

# Impact of the environmental factors on the total cholesterol content in the meat of freshwater fish of Poland

## Wpływ czynników środowiskowych na zawartość cholesterolu całkowitego w mięsie ryb słodkowodnych Polski

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### Abstract

The aim of the work was to determine the total cholesterol content in the meat of perch (*Perca fluviatilis* L.), Prussian carp (*Carassius auratus gibelio*), ruffe (*Gymnocephalus cernua* L.) and sander (*Sander lucioperca* L.) collected from Lake Gopło, Lake Góreckie and to compare the cholesterol content between females and males of ruffe caught in different seasons from Lake Gopło. The study involved 84 samples of fish meat. The cholesterol content was determined with the modified Liebermann-Burchardt colorimetric method using a Shimadzu spectrophotometer (UV-VIS-NIR-3100). As analyses indicated there were no statistically significant differences in the total cholesterol content in the meat of females and males of ruffe caught during spring (42.27 and 44.35 mg·100 g<sup>-1</sup>, respectively). The statistically significant differences were determined between individuals of females and males of ruffe collected in autumn from Lake Gopło. These values ranged from 48.95 mg·100 g<sup>-1</sup> for females to 59.29 mg·100 g<sup>-1</sup> for males. There were found no statistically significant differences in the total cholesterol content in the meat of perch collected from Lake Gopło (57.80 mg·100 g<sup>-1</sup>) and Lake Góreckie (61.45 mg·100 g<sup>-1</sup>). Analyses which concerned the total cholesterol content in the meat of four different fish species collected from Lake Gopło confirmed a statistically significant interspecies differences in the total cholesterol content. These values ranged from 52.77 mg·100 g<sup>-1</sup> (in the meat of sander) to 61.12 mg·100 g<sup>-1</sup> (in the meat of Prussian carp).

**Keywords:** freshwater fish, meat, total cholesterol

## Streszczenie

Celem pracy było określenie całkowitej zawartości cholesterolu w mięsie okonia (*Perca fluviatilis* L.), karasia srebrzystego (*Carassius auratus gibelio*), jazgarza (*Gymnocephalus cernua* L.) oraz sandacza (*Sander lucioperca* L.) odłowionych z jeziora Gopło i jeziora Góreckiego oraz porównanie zawartości cholesterolu między samicami i samcami jazgarza złowionego w różnych porach roku w jeziorze Gopło. Badaniom poddano 84 próbek mięsa. Zawartość cholesterolu oznaczano zmodyfikowaną metodą kolorymetryczną Liebermanna-Burchardta przy pomocy spektrofotometru Shimadzu (UV-VIS-NIR, 3100). Jak wykazały analizy, nie było statystycznie istotnych różnic w całkowitej zawartości cholesterolu w mięsie samic i samców jazgarza złowionego w okresie wiosny ( $42,27$  i  $44,35$   $\text{mg} \cdot 100 \text{ g}^{-1}$ , odpowiednio). Istotne statystycznie różnice określono między osobnikami samicami i samcami jazgarza pozyskanego jesienią z jeziora Gopło. Wartości te wahały się od  $48,95$   $\text{mg} \cdot 100 \text{ g}^{-1}$  dla samic do  $59,29$   $\text{mg} \cdot 100 \text{ g}^{-1}$  dla samców. Nie stwierdzono statystycznie istotnych różnic w całkowitej zawartości cholesterolu w mięsie okonia odłowionego z jeziora Gopło ( $57,80$   $\text{mg} \cdot 100 \text{ g}^{-1}$ ) i jeziora Góreckiego ( $61,45$   $\text{mg} \cdot 100 \text{ g}^{-1}$ ). Analizy, które dotyczyły porównania całkowitej zawartości cholesterolu w mięsie czterech różnych gatunków ryb pozyskanych z jeziora Gopła, potwierdziły statystycznie istotne różnice międzygatunkowych w zawartości cholesterolu. Wartości te wynosiły od  $52,77$   $\text{mg} \cdot 100 \text{ g}^{-1}$  (w mięsie sandacza) do  $61,12$   $\text{mg} \cdot 100 \text{ g}^{-1}$  (w mięsie karasia srebrzystego).

