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RESEARCH ARTICLE

Effect of fishing season on value in use, intrinsic properties, proximate composition and fatty acid profile of perch (*Perca fluviatilis*) muscle tissue

Piotr Skałecki, Mariusz Florek, Agnieszka Staszowska

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Abstract. The aim of study was to assess the effect of fishing season on value in use, intrinsic properties, chemical composition, and the fatty acid profile of the muscle tissue of free-living perch *Perca fluviatilis* L. caught in the Bystrzyca River. The research material comprised forty specimens of both sexes aged over 4 years. The fish were caught during two seasons in 2011, i.e. 20 specimens in spring (March/April), and 20 specimens in fall (October/November). No significant differences in the weight, length and condition, or in the value in use of the fish from the spring and fall seasons were noted. Fishing season had no significant effect on pH or the electrical conductivity value of perch muscle tissue. However, the color of the muscle tissue of fish from the spring season was redder and more intense. Significantly higher levels of fat and ash were noted in the muscle tissue of perch from the fall season, and this contributed to its higher nutritional value in comparison to fish caught in the spring. Furthermore, the muscle tissue of fish caught in the fall season was of greater preventive health value for consumers because of the significantly lower share of saturated fatty acids and higher concentration of long-chain n-3 polyunsaturated fatty acids, especially eicosapentaenoic, docosapentaenoic and docosahexaenoic.

Keywords: fatty acid profile, intrinsic properties, muscle tissue, perch, proximate composition, season

P. Skałecki, M. Florek [✉], A. Staszowska
Department of Commodity Sciences and Processing of Animal Raw Materials
University of Life Sciences in Lublin
Akademicka 13, 20-950 Lublin, Poland
e-mail: mariusz.florek@up.lublin.pl

Introduction

The increasing interest in *Percidae* fish results, inter alia, from the growing economic importance of the family and its augmented production in European aquaculture, including in Poland. It is worth noting that perch, *Perca fluviatilis* L., meat is characterized by very favorable organoleptic properties, i.e., white color, delicate texture, and mild flavor (Jankowska et al. 2010, Zakęś et al. 2010a). Demand to date for perch has been met largely with catches of wild fish mainly in Finland, Russia, and Estonia (Zakęś et al. 2010a). However, perch grow relatively slowly under natural conditions, and this has, in recent years, prompted interest in increasing production of both stocking material and commercial fish. Attempts to cultivate perch under artificial conditions, including the earliest stages of development, have been undertaken. Unfortunately, resources of *Percidae* fish in many Polish lakes are decreasing. In 2009, approximately 10,000 fishers caught more than two tons of perch from waters in the Lublin Branch of the Polish Angling Association (PAA), of this amount, approximately 160 kg were caught in the Bystrzyca River (PAA 2009).

The quality of fish meat, slaughter yield, and proximate composition are determined by species, sex, age, maturity stage, environmental conditions, and season (Guler et al. 2008, Stanek 2010). Among these parameters, the time of year can be the most important because it determines the composition of the diets that are available in different seasons (Szlinder-Richert et al. 2010). Perch is an interesting fish species because it is highly plastic in its feeding, and it feeds on both invertebrates and fish regardless of its size. This allows this species to react relatively rapidly to qualitative and quantitative changes in seasonal food resources to prey that are the most numerous or the most easily caught (Terlecki 1987). Many authors (González et al. 2006, Orban et al. 2007, Jankowska et al. 2007, 2010, Stanek et al. 2008, Kupcewicz et al. 2011) have analyzed the proximate composition and fatty acid profile of the meat of wild and cultivated perch. However, these studies were performed on fish from stagnant waters. Therefore, the aim of the present study was to assess the effect of fishing season on value in use, intrinsic properties, chemical composition, and the fatty acid profile of the meat of free-living perch from the Bystrzyca River.

