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**Karotenoidy u ryb. 13. *Coregonus peled* (G m e l.)
z polskich wód****Carotenoids in fish. 13. *Coregonus peled* (G m e l.)
from Polish waters**

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Abstract — Using column and thin-layer chromatography, the occurrence of individual carotenoids in the fins, skin, muscles, liver, intestines, and generative cells of *Coregonus peled* (G m e l.) was investigated. The obtained results were compared with the data obtained for specimens of *Coregonus albula* (L.).

Coregonus peled (G m e l.) occurs in water bodies of the north, beginning in the west from the River Mezeń, which flows into the White Sea, while in the east the area of its distribution ends on the River Kolyma, which drains its waters into the East-Siberian Sea. On this area *Coregonus peled* lives chiefly in flood-lakes, old riverbeds, and streams and feeds on crustacean plankton. The species has no specific requirements with regard to low temperature and a great concentration of oxygen dissolved in water, hence it is regarded as a good subject of acclimatization in other geographical latitudes where numerous water bodies of far advanced eutrophication occur but the species of the family *Salmonidae* no longer appear in the ichthyofauna. On the other hand, rapid growth is characteristic for this species and its flesh is delicious. For this reason, some time ago roe of this species was imported from the Soviet Union with a view to its acclimatization in Polish waters (B e r n a t o w i c z 1968). Therefore, the question arises as to what is the nutritive value of *Coregonus peled* flesh with regard to the content of carotenoids as provitamin of the vitamin A.

Material and method

The specimens of *Coregonus peled* (Gmel.) of the two sexes at the age of 2+ were taken from Lake Dobki and those of *Coregonus albula* (L.) from Lake Rospuda, in December 1975. Such body parts as fins, skin, muscles, liver, intestines, and sexual organs were chromatographically analysed.

The material was treated with 95% acetone in dark bottles and kept in a refrigerator in nitrogen atmosphere to the moment of analysis. The separation of particular carotenoid pigments was carried out using column and thin-layer chromatography. Before chromatography the material was hydrolysed in nitrogen atmosphere at room temperature during 24 hours. After hydrolysis the extract was passed through a column filled with Al_2O_3 , the length of the column being 15—25 cm. The separated fractions were eluted using various systems of solvents (Czeczuga, Czerpak 1976), after which the eluents were evaporated and after evaporation the residue was dissolved in a suitable solvent in order to draw the absorption maximum curve, which among other uses, served for identification of the carotenoid. The absorption maxima were determined using a Unicam spectrophotometer or Spectrocolorimeter.

Independently of column chromatography the obtained acetone extract was separated into individual strains using thin-layer chromatography. Glass plates 15×40 cm in size were covered with silica gel and the acetone extract was placed with a micropipette on the starting line, various solvent systems being used as well. The R_f value was determined according to the generally accepted rules.

The identification of the individual carotenoids was carried out on the basis of the absorption maxima of separate fractions, on the R_f values, on the epoxide test, and also on the obtained epiphase and hypophase relations. The quantitative relations of the individual carotenoids were determined according to the Davies method (Czeczuga, Czerpak 1976).

Results

The results of the chromatographic analysis of the content of carotenoids in the different parts of the body of *Coregonus peled* (Gmel.) are given in Tables I and II. Table I contains data for males

and Table II for females. The data in Table I show that the greatest amounts of carotenoids were found in the intestines and liver of males, the smallest content was noted in the skin and muscles, while different carotenoids dominated in various body parts of the investigated male specimens. As far as the investigated females are concern-

Tabela I. Zawartość stwierdzonych karotenoidów w badanych częściach ciała samca pelugi *Coregonus peled* (Gmel.)

Table I. Carotenoid content found in the investigated parts of the body of male *Coregonus peled* (Gmel.)

Nazwa karotenoidu Name of carotenoid	w in %				
	płatwy fins	skóra skin	mięśnie muscles	wątroba liver	jelita intestine
Bobinenon	20.0	17.8			14.3
Kantaksantyna Canthaxanthin		22.7	47.3	35.7	
Kryptoksantyna Cryptoxanthin	17.1				
Foenikoksantyna Phoenicoxanthin				11.7	
Tunaksantyna Tunaxanthin	21.5		17.9		34.1
Isozeaksantyna Isozeaxanthin		19.2		11.8	
Astaksantyna Astaxanthin	18.4		16.8	19.5	
Ester astaksantyny Astaxanthin ester	8.4	40.3		15.4	
3,4-didehydro- α -karoten 3,4-didehydro- α -carotene			18.0		15.0
Nieznane Unknown	12.6			5.9	36.6
Ogólna zawartość w $\mu\text{g/g}$ żywej wagi Total content in $\mu\text{g/g}$ of fresh weight	0.733	0.468	0.051	1.984	4.192

Tabela II. Zawartość stwierdzonych karotenoidów w badanych częściach ciała samicy pelugi *Coregonus peled* (Gmel.)