**Słowa kluczowe:** całkowity cholesterol, mięso, ryby słodkowodne

## Streszczenie szczegółowe

Celem pracy było określenie całkowitej zawartości cholesterolu w mięsie okonia (*Perca fluviatilis* L.), karasia srebrzystego (*Carassius auratus gibelio*), jazgarza (*Gymnocephalus cernua* L.) oraz sandacza (*Sander lucioperca* L.) odłowionych z jeziora Gopło i Jeziora Góreckiego oraz porównanie zawartości cholesterolu między samicami i samcami jazgarza złowionego w różnych porach roku w jeziorze Gopło. Na każdym osobniku dokonano pomiarów biometrycznych: masy ciała (BW) ( $\pm 0,01$  g) i długości ciała (Lc) ( $\pm 0,1$  cm). Próbki mięsa pobierano z mięśnia bocznego wielkiego powyżej linii bocznej ciała. Do badań wybrano osobniki posiadające zbliżone wartości wskaźników biometrycznych. Badaniom poddano 84 próbek mięsa. Wszystkie próbki mięsa zliofilizowano w liofilizatorze firmy Finn-Aqua Lyovac GT2 przy parametrach: temperatura  $-40^{\circ}\text{C}$ , ciśnienie  $6 \cdot 10^{-2}$  mbar. Zawartość cholesterolu oznaczano zmodyfikowaną metodą kolorymetryczną Liebermanna-Burchardta przy pomocy spektrofotometru Shimadzu (UV-VIS-NIR, 3100). Jak wykazały analizy, nie było statystycznie istotnych różnic w całkowitej zawartości cholesterolu w mięsie samic i samców jazgarza złowionego w okresie wiosny ( $42,27$  i  $44,35$   $\text{mg} \cdot 100 \text{ g}^{-1}$ , odpowiednio). Istotne statystycznie różnice określono między osobnikami samicami i samcami jazgarza pozyskanego jesienią z jeziora Gopło. Wartości te wahały się od

48,95 mg·100 g<sup>-1</sup> dla samic do 59,29 mg·100 g<sup>-1</sup> dla samców. Nie stwierdzono statystycznie istotnych różnic w całkowitej zawartości cholesterolu w mięsie okonia odłowionego z jeziora Gopło (57,80 mg·100 g<sup>-1</sup>) i jeziora Góreckiego (61,45 mg·100 g<sup>-1</sup>). Analizy, które dotyczyły porównania całkowitej zawartości cholesterolu w mięsie czterech różnych gatunków ryb pozyskanych z jeziora Gopła, potwierdziły statystycznie istotne różnice międzygatunkowych w zawartości cholesterolu. Wartości te wynosiły od 52,77 mg·100 g<sup>-1</sup> (w mięsie sandacza) do 61,12 mg·100 g<sup>-1</sup> (w mięsie karasia srebrzystego).

## Introduction

Cholesterol is the precursor of bile acids, provitamin D<sub>3</sub> and steroid hormones. It plays an extraordinary role as a part of cell membranes, where it is dynamically involved in their fluidity and rigidity. It is very important to analyze this sterol content in foods, because the daily exogenous cholesterol intake should not exceed 300 mg. As it's commonly known, intake of cholesterol in a large amounts cause the increase LDL cholesterol in the blood serum (Vorlová et al., 2001). The total cholesterol content in the meat of fish depends on the species, age, sex, spawning cycle, harvesting period and geographical location of the reservoir (Donmez, 2009; Komprda et al., 2003; Piironen et al., 2002; Živković et al., 2002). Bieniarz et al. (2001) confirmed a statistically significant differences in the total cholesterol content in the meat of some line of carp (*Cyprinus carpio* L.) depending on the age and season. These values ranged from 59.6 (the Japanese line) to 233.5 mg·100 g<sup>-1</sup> (the Starzawski line). Piironen et al. (2002) showed that cholesterol concentration was independent of the fat content. Furthermore, cholesterol concentration in the fish meat seems to be genetically determined and constant within individual families. The values ranged from 49 to 92 mg·100 g<sup>-1</sup>. Mathew et al. (1999) determined that the concentration of cholesterol in the fish meat ranged from 22 to 148 mg·100 g<sup>-1</sup>. Oehlenschläger (2006) analyzed 70 fish species and confirmed interspecies differences in the cholesterol content. The same results demonstrated Krzynowek et al. (1989) and Ljubojević et al. (2013a). The aim of the work was to determine the total cholesterol content in the meat of Prussian carp (*Carassius auratus gibelio*), perch (*Perca fluviatilis* L.), sander (*Sander lucioperca* L.) and ruffe (*Gymnocephalus cernua* L.) collected from Lake Gopło and Lake Góreckie and to compare the cholesterol content between females and males of ruffe caught in different seasons from Lake Gopło.