Material and methods

The research material comprised perch caught in the Bystrzyca River in Strzyżewice in accordance with recreational fishing regulations of the PAA. The Bystrzyca River flows wholly through Lublin Voivodeship, and is a left tributary of the Wieprz River. The area of the river, without tributaries, is 15 hectares and the length is 70.3 km. The administrator of the river is the Lublin Branch of the PAA. The Bystrzyca River is classified as a mountain water in its upper reaches, and, according to Voivodeship Inspectorate for Environmental Protection, its ecological potential is evaluated from good to moderate depending on the section (VIEP 2010). Numerous fish ponds are located on the river section from which the fish were caught. The perch used in this study are probably escapees from these ponds, of which their high density in this section could have been indicative. The "no take" rule was in effect for *Salmonidae* fish in the area in which the perch were caught, but other fish species could be taken as they are classified as undesirable for trout management as administered by the PAA.

The study material comprised forty perch caught by angling in two seasons in 2011. Twenty specimens were caught in spring (March/April) before spawning, and 20 in the fall (October/November). The share of females and males was equal. After being caught, the perch were stunned mechanically, and their spinal cords were severed. The fish were placed in coolers and transported within two hours to the laboratory at the Department of Commodity Science and Processing of Raw Animal Materials, University of Life Sciences in Lublin. Fish age was determined by counting the number of annuli in the scales, and all of the specimens were over 4 years old (4+). The value in use of the fish was also evaluated by measuring total length (TL ± 1 mm), weight (BW ± 0.1 g), weight of meat on the carcass (Mw ± 0.01 g), share of meat on the carcass (%), and Fulton's condition factor (Bagenal et al. 1978).

After initial processing (i.e., scaling, eviscerating, deheading, removing fins and skin) the intrinsic qualities of the dorsal fillet were analyzed. The pH value (by CP-401 pH-meter) and specific electrical conductivity – EC (mS cm^{-1}) using a PQM I-KOMBI apparatus (INTEK, Aichach, Germany) were measured directly in the muscle tissue after 45 min (pH_1 and EC_1) and after 24 h (pH_2 and EC_2). Meat color was determined after 30 min exposure to oxygen under refrigerated conditions (4°C) with a CR-310 Minolta (Minolta Camera Co., Ltd., Osaka, Japan) portable chroma meter under the following conditions: illumination D65, geometry 0 projection angle, and 50 mm measuring area. The absolute results are presented as CIE L*a*b* values (CIE 2004), where L* – lightness, a* – redness-greenness, b* – yellowness-blueness, and h° – hue.

The proximate composition of the perch fillets was determined using reference methods, i.e., water content – drying method (103°C) according to PN-ISO 1442:2000; ash content – combustion method in a muffle furnace (550°C) according to

Table 1
Morphometric measurements of the perch (*P. fluviatilis*) with regard to season (mean ± SD)

	Season	
Specification	Spring (n=20)	Autumn (n=20)
Water temperature (°C)	6	9
Fish weight (g)	75.08 ± 19.25	70.81 ± 15.13
Total length (cm)	18.54 ± 1.45	18.26 ± 1.15
Fulton's condition coefficient	1.17 ± 0.22	1.15 ± 0.10
Carcass length (cm)	11.00 ± 1.00	10.46 ± 1.19
Skinned fillet weight (g)	26.52 ± 6.14	20.86 ± 5.72
Skinned fillet percentage (%)	56.30 ± 3.44	53.15 ± 5.13

Table 2
Intrinsic properties of perch (*P. fluviatilis*) muscle tissue by season (mean ± SD). Values with different letter indexes in the same row differ significantly statistically ($P \leq 0.05$)

	Season	
Specification	Spring (n=20)	Autumn (n=20)
pH_1	6.78 ± 0.21	6.68 ± 0.24
pH_2	6.60 ± 0.22	6.66 ± 0.30
EC_1 ($mS\ cm^{-1}$)	1.54 ± 0.21	1.28 ± 0.35
EC_2 ($mS\ cm^{-1}$)	1.74 ± 0.70	1.81 ± 0.58
CIE		
L*	56.12 ± 2.42	56.73 ± 2.05
a*	6.98^{b} ± 1.36	5.48^{a} ± 0.74
b*	7.56 ± 0.94	6.98 ± 1.50
C*	10.36^{b} ± 0.84	8.94^{a} ± 1.17
h^{o}	47.48 ± 7.87	51.41 ± 7.83

Table 3
Proximate composition ($g\ 100\ g^{-1}$) and calorie value ($kJ\ 100\ g^{-1}$) of perch (*P. fluviatilis*) muscle tissue by season (mean ± SD). Values with different letter indexes in the same row differ significantly statistically (a, b – $P \leq 0.05$; A, B – $P \leq 0.01$)