Table II. Carotenoid content found in the investigated parts of the body of female *Coregonus peled* (Gmel.)

Nazwa karotenoidu Name of carotenoid	w in %					
	płatwy fins	skóra skin	mięśnie muscles	wątroba liver	jelita intestine	ikra roe
Kantaksantyna Canthaxanthin			26.8	15.2		5.3
Tunaksantyna Tunaxanthin			35.7			
Luteina-5,6-epoxy Lutein-5,6-epoxide						5.3
Astaksantyna Astaxanthin	100.0	100.0		19.0	100.0	35.8
Ester astaksantyny Astaxanthin ester			37.5			53.6
4-hydroksy- α -karoten 4-hydroxy- α -carotene				55.7		
Nieznane Unknown				10.1		
Ogólna zawartość w $\mu\text{g/g}$ żywej wagi Total content in $\mu\text{g/g}$ of fresh weight	0.023	0.008	0.002	0.239	0.818	0.264

Tabela III. Zawartość stwierdzonych karotenoidów w badanych częściach ciała samca sielawy *Coregonus peled* (Gmel.)Table III. Carotenoid content in the investigated parts of the body of male *Coregonus peled* (Gmel.)

Nazwa karotenoidu Name of carotenoid	in %					
	płetwy fins	skóra skin	mięśnie muscles	jelito intestine	wątroba liver	mlecz milt
Kantaksantyna Canthaxanthin			9.6		15.2	
Luteina-5,6-epoksy Lutein-5,6-epoxide		24.4	8.2			
Izoeaksantyna Isoeoxanthin			12.4			
Tanakasantyna Tanaxanthin	100.0					
Ester astaksantyny Astaxanthin ester			31.4			
Astaksantyna Astaxanthin		30.1	19.8			
3,4-didehydro- α -karoten 3,4-didehydro- α -carotene					15.7	
4-hydroksy- α -karoten 4-hydroxy- α -carotene		33.1	12.0			
Nieznane Unknown		12.4	6.6	100.0	69.1	100.0
Ogólna zawartość w $\mu\text{g/g}$ żywej wagi Total content in $\mu\text{g/g}$ of fresh weight	0.241	1.231	0.170	0.400	0.790	0.124

ed, Table II shows that both the total amount of carotenoids found and the number of carotenoids identified in the different body parts were smaller than those noted in males. The greatest amounts of carotenoids were found in the intestines, eggs, and liver, and the smallest ones in the muscles and skin of the investigated females. For the sake of comparison, some specimens of *Coregonus albula* (L.), caught at the same time, were examined since they also fed on crustacean plankton. The results of the analysis are quoted in Tables III, IV, and V. Both in males and females the total content of carotenoids was much higher in all the investigated body parts than in the investigated specimens of *Coregonus peled*. Moreover, some carotenoids which were not found at all in *Coregonus peled*, were identified in the female *Coregonus albula*, among these the occurrence of Σ -carotene being noted in the fins of the latter.

Discussion

The carotenoids found in the specimens of *Coregonus peled* may be divided into two groups. One group, more numerous, includes the so-called common carotenoids, which have frequently been reported in various animal species. The second group includes the so-called

Tabela IV. Zawartość stwierdzonych karotenoidów w badanych częściach ciała samicy sielawy *Coregonus albula* (L.) z niedojrzałą ikrą

Table IV. Carotenoid content found in the investigated parts of the body of female *Coregonus albula* (L.) with immature roe

Nazwa karotenoidu Name of carotenoid	in %					
	płatwy fins	skóra skin	mięśnie muscles	jelita intestine	wątroba liver	ikra roe
Kantaksantyna Canthaxanthin			32.3			
Luteina-5,6-epoksy Lutein-5,6-epoxide			20.5			
Izoseksantyna Isoeaxanthin			5.9			
Tunaksantyna Tunaxanthin			3.8			
Ester astaksantyny Astaxanthin ester		46.2	6.7			
Astaksantyna Astaxanthin		26.0	30.8			
4-hydroksy- β -karoten 4-hydroxy- β -carotene		8.0				
Nieznane Unknown	100.0	19.8		100.0	100.0	100.0
Ogólna zawartość w $\mu\text{g/g}$ żywej wagi Total content in $\mu\text{g/g}$ of fresh weight	0.154	1.335	0.460	0.627	0.556	0.036

Tabela V. Zawartość stwierdzonych karotenoidów w badanych częściach ciała samicy sielawy *Coregonus albula* z dojrzałą ikrą

Table V. Carotenoid content in the investigated parts of the body of female *Coregonus albula* (L.) with mature roe