## Materials and Methods

### Study area

Lake Góreckie is located in Wielkopolska National Park (Western Poland) (Figure 1). It's a dimictic lake with a surface area of ca. 104 ha, maximum and mean depths of 17.25 m and 8.97 m, respectively and a shore line of 8300 m. The degree of antropopressure from the annual nitrogen and phosphorus for the eutrophic Lake Góreckie is estimated at 9.5 g·m<sup>-2</sup>·year<sup>-1</sup> for total nitrogen and 0.36 for total phosphorus g·m<sup>-2</sup>·year<sup>-1</sup> (Pełechaty and Owsiany, 2003; Sobczyński et al., 2012).

Lake Gopło is a flow-through container which is located in the southern part of Kuyavian-Pomeranian Province (Figure 1). The maximum length of Lake Gopło is 25 km, and the surface of water exceeds 2100 ha. The greatest depth oscillates around 16,6 m, and the mean depth is 3,6 m. The biggest tributary of Lake Gopło is the Noteć River, and a few smaller tributaries also flow into it. These flows are significantly overloaded with biogenes. The conditions of the catchment cause unfavorable, i.e. III class of susceptibility to degradation of the waterbody, which has an adverse effect on the quality of water. The western part of this lake is a strict nature reserve (Report WIOŚ, 2014).

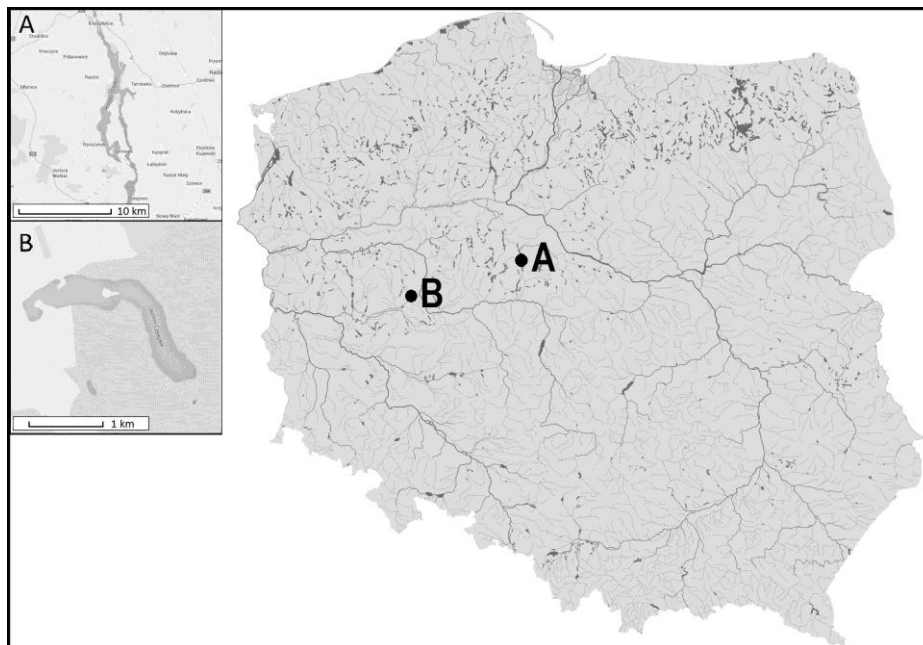


Figure 1. Map of Poland and location of Lake Gopło (A), Lake Góreckie (B)  
Ilustracja 1. Mapa Polski i lokalizacja jeziora Gopło (A), jeziora Góreckiego (B)

### Material collecting

The study involved 84 meat samples. 54 samples of perch (*Perca fluviatilis* L.), Prussian carp (*Carassius auratus gibelio*), ruffe (*Gymnocephalus cernua* L.) and sander (*Sander lucioperca* L.) caught in autumn from Lake Gopło. 10 meat samples of perch were collected in autumn from Lake Góreckie and 20 samples of ruffe were taken in spring from Lake Gopło. The experimental fish were obtained in natural condition. Measurements of the mass of the fish body (BW) ( $\pm 0.01$  g) and body length (Lc) ( $\pm 0.1$  cm) were taken on the each individuals. The meat samples for analyses were taken from the large side muscle of fish body above the lateral line. Due to a relatively low amounts of meat obtained from one individuals of ruffe, the material was combined (about 2 pieces of each). There were chosen for analysis individuals with similar biometric measurements (Table 1).