	Season	
Specification	Spring (n=20)	Autumn (n=20)
Water	80.65^{b} ± 0.62	79.68^{a} ± 0.85
Ash	1.23^{a} ± 0.33	1.65^{b} ± 0.37
Fat	0.11^{A} ± 0.04	0.29^{B} ± 0.09
Protein	18.06 ± 0.58	18.38 ± 0.74
Gross calorific value	428.67^{a} ± 13.40	445.30^{b} ± 17.40
Net calorific value	291.29^{a} ± 9.05	305.02^{b} ± 11.95

PN-ISO 936:2000; total protein content – Kjeldahl's method using a Büchi B-324 apparatus (Flawil, Switzerland) according to PN-75/A-04018; intramuscular fat content by Soxhlet's method (with n-hexane as the solvent) using a Büchi B-811 apparatus (Flawil, Switzerland) according to PN-ISO 1444:2000. The gross and net calorie values of 100 g of meat were calculated based on the content of protein and intramuscular fat using gross (protein 23.67 kJ per gram and fat 39.6 kJ per gram) and Atwater's (protein 16.7

kJ per gram and fat 37.6 kJ per gram) equivalents, respectively (Jeszka 2010). The content and profile of fatty acid were determined using a CG 3900 Varian gas chromatograph (Walnut Creek, CA USA) with a flame-ionizing detector (FID) and a CP Sil 88 capillary column running Star GC Workstation, 5.5. ver. The analysis of the fatty acid content was conducted after fat extraction performed according to the methodology of Folch et al. (1957), and further processing was done based on the PN-EN ISO 5509:2001 standard. The relative proportion of individual fatty acids was expressed in percentages. The mean value of the fatty acids identified was used to calculate the sum of the saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acids. The results obtained were analyzed statistically with one-way analysis of variance using STATISTICA ver. 6.0 (StatSoft 2003). The values reported in the tables are means ± standard deviation (SD). The significance of differences between the mean values of the groups was determined with the LSD Fisher test ($P \leq 0.05$ and $P \leq 0.01$).

Results

No significant differences in the weight, length and condition of the fish, or in their value in use were noted (Table 1). However, higher fish (by 5.7%), meat (by 21.3%), and meat share of the carcass (by 5.6%) weights were noted in the fish from the spring season. Fishing season had no significant effect on the pH value of perch muscle (Table 2), and the average pH_1 and pH_2 values of fish muscles in the spring were 6.78 and 6.60, respectively, while in the fall they were 6.68 and 6.66, respectively. No statistically significant differences between the seasons were noted regarding perch muscle tissue electrical conductivity. Compared to the perch from the fall season, the muscle tissue of those caught in spring was of similar lightness (L*), yellowness (b*), and hue (h°), but was characterized by significantly higher ($P \leq 0.05$) shares of red color (a*) and chroma (C*) (respectively, by 1.50 and 1.42 units) (Table 2).

The proximate composition of the fish differed significantly in the contents of water, ash, fat, and calorie value depending on fishing season (Table 3). The muscle tissue of perch from the spring contained significantly ($P \leq 0.05$) more water (by 0.97 g 100 g^{-1}) and concurrently less ash (by approximately 0.42 g 100 g^{-1}), and it had threefold (0.11 *vs* 0.29 g 100 g^{-1}) less fat ($P \leq 0.01$) in comparison to the meat of fish from the fall. The protein content in perch muscle tissue did not differ significantly, and ranged from 18.06 to 18.38 g 100 g^{-1}. The perch from the spring were characterized by significantly ($P \leq 0.05$) lower calorie values (net and gross energy) in comparison to those caught in the fall.

