary history, fish prepared according to the traditional, regional kitchen in Warmia and Mazury (for example, vendace smoked over specific types of hardwood, or tench in cream sauce) should become permanent elements of the traditional regional cuisine and receive the same protection as analogous traditional dishes and food products from Poland and other European Union countries.

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