Table 1. Biometric data of the species under analysis

Tabela 1. Pomiary biometryczne badanych gatunków

Fish species	n	Body length (cm)	Body weight (g)
Perch	20	15.0 – 18.0	50.35 – 105.57
Prussian carp	14	9.0 – 12.0	25.14 – 48.87
Ruffe	40	10.5 – 12.0	20.59 – 35.17
Sander	10	40.0 – 41.5	700.20 – 788.70

### Chemical analyses

The samples of fish organs were immediately frozen after preparation and kept in the deep freezer before analyzing. All frozen samples were freeze dried in a Finn-Aqua Lyovac GT2 freeze drier (parameters: temperature  $-40^{\circ}\text{C}$ , pressure  $6 \cdot 10^{-2}$  mbar, duration at least 48h).

The freeze dried samples were mineralized in microwave mineralizator Ethos Plus, Milestone. For the mineralization 0.1 g of the tissue was weighted and then  $\text{HNO}_3$  and  $\text{H}_2\text{O}_2$  were added in ratio 4:1. During the first 10 minutes, the temperature was increased to  $190^{\circ}\text{C}$ . During the next 7 minutes the temperature was kept at a level of  $190 \pm 5^{\circ}\text{C}$ . The mineralized samples have been carried quantitatively to the measuring flask with a capacity of  $50 \text{ cm}^3$ .

The cholesterol content was determined with the modified Liebermann-Burchardt colorimetric method (Strzeżek and Wołos, 2006) using a Shimadzu (Japan) spectrophotometer. The cholesterol was extracted from samples of 0.25 g of freeze-dried tissue with  $15 \text{ cm}^3$  of chloroform. After filtration, the solution was supplemented with chloroform in the measurement container to a volume of  $25 \text{ cm}^3$ . One  $\text{cm}^3$  of acetic anhydride and  $0.25 \text{ cm}^3$  of sulphuric acid(VI) were added to  $2 \text{ cm}^3$  of the filtrate obtained. After 5 minutes the absorption value was measured in a blind test at a wavelength of 620 nm. The results are presented as  $\text{mg } 100 \text{ g}^{-1}$  of wet weight. A standard curve was made using standard cholesterol Sigma-Aldrich. The absorbance value measured for the standard solutions in the concentration range from 0.05 to  $0.35 \text{ mg} \cdot \text{cm}^{-3}$ .

### Statistical analyses

Data analyses were performed by using the Statistica 8.0 software (StatSoft, USA). Significance of differences in the average content of cholesterol in the meat of females and males of ruffe were calculated by two-way analysis of variance (ANOVA) and Tukey test was used. In this case, a significance of differences in the average content of the total cholesterol in the meat of perch caught from different lakes and in the meat of three different species collected from Lake Gopło were calculated by one-way analysis of variance (ANOVA) and Tukey test was used. The normality of data was tested using the Shapiro-Wilk's test, and the homogeneity of variance was tested with Levene's test.

## Results and Discussion

As analyses indicated there were no statistically significant differences in the total cholesterol content in the meat of females and males of ruffe caught during spring (42.27 and 44.35 mg·100 g<sup>-1</sup>, respectively) from Lake Gopło (Table 2). The statistically significant differences were determined between individuals of different sex collected in autumn. These values ranged from 48.95 mg·100 g<sup>-1</sup> for females to 59.29 mg·100 g<sup>-1</sup> for males.