In present study, the fatty acid profile of fish muscle tissue was affected significantly by fishing season (Table 4). The average content of saturated fatty acids (SFA) in the spring was significantly ($P \leq 0.05$) higher (34.60%) than in the fall (25.54%). Among the SFA, palmitic acid (C16:0) dominated in the fish muscle tissue, while its share varied significantly ($P \leq 0.05$) between seasons with a spring content that was 31.3% higher in relation to that in the fall. Significant differences ($P \leq 0.05$) were also noted for myristic acid (C14:0), the percentage of which was 94.3% higher in the meat of perch caught in spring. Higher proportions of monounsaturated fatty acids (MUFA) were noted as compared to those of polyunsaturated (PUFA). While season did not have an effect on MUFA, it influenced ($P \leq 0.01$) the share and profile of polyunsaturated fatty acids significantly. Compared to the fish from the spring season, the muscle tissue of perch caught in the fall contained significantly ($P \leq 0.01$) more arachidonic acid C20:4n-6 (by 80.4%), docosapentaenoic acid C22:5n-3 (by almost 2.5-fold), and docosahexaenoic acid C22:6n-3 (by 2-fold). The lower content of n-3 PUFA in the muscle tissue of perch from the spring resulted in a decreased n-3:n-6 ratio (Table 3).

Table 4
Content of fatty acid (% of total FA) of perch (*P. fluviatilis*) muscle tissue by season (mean ± SD). Values with different letter indexes in the same row differ significantly statistically (a, b – P ≤ 0.05; A, B – P ≤ 0.01)

Specification	Season	
	Spring (n=20)	Autumn (n=20)
C12:0	0.53 ± 0.39	0.18 ± 0.08
C14:0	4.10^{b} ± 1.89	2.12^{a} ± 0.22
C15:0	0.95 ± 0.15	0.88 ± 0.15
C16:0	27.85^{a} ± 2.13	21.21^{b} ± 1.48
C17:0	0.51 ± 0.25	0.75 ± 0.12
C18:0	8.32 ± 1.66	4.98 ± 0.90
Σ SFA	34.60^{b} ± 2.55	25.54^{a} ± 1.68
C14:1	0.56 ± 0.21	0.44 ± 0.11
C16:1	9.94 ± 1.85	10.65 ± 1.23
C17:1	0.89 ± 0.48	0.72 ± 0.28
C18:1	28.17 ± 1.53	26.53 ± 1.72
C20:1	0.06 ± 0.11	0.53 ± 0.40
Σ MUFA	39.62 ± 3.23	38.87 ± 2.86
C18:2n-6	5.33 ± 1.48	6.53 ± 1.25
C18:3n-3	2.31 ± 1.69	3.43 ± 1.41
C18:4n-3	0.42 ± 0.68	0.37 ± 0.13
C20:4n-6	2.14^{A} ± 0.68	3.86^{B} ± 0.65
C20:5n-3	3.25 ± 0.77	5.26 ± 1.61
C22:5n-3	0.50^{A} ± 0.38	1.65^{B} ± 0.38
C22:6n-3	4.21^{A} ± 0.85	8.51^{B} ± 1.15
Σ PUFA	18.15^{A} ± 2.52	29.61^{B} ± 3.40
n-3/n-6	1.5 ± 0.5	1.9 ± 0.5

Discussion

Jankowska et al. (2007) compared cultivated (age 1+) and wild perch (age 3+) and reports similar biometric parameters to those of the current study. Nevertheless, the measurement of weights and total lengths of fish (116.1-119.4 g and 20.1-20.8 cm, respectively) as well as condition factor (1.29-1.47) reported by these authors were higher than the results of present study. These differences probably stemmed from the varied living conditions of the fish (Mazurian Lake District vs. the Lublin area). Kupcewicz et al. (2011), who examined the perch from Gopło Lake and Włocławski Reservoir, also report higher biometric measurements in comparison with those of the present study. However, these dissimilarities presumably stem from the different ages of the fish analyzed, i.e. 5+ in the study by Kupcewicz et al. (2011), and 4+ in present study. Furthermore, according to Szypuła (2002), the precision of the mathematical functions used to assess fish condition are related to fish size, water temperature, and feeding intensity.

According to Marx et al. (1997), the pH_{24} value limit for fresh fish meat is 6.5. Orban et al. (2007), who assessed perch from Italian lakes, report a similar pH range (6.60-6.78) to that of the present study. However, Litwińczuk et al. (2006) do not report that season had an effect on the pH value of Prussian carp *Carassius gibelio* (Bloch) meat. Therefore, it should be noted that the fish muscles analyzed were characterized by typical *post mortem* changes.