Nazwa karotenoidu Name of carotenoid	in %					
	płatwy fins	skóra skin	mięśnie muscles	jelito intestine	wątroba liver	ikra roe
β -karoten β -carotene	11.2					
Kantaksantyna Canthaxanthin			32.0			
Luteina Lutein		16.1	20.5			
Luteina-5,6-epoksy Lutein-5,6-epoxide	7.0	7.8				
Izoseksantyna Isoeaxanthin			6.9			
Foenikoksantyna Phoenicoxanthin			25.9			
Tunaksantyna Tunaxanthin	10.8	28.8				
Ester astaksantyny Astaxanthin ester		27.3	8.6			
Astaksantyna Astaxanthin	65.0		1.7			15.5
4-hydroksy- β -karoten 4-hydroxy- β -carotene	6.0		4.4			53.4
Nieznane Unknown		20.0		100.0	100.0	
Ogólna zawartość w $\mu\text{g/g}$ żywej wagi Total content in $\mu\text{g/g}$ of fresh weight	5.595	0.602	0.162	0.250	0.587	0.214

rare carotenoids which have so far been found only in a few species of fish. Thus, such carotenoids as echinenon, cryptoxanthin, phoenicoxanthin, and 3.4-didehydro- α -carotene should be classified in the second group. Up to the present, echinenon was reported by Katayama et al. (1973) in the internal organs of the sea fish *Chrysophrys major*. The occurrence of cryptoxanthin was determined in several species of fish also living in Japanese waters (Matsumo et al. 1974, 1975), phoenicoxanthin being noted in the pike (Czeczuga 1976). The carotenoid 3.4-didehydro- α -carotene has been separated in specimens of the eel (Czeczuga 1977). Of these carotenoids only phoenicoxanthin was also found in *Coregonus albula*, its presence being noted in the muscles of one female of this species.

In comparing the total content of carotenoids in the skin and muscles of the investigated specimens of *Coregonus peled* and *C. albula*, a considerably smaller content of biologically active pigments, as are carotenoids, should be observed in the latter. It might be supposed that in consequence of similar food conditions, secured by great quantities of the crustacean plankton in the lakes, where *Coregonus peled* occurs in the Mazurian Lake District, the accumulation of large quantities of carotenoids would be observed. However, the chromatographic analysis did not support the assumption. This is probably accounted for by the biology of the species *Coregonus peled*. Some years ago, detailed investigations carried out on the content of carotenoids in *Coregonus lavaretus*, a ground-fish of the family *Salmonidae*, also showed greater amounts of carotenoids both in the muscles and in other body parts of this species (Czeczuga 1975).

The very small amounts of carotenoids in the skin and muscles of female *Coregonus peled* may be explained by the movement of carotenoids to the gonads in the maturing period of sexual cells. This is supported by the observed difference in the content of carotenoids in female *Coregonus albula* with immature and mature roe: the skin and muscles of *Coregonus albula* with not quite mature roe contained an almost double amount of carotenoids as compared with the skin and muscles of *C. albula* with wholly mature roe. Moreover, in the mature roe of *Coregonus albula* the content of carotenoids was 5 times greater than that in not quite mature roe. A female with mature roe also had a very large amount of carotenoids in the fins, the variety of these constituents being very great, while in the fins of a female *Coregonus albula* with less mature roe the content of carotenoids was much smaller and it was difficult to identify them.

As our last investigation showed, the type of food was decisive for the occurrence of individual carotenoids and their quantitative relations in fish (Czeczuga, Czerpak 1976), the content of carotenoids in the food of fish being of particular importance here. However, in

the individual organs of fish not all carotenoids accumulate with the same intensity. We may speak now about selectivity in carotenoid accumulation by the various fish species.

In recapitulating, one should say that the total content of carotenoids in the specimens of *Coregonus peled* acclimatized in the waters of the Mazurian Lake District is rather small as compared with the specimens of *Coregonus albula*.

STRESZCZENIE

Autor stosując chromatografię kolumnową i cienkowarstwową badał występowanie poszczególnych karotenoidów w płetwach, skórze, mięśniach, wątrobie i w komórkach rozrodczych pelugi *Coregonus peled* (Gmel.) aklimatyzowanej w niektórych jeziorach mazurskich.

W wyniku badań ustalono obecność takich karotenoidów, jak: echinenonu, kanta ksantyny, kryptoksantyny, luteiny-5,6-epoksy, foenikoksantyny, tunaksantyny, izoze aksantyny, astaksantyny (formy czystej i estrowej), 4-hydroksy- α -karotenu oraz 3,4-dide hydro- α -karotenu. Podano również stosunki procentowe poszczególnych karotenoidów w badanych częściach pelugi. Ponadto dane porównano z danymi uzyskanymi dla sie lawy (*Coregonus albula* (L.)).

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