Table 2. The total cholesterol content (mg·100 g<sup>-1</sup>) in the meat of females and males of ruffe (*Gymnocephalus cernua* L.) caught during spring and autumn from Lake Gopło

Tabela 2. Zawartość cholesterolu całkowitego (mg·100 g<sup>-1</sup>) w mięsie samic i samców jazgarza (*Gymnocephalus cernua* L.) odłowionego podczas wiosny i jesieni z jeziora Gopło

Fishing season	n	Sex	Total cholesterol content mean ± SD
Spring	10	Females	42.27 ± 2.10 <sup>a</sup>
	10	Males	44.35 ± 3.44 <sup>a,b</sup>
Autumn	10	Females	48.95 ± 7.06 <sup>b</sup>
	10	Males	59.29 ± 2.33 <sup>c</sup>

<sup>a,b,c</sup> The values in the same column marked with different letters differ statistically significant at p≤0.05

Analyses of roach (*Rutilus rutilus* L.) collected from Brda River (Poland) indicated that the total cholesterol content was higher in the meat from autumn (64.17 mg·100 g<sup>-1</sup>) than from spring (56.25 mg·100 g<sup>-1</sup>) (Stanek et al., 2012). Anuradha and Praveen (2013) studied the impact of sex on the chemical composition of the meat of indo-Pacific mackerel (*Rastrelliger kanagurta* C.) caught from the southern coast of India. The results showed statistically significant differences in the cholesterol content between females and males. The level of cholesterol in the meat of males was even a half higher than in females. It proves that the chemical composition of fish meat depends on the sex and may vary depending on the state of sexual maturity, the reproductive period and the rate of growth. In addition, cholesterol can fluctuate depending on the level of sex hormones, which a precursor it is. Komprda et al. (2003) analyzed the content of the cholesterol in the meat of males and females of carp harvested from Czech ponds and showed that the cholesterol content was significantly higher (P<0.001) in the mat of males (77.6 mg·100 g<sup>-1</sup>) than females (69.4 mg·100 g<sup>-1</sup>). The differences could be due to different levels of sex hormones in the serum of fish of different sexes.

Fishing season it's a very important factor determining the level of the cholesterol in the fish meat, which is caused by a changes in the biological activity of fish (living conditions and reproductive) over the year. Oehlschläger (2006) analyzed the cholesterol content in the meat of roundnose grenadier (*Coryphaenoides rupestris*

G.), blue ling (*Molva dypterygia* P.), whiting (*Merlangius merlangus* L.), mackerel (*Scomber scombrus* L.), anchovies (*Anchoa guineensis*), sardines (*Sardina pilchardus* R.), hake (*Merluccius merluccius* C.), pollock (*Pollachius pollachius* L.), saithe (*Pollachius virens* L.) and Atlantic herring (*Clupea harengus* L.), depending on the season. Analyses confirmed that differences in the cholesterol content between species were not statistically significant, but the cholesterol concentration in the meat of blue ling, hake and pollock caught in different seasons were differ. In the case of herring, these differences were the most significant. This was confirmed by study carried out by Kotońska (2009), who showed that the highest cholesterol content appeared in the samples of the meat collected in the summer, less sterol was determined in meat collected in spring (by approx. 20%) and the lowest amount of this compound was determined in samples collected in winter (approx. half of the year). Similar results were obtained by El-Sayed et al. (1984) in the meat of tilapia (*Tilapia sparrmanii* L.) and sea bream (*Sparus auratus* L.), Nettleton and Exler (1992) in the meat of channel catfish (*Ictalurus punctatus* L.), Živković et al. (2002) in the fish carp, ie.: white bream (*Blicca bjoerkna* L.), common bream (*Abramis brama* L.), vimba (*Vimba vimba* L.), blue bream (*Ballerus ballerus* L.) and crucian carp (*Carassius carassius* L.), derived from the river Danube and Özyurt et al. (2013) in Mediterranean fish and shellfish. Cholesterol content in fish meat varies seasonally because in warmer months water temperature increases and fish adjust their cell membrane components composition in relation to that temperature. The other studies also showed that the percentage of cholesterol was directly proportional to the body weight. It was probably caused by the intensification of the cholesterol synthesis as a result of the of metabolic and physiological processes acceleration in the warm months (Dukes, 1975). It would be also assume that increasing the level of cholesterol is associate with the higher feed intake and higher alimentary intake (2/3 of cholesterol develops by synthesis and the rest is taken in with the food) (Živković et al., 2002). Trbović et al. (2009) have shown that the cholesterol content in the meat of annual carp was lower in the samples obtained in April ( $48.9 \text{ mg} \cdot 100 \text{ g}^{-1}$ ) than in July ( $54.3 \text{ mg} \cdot 100 \text{ g}^{-1}$ ). On the other hand, analyses carried out by Stanek et al. (2008) on the females of perch caught from the Włocławski Reservoir showed a higher concentration of cholesterol in the body of fish harvested in the autumn ( $53.91 \text{ mg} \cdot 100 \text{ g}^{-1}$ ) as opposed to individuals caught in the spring ( $44.74 \text{ mg} \cdot 100 \text{ g}^{-1}$ ). Similarly results were obtained by Luzia et al. (2003) and they showed that the cholesterol content was in summer and winter respectively:  $72.6$  and  $86.4 \text{ mg} \cdot 100 \text{ g}^{-1}$  in sardines,  $71.6$  and  $83.0 \text{ mg} \cdot 100 \text{ g}^{-1}$  in golden umbrina (*Micropogonias furnieri* D.),  $66.8$  and  $71.4 \text{ mg} \cdot 100 \text{ g}^{-1}$  in tilapia and  $92.0$  and  $72.4 \text{ mg} \cdot 100 \text{ g}^{-1}$  in the species of *Prochilodus* spp. They found that in the case of sardines and tilapia, season did not affect significantly the cholesterol level. The same results were obtained by Orban et al. (2006) for whitefish (*Coregoninae* subfamily). Krzynowek et al. (1989) confirmed that the environmental conditions, especially water temperature, pollution and photoperiod, have an effect on the cholesterol concentration in the fish meat. In organisms living in deeper and colder waters, higher cholesterol content is determined physiologically. Similarly to the cholesterol, there have been carried out many analyses concerning seasonal variations of steroid hormone levels in the fish blood plasma (Cornish, 1998, Bagheri et al., 2008, Sisneros et al., 2004). All of the authors confirmed that the level of these compounds is associated with the season, environmental conditions and gonad development and activity.