The values of EC determined in the spring and fall confirm the progression of autolysis and changes in the resistance of the muscle tissue of fish examined. Litwińczuk et al. (2006) reports that the season in which Prussian carp are caught had a significant effect on electrical conductivity values. According to them, the meat of fish caught in fall was characterized by significantly lower conductivity (1.8 mS cm^{-1}) than that in the muscle tissue of specimens caught in the spring (4.0 mS cm^{-1}).

The flesh color of both groups of fish was similar according to the values of parameters L*, b* and h°. Significant differences were noted in redness (a*) and color saturation (C*) ($P \leq 0.05$; Table 2) between the muscles of specimens from spring and fall. Similar tendencies regarding the flesh color of different predatory freshwater fish species, like pikeperch *Sander lucioperca* (L.) or perch, are reported by Jankowska et al. (2003, 2007). However, in contrast to the present results, Jankowska et al. (2007) report lower values for lightness (L*) and negative values of the a* and h° parameters of wild perch flesh. According to González et al. (2006), wild perch expend more energy moving than do fish reared in basins, which could contribute to different values of a*. Furthermore, varied growth rates among perch inhabiting different conditions can potentially impact the quantity and diameter of the muscle fibers, and this could influence flesh color (Johnston 1999).

The utilization of feed by fish and fat metabolism depend on a variety of factors such as fish age and size, feed composition, and feed ration (Shearer 1994). The ability of predatory fish to utilize carbohydrates is limited, therefore, the diet must contain fat, which is exploited primarily as a source of energy (Lie 2001). Lipid content in lean fish meat is relatively constant because the fish accumulate fat in the liver. In the meat of fatty fish, which collect lipids in the skin and the "red" muscles, fat content is highly variable and depends on the fishing season (Brzozowska 1998). Depending on the season, wild perch store their energy reserves, primarily in perivisceral fat or in the gonads (Sulistyo et al. 1998, 2000). However, cultivated perch deposits excess fat from feed mainly around the intestines and in the liver (Xu et al. 2001) or in the muscles (Jankowska et al. 2007). According to Zakęś et al. (2010b), concentrations of energy in the viscera of Percidae are reflected by a fat content that is several-fold higher than that in other organs or body parts. According to Uysal et al. (2006), under conditions such as reduced feeding or gonadal maturation, fats (or nutrients) are transferred from stores in the liver and muscle to the tissues that need these compounds. Similar observations were made in the present study. The muscle tissue of perch from the spring before spawning contained significantly more water and concurrently less fat compared to that of the fish from the fall (Table 3). The increased availability of food and beneficial water conditions allowed fish to accumulate fat reserves *de novo* during the summer.

The inverse relationship between fat and water content in perch flesh has been reported previously by other authors (Jankowska et al. 2007, Orban et al. 2007, Zakęś et al. 2008). A slightly higher fat content (0.41%) was noted by Stanek (2010) in the meat of perch caught in April and June from Lake Gopło and Włocławski Reservoir. Orban et al. (2007) report even higher percentages of fat in the range of 0.86 to 0.99% depending on fishing location than those in the present study. The calorie value of fish meat reflects the content of basic chemical components, particularly fat. Crucial factors determining the share of lipids in fish muscle tissue include species, age and maturity of fish, and climate, temperature, water pollution, and the availability and type of food (Çelik et al. 2005, Guler et al. 2008, Stanek et al. 2009). Zakęś et al. (2008) report energy values of wild perch fillets that are similar to those in the present study at 434.1 kJ 100 g^{-1}.

Stanek et al. (2008) analyzed the impact of different fishing seasons on the fatty acid profile in the muscles of perch from the Włocławski Reservoir, and they report that the highest percentage share of the SFAs was of C16:0 both in the spring (31.53%) and fall (33.31%). In the present study, comparable levels of C16:0 (27.9%) were determined in the muscle tissue of perch from the spring. González et al. (2006), however, report a similar total content of SFA in the meat of wild perch, while the contents of C14:0 and C16:0 significantly are lower compared to the present study at 0.78 and 4.09%, respectively. However, Kupcewicz et al. (2011) reported considerably higher SFA content (44.6-46.4%) depending on the location from which the fish were obtained.

Lower total MUFA content was noted in perch from Włocławski Reservoir than in the fish from the present study at 32.24% in the spring, and 23.83% in the fall (Stanek et al. 2008). Similarly, Jankowska et al. (2010) report a value of 29.20% MUFA in wild perch fillets. The present study revealed that the muscle tissue of perch caught in the fall contained significantly higher total contents of PUFA compared to those caught in the spring season. Wang et al. (1990) and Stanek et al. (2008) report similar effects of fishing season on PUFA content. However, according to Uysal et al. (2011), fish caught from waters of lower temperatures have a more favorable fatty acid profile for human health than do those fished at moderate temperatures. Fish can adapt to lower water temperatures by regulating the fatty acid composition of their biological membranes, and PUFAs play a critical role in this process because of their lower melting points (Uysal et al. 2008). The reproduction period is another important factor, because during it the most remarkable changes in fatty acid composition are observed, and the quality of the flesh can decreased in terms of fatty acids (Uysal and Aksoylar 2005).

Stanek et al. (2008) report that the PUFA content of perch caught in the Włocławski Reservoir varied according to fishing season, which was also observed in the current study. These authors report significantly lower contents of C20:4, C20:5, and C22:6 in the muscles of fish from the spring in comparison to those caught during fall. Zakęś et al. (2010a) reports higher PUFA content in wild perch fillets (43.01%) in comparison to those of cultivated fish (34.97%). Docosahexaenoic acid (C22:6) dominated among the polyunsaturated fatty acids, and the content of it in the muscle tissue of perch from the spring season was 4.21% and from the fall season 8.51%. Higher contents of DHA in perch meat, in comparison to other polyunsaturated fatty acids, are the result of the selective retention of the acid or a biochemical transformation of n-3 acids into long-chain fatty acids. Xu and Kestemont (2002) report the phenomenon of n-3 fatty acid bioconversion in perch tissues. Moreover, the metabolic effectiveness of this process in freshwater fish species is usually greater in comparison with marine species (Sargent et al. 2002).

It is widely accepted that a high n-3/n-6 (ω-3/ω-6) fatty acid ratio is healthful, particularly with regard to reducing the risk of cardiovascular disease (Simopoulos 2008). The values of this ratio in the present study ranged from 1.5 to 1.9 without the significant impact of season. Steffens (1997) reports that freshwater fish contain higher levels of n-6 PUFA resulting a much lower n-3:n-6 FA ratios ranging from 1 to 4 as compared with marine fish, in which they range from 5 to 10.

Conclusions

1. Fishing season had no statistically significant effects on the value in use or physicochemical properties of perch muscle tissue.
2. Perch meat contained significantly more fat and mineral components and less water in fall than it did in spring. Perch meat had a more favorable profile of fatty acids in fall thanks to the significantly lower share of saturated fatty acids (SFA) and the higher share of polyunsaturated fatty acids (PUFA), especially long-chain EPA, DPA and DHA in fall than it did in spring.

Author contributions. P.S. designed the research; P.S. and A.S. performed the research; M.F. analyzed the data; P.S., A.S., and M.F. wrote the paper.

References

Bagenal T.B., Tesh F.W. 1978 – Age and growth – In: Methods for Assessment of Fish Production in Freshwater. Oxford. Blackwell Scientific Publications: 81-89.

Brzozowska E. 1998 – Fish - nutritional value and culinary suitability – Przem. Spoż. 7: 37-38 (in Polish).

CIE 2004 – Colorimetry – 3rd ed., Commission International de l'Eclairage. Vienna Austria: 16-20.

Çelik M., Diler A., Küçükgülmez A. 2005 – A comparison of the proximate compositions and fatty acid profiles of zander (*Sander lucioperca*) from two different regions and climatic conditions – Food Chem. 92: 637-641.

Folch J., Less M., Sloane G.H. 1957 – A simple method for the isolation and purification of total lipids from animal tissue – J. Biol. Chem. 226: 497-509.

González S., Flick G.J., O'Keefe S.F., Duncan S.E., McLean E., Craig S.R. 2006 – Composition of farmed and wild yellow perch (*Perca flavescens*) – J. Food Comp. Anal. 19: 720-726.