On the basis of the analyses there were found no statistically significant differences in the total cholesterol content in the meat of perch collected from two different reservoirs (Table 3). Fish with the same biometric measurements were caught in autumn. Similar results were obtained by Oehlenschläger (2006), who confirmed no statistically significant differences in the cholesterol content in the meat of cod collected from five different places of the Baltic Sea. As Krzynowek et al. (1989) analyzed, cholesterol concentration in the meat can vary between individuals of one species of fish, living in the same area of the country and having similar eating habits. Oehlenschläger (2006) showed that the tropical fish meat may be a richer source of cholesterol, in contrast to individuals collected from low temperate climate. In the meat of sardines obtained from the north Atlantic and Adriatic total cholesterol content was from 24 to 131 mg·100 g<sup>-1</sup> (De Leonardis and Macciola, 2004; Oehlenschläger, 2006).

Table.3. The total cholesterol content (mg·100 g<sup>-1</sup>) in the meat of perch (*Perca fluviatilis* L.) caught in autumn from Lake Gopło and Lake Góreckie

Tabela 3. Zawartość cholesterol całkowitego (mg·100 g<sup>-1</sup>) w mięsie okonia (*Perca fluviatilis* L.) odłowionego jesienią z jeziora Gopło i jeziora Góreckiego

Reservoir	n	Total cholesterol content mean ± SD
Lake Gopło	10	57.80 ± 4.97 <sup>a</sup>
Lake Góreckie	10	61.45 ± 4.99 <sup>a</sup>

<sup>a</sup> The vales in the same column marked with the same letters not differ statistically significant at p≤0.05