Guler G.O., Kiztanir B., Aktumsek A., Citil O.B., Ozparlak H. 2008 – Determination of the seasonal changes on total fatty acid composition and ω3/ ω6 rations of carp (*Cyprinus carpio* L.) muscle lipids in Beysehir Lake (Turkey) – Food Chem. 108: 689-694.

Jankowska B., Zakęś Z., Żmijewski T., Szczepkowski M. 2003 – A comparison of selected quality features of the tissue and slaughter yield of wild and cultivated pikeperch (*Sander lucioperca* (L.)) – Eur. Food Res. Technol. 217: 401-405.

Jankowska B., Zakęś Z., Żmijewski T., Szczepkowski M., Kowalska A. 2007 – Slaughter yield, proximate composition, and flesh colour of cultivate and wild perch (*Perca fluviatilis* L.) – Czech J. Anim. Sci. 52: 260-267.

Jankowska B., Zakęś Z., Żmijewski T., Szczepkowski M. 2010 – Fatty acid profile of muscles, liver and mesenteric fat in wild and reared perch (*Perca fluviatilis* L.) – Food Chem. 118: 764-768.

Jeszka J. 2010 – Energy – In: Human nutrition. Basics of food science (Ed) J. Gawęcki, Wyd. PWN, Warszawa: 146-150 (in Polish).

Johnston I. A. 1999 – Muscle development and growth: potential implications for flesh quality in fish – Aquaculture 177: 99-115.

Kupcewicz B., Stanek M., Janicki B. 2011 – Chemometric analysis of fatty acids profile of bream (*Abramis brama*), ruffe (*Gymnocephalus cernua*) and perch *(Perca fluviatilis)* meat from Lake Gopło and Włocławski Dam Reservoir – J. Cent. Eur. Agric. 12: 608-621.

Lie Ø. 2001 – Flesh quality - the role of nutrition – Aquac. Res. 32: 341-348.

Litwińczuk A., Skałecki P., Florek M., Grodzicki T. 2006 – Value in use and physical-chemical quality of meat of Prussian carp (*Carassius auratus gibelio* L.) fished in spring and fall seasons – Rocz. Nauk. Pol. Tow. Zoot. 2: 97-101 (in Polish).

Marx H., Brunner B., Weinzierl W. 1997 – Methods of stunning freshwater fish: impact on meat quality and aspects of animal welfare – Z. Lebensm. Unters. F A 204: 282-286.

Orban E., Neviato T., Masci M., Di Lena G., Casini I., Caproni R., Gambelli L., De Angelis P., Rampacci M. 2007 – Nutritional quality and safety of European perch *(Perca fluviatilis)* from three lakes of Central Italy – Food Chem. 100: 482-490.

PAA (Polish Angling Association) 2009 – Collective record of fishing in the Lublin Branch in 2009 – http://www.pzw.org.pl/naszewody/cms/6703/rejestr_p olowu (in Polish).

Sargent J.R., Tocher D.R., Bell J.G. 2002 – The lipids – In: Fish nutrition (Eds) J.E. Halver, R.W. Hardy, Academic Press, San Diego, CA, USA: 181-257.

Shearer K.D. 1994 – Factors affecting the proximate composition of cultured fish with emphasis on salmonids – Aquaculture 119: 63-88.

Simopoulos A.P. 2008 – The omega-6/omega-3 fatty acid ratio, genetic variation, and cardiovascular disease – Asia Pac. J. Clin. Nutr. 17: 131-134.

Steffens W. 1997 – Effects of variation in essential fatty acids in fish feeds on nutritive value of freshwater fish for humans – Aquaculture 151: 97-119.

Stanek M., Dąbrowski J., Roślewska A., Janicki B. 2009 – Estimation of fat and cholesterol content in the muscles of female and male perch (*Perca fluviatilis L.*) from Lake Gopło – Folia Pomer. Univ. Technol. Stetin. Agric. Aliment. Pisc. Zootech. 271: 5-10 (in Polish).

Stanek M., Dąbrowski J., Roślewska A., Kupcewicz B., Janicki B. 2008 – Impact of different fishing seasons on the fatty acids profile, cholesterol content, and fat in the muscles of perch, *Perca fluavitilis* L. from the Włocławski Reservoir (central Poland) – Arch. Pol. Fish. 16: 213-220.

Stanek M. 2010 – Fat and cholesterol content in the meat of selected species of fish from central Poland – Komun. Ryb. 2 (115): 5-7 (in Polish).

StatSoft 2003 – STATISTICA, data analysis software system, ver. 6.

Sulistyo I., Fontaine P., Rinchard J., Gardeur J.N., Migaud H., Capdeville B., Kestemont P. 2000 – Reproductive cycle and plasma levels of steroids in male Eurasian perch *Perca fluviatilis* – Aquat. Living Resour., 13: 99-106.

Sulistyo I., Rinchard J., Fontaine P., Gardeur J.N., Capdeville B., Kestemont P. 1998 – Reproductive cycle and plasma levels of sex steroids in female Eurasian perch *Perca fluviatilis* – Aquat. Living Resour. 11: 101-110.

Szlinder-Richert J., Usydus Z., Wyszynski M., Adamczyk M. 2010 – Variation in fat content and fatty-acid composition of the Baltic herring *Clupea harengus* membras – J. Fish Biol. 77: 585-599.

Szypuła J. 2002 – The length-weight relationship and condition of pike and perch in Lake Miedwie – Acta Ichthyol. Piscat. 32: 93-106.

Terlecki J. 1987 –The diet of adult perch, *Perca fluviatilis* L., in the Vistula Dam Reservoir in Włocławek – Acta Ichthyol. Piscat. 27: 43-57.

Uysal K., Aksoylar M.Y. 2005 – Seasonal variations in fatty acid composition and the n-6/n-3 fatty acid ratio of pikeperch (*Sander lucioperca*) muscle lipids – Ecol. Food Nutr. 44: 23-35.

Uysal K., Bülbül M., Dönmez M., Seçkin A.K. 2008 – Changes in some components of the muscle lipids of three freshwater fish species under natural extreme cold and temperate conditions – Fish Physiol. Biochem. 34: 455-463.

Uysal K., Taykurt N., Bulut S., Emiroglu O. 2011 – Comparison of fatty acid amounts and ratios of ω3 and ω6 fatty acids in muscle of some freshwater fish under natural extreme cold conditions – Chem. Nat. Compd. 47: 431-433.

Uysal K., Yerlikaya A., Aksoylar M.Y., Yöntem M., Ulupunar M. 2006 – Variations in fatty acids composition of pikeperch (*Sander lucioperca*) liver with respect to gonad maturation – Ecol. Freshw. Fish. 15: 441-445.

Wang Y.J., Miller L.A., Perren M., Addis P.B. 1990 – Omega-3 fatty acids in lake superior fish – J. Food Sci. 55: 71-76.

VIEP (Voivodship Inspectorate of Environmental Protection) 2010 – Report on the state of the environment in the Lublin Voivodeship in 2010 – http://www.wios.lublin.pl/tiki-list_file_gallery.php?galleryId=26 (in Polish).

Xu X. L., Fontaine P., Mélard C., Kestemont P. 2001 – Effects of dietary fat levels on growth, feed efficiency and biochemical composition of Eurasian perch *Perca fluviatlis* – Aquacult. Int. 9: 437-449.

Xu X., Kestemont P. 2002 – Lipid metabolism and FA Composition in tissues of Eurasian Perch *Perca fluviatilis* as Influenced by Dietary Fats – Lipids 37: 297-304.

Zakęś Z., Jankowska B., Żmijewski T., Szczepkowski M. 2008 – Effect of feeding on the slaughter yield and basic chemical composition of fillets of sea perch (*Perca fluviatilis*) – Komun. Ryb. 4 (105): 7-10 (in Polish).

Zakęś Z., Jankowska B., Żmijewski T., Szczepkowski M. 2010a – Comparison of the chemical composition of selected body parts of wild and cultivated sea perch – Komun. Ryb. 2 (115): 5-7 (in Polish).

Zakęś Z., Kowalska A., Jankowska B., Demska-Zakęś K., Hancz C., Jarmołowicz S. 2010b – Impact of feeding juvenile pikeperch (*Sander lucioperca* (L.)) diets supplemented with vegetable oils on proximate body composition and fatty acid profile – Arch. Pol. Fish. 18: 135-147.