In the Table 4. are presented results of analyses concerning the total cholesterol content in the meat of four different fish species collected from Lake Gopło. These researches confirmed a statistically significant interspecies differences in the total cholesterol content. As Ljubojević et al. (2013a) reported, cholesterol content in the meat of sander was 42,34 mg·100 g<sup>-1</sup>. In the meat of perch, concentration of this sterol ranged from 72 mg·100 g<sup>-1</sup> (Oehlenschläger, 2006) to 92 mg·100 g<sup>-1</sup> (Piironen et al., 2002). In the meat of ruffe, mean cholesterol content was 88 mg·100 g<sup>-1</sup> (Oehlenschläger, 2006). Statistically significant differences in the cholesterol content between different species of fish may be a confirmation of the hypothesis put forward by Piironen et al. (2002) about the genetic conditioning of cholesterol content. This is confirmed by numerous studies of other authors who showed great differences in the level of cholesterol in different species of fish. Mathew et al. (1999) carried out analyses concerning 97 samples of fish and shellfish meat and marked cholesterol in the range from 22 to 148 mg·100 g<sup>-1</sup>. There were observed differences in the total cholesterol content between families, and the differences within families were small. The same results were obtained by Oehlenschläger (2006) and Osman et al. (2001). Ljubojević et al. (2013b) analyzed six fish species caught from the Danube River – asp (*Aspius aspius* L.), common bream (*Abramis brama* L.), common barbel (*Barbus barbus* L.), common carp (*Cyprinus carpio* L.), sterlet (*Acipenser ruthenus* L.) and northern pike (*Esox lucius* L). The lowest value of cholesterol was recorded in the meat of asp (36.26 mg·100 g<sup>-1</sup>), and the highest in sterlet (73.59 mg·100 g<sup>-1</sup>). The



differences were statistically significant, what confirm the variability of the species in cholesterol content. Osman et al. (2001) have shown that the cholesterol content in the meat of 10 fish species caught from Malaysian water was low, and ranged from 37 to 49 mg·100 g<sup>-1</sup>. De Konig et al. (1993) determined that the average cholesterol content in the meat of South African fish was 130 mg·100 g<sup>-1</sup>.

Table 4. The total cholesterol content (mg·100 g<sup>-1</sup>) in the meat of perch (*Perca fluviatilis* L.), Prussian carp (*Carassius auratus gibelio*), ruffe (*Gymnocephalus cernua* L.) and sander (*Sander lucioperca* L.) caught in autumn from Lake Gopło

Tabela 4. Zawartość cholesterolu całkowitego (mg·100 g<sup>-1</sup>) w mięsie okonia (*Perca fluviatilis* L.), karasia (*Carassius auratus gibelio*), jazgarza (*Gymnocephalus cernua* L.) and sandacza (*Sander lucioperca* L.) odłowionego jesienią z jeziora Gopło

Species	n	Total cholesterol content (mean ± SD)
Perch	10	57.80 ± 4.97 <sup>a,b</sup>
Prussian carp	14	61.12 ± 2.34 <sup>a</sup>
Ruffe	20	54.12 ± 7.37 <sup>b</sup>
Sander	10	52.77 ± 1.13 <sup>b</sup>

<sup>a,b</sup> The values in the same column marked with different letters differ statistically significant at p≤0.05

As numerous studies confirm, the cholesterol content of fish meat is not correlated with the fat content in their body. Krzynowek et al. (1989) analyzed the cholesterol content in 22 species of northwest Atlantic finfish and showed differences in the cholesterol content from 43 mg·100 g<sup>-1</sup> (red hake, *Urophycis chuss* W.) to 80 mg·100 g<sup>-1</sup> (ocean pout, *Zoarces americanus*). Most fish had a low fat concentration in the meat, and low content of cholesterol, but there were specimens with large amounts of fat and had a low cholesterol level. Butterfish (*Perilu triacanthus* L.) contained 3.6% of fat and 69 mg·100 g<sup>-1</sup> of cholesterol, Atlantic herring (*Clupea harengus* L.) 8.7% fat and 65 mg·100 g<sup>-1</sup> of cholesterol, Atlantic mackerel (*Scomber scombrus* L.) 4.4% fat and 72 mg·100 g<sup>-1</sup> cholesterol, silver hake (*Merluccius bilinearis* M.) 3.8% fat and 45 mg·100 g<sup>-1</sup> cholesterol, and bluefin tuna (*Thunnus thynnus* L.) - 23% fat and 53 mg·100 g<sup>-1</sup> cholesterol. Lean fish, for example Atlantic cod (*Gadus morhua* L.) contained 0.6% of fat and 57 mg·100 g<sup>-1</sup> of cholesterol, red hake 0.5% fat and 43 mg·100 g<sup>-1</sup> cholesterol, ocean pout 0.8% fat and 80 mg·100 g<sup>-1</sup> of cholesterol.

## Conclusions

As analysis indicated, the species is the main factor determining the cholesterol content in the meat of fish. In addition, this level may vary depending on the fishing season and the reservoir location, physicochemical parameters of water and the age and sex of the individuals.

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