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ON THE ORIGIN OF THE CHARACTERISTIC FATTY ACID COMPOSITION OF WATER ORGANISMS

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One of the interesting questions emerging from the works on the constitution of natural fats (Hilditch 1956) is the origin of the characteristic fatty acid composition in water organisms. This paper gives an account of our investigations on algae, on the most abundant planctonic crustaceans and on fishes.

Material and methods

In the case of algae and crustaceans, where as a rule, very little materia was available, the total lipid was hydrogenated and the fatty acids, prepared from it as usually, were paperchromatographed according to KAUFMANN (1954). The quantitative evaluation took place photometrically and the quantities of the fatty acids of the same chain-length were expressed in the percentage of the total fatty acids. In fishes the same procedure was carried out with one part of the lipid. From the other, unhydrogenated part the fatty acids were isolated and fractionated according to TWITCHELL. The solid fraction so gained, including the saturated acids, was separately paperchromatographed. On the basis of the quantitative distribution according to chain length of the total and separately of the saturated fatty acids and of the weight ratio of the two TWITCHELL fractions, under consideration of the molecular weigths, the quantities of the saturated and unsaturated fatty acids of the same chain length were expressed as weight percentage of the total fatty acids.

The result has a similar form as the data of the fractionated vacuum destillation. This is advantageous, because most analyses of the fats of water organisms are carried out by this later technique. The immediate hydrogenation in our procedure protects the samples from the eventual damage of its highly unsaturated fatty acids. Among the samples analysed, the 2 unicellular green alga species — *Chlorella sp.* and *Scenedesmus sp.* — originated from pure cultures. The mixed phytoplankton was gained from 200 l water of Lake Belső-tó, filtered through a net Nr. 6. and centrifugated at 30 000 tourn/min. The planctonic crustaceans were collected with a net Nr. 6 from the lakes Balaton, Belső-tó, Velencei-tó. In the case of mixed crustacean plankton, different methods were applied to separate the species wanted. The fishes were taken from Lake Balaton and always their intestinal fat was analysed with the exception of *Alburnus alburnus* L. where the whole eviscerated body was investigated.

Results and discussion

The analitycal data of the algae and crustaceans are given in *Table 1.* It shows, that neither the 2 unicellular green algae — *Chlorella sp.* and *Scenedesmus obtusiusculus* — did contain fatty acids longer than C 18. Their iodine values were high enough — 121 and 219 respectively — prooving especially in the later case, that the C 16—18 series are dominated by polyenoic acids. The phytoplankton, more exactly centrifuge plankton of Lake Belső-tó, contained fairly large amounts of C 20 acids, nevertheless the quantity of C 22 acids is low.

Of the planctonic crustaceans *Daphnia magna*, collected from Lake Belső-tó, never contained C 22 acids and even the quantity of C 20 acids was only about half of that in the phytoplankton. In the sample collected from Lake Balaton, composed of about equal amounts of *Daphnia cucullata* and *Diaphanosoma brachyurum*, the percentage of C 22 acids was low. We do not know whether these acids are present in both species or they came mainly from one of them, but even in the later case their percentage in neither of the species can surpass the double of the very low value given for the mixture. We

Table 1 — 1. táblázat

Fatty acid composition (in weight %) of fresh water algae and planktonic crustaceans

Édesvízi algák és planktonrákok zsírsavösszetétele (súly %)

Species — Faj	Place of sampling Gyűjtőhely	Date of sampling Gyűjtés ideje	Fatty acids — Zsírsavak				
			C_{14}	C_{16}	C_{18}	C_{20}	C_{22}
Chlorella pyrenoiolosa Chick	pure culture tiszta tenyészet	—	—	35,7	64,3	—	—
Scenedesmus obtusiusculus Chod.	tiszta tenyészet	—	—	47,4	52,6	—	—
Mixed phytoplankton	Belső-tó	1960. XII. 10.	—	19,4	62,1	13,6	4,9
Mixed phytoplankton	Belső-tó	1961. VI. 13.	—	37,5	40,4	16,7	5,4
Mixed phytoplankton	Belső-tó	1961. VII. 20.	—	32,6	42,4	20,9	4,1
Mixed phytoplankton	Belső-tó	1961. XI. 10.	—	36,4	40,4	15,9	7,3
Daphnia magna Straus	Belső-tó	1961. VI. 13.	—	57,0	35,3	7,7	—
Daphnia magna Straus	Belső-tó	1961. XI. 10.	—	37,7	54,5	7,8	—
Diaphanosoma brachiurum Lievin+Daphnia cucullata G. O. Sars	Balaton	1961. VI.	—	39,4	43,9	14,8	1,9
Bosmina longirostris f. pellucida Stingelin	Velencei-tó	1961. XII. 12.	—	36,5	41,5	19,8	2,2
Eudiaptomus gracilis G. O. Sars	Balaton	—	15,7	14,8	35,8	16,9	16,8
Cyclops vicinus Uljanin	Balaton	—	10,8	18,4	36,7	16,7	17,4
Cyclops vicinus Uljanin	Belső-tó	1960. XII. 10.	—	18,4	22,7	23,0	35,9
Cyclops vicinus Uljanin	Belső-tó	1961. VI. 13.	—	37,0	29,3	15,0	18,7
Cyclops vicinus Uljanin	Belső-tó	1961. VII. 20.	—	21,9	40,9	21,6	15,6
Cyclops vicinus Uljanin	Belső-tó	1961. XI. 10.	—	29,3	30,3	19,6	20,8
Cyclops vicinus Uljanin	Velencei-tó	1961. XII. 12.	—	22,4	26,9	21,5	29,2
Mesocyclops (s. str.) leuckarti (Claus) + Eudiaptomus gracilis G. O. Sars	Balaton	1959. VIII. 24.	1,4	27,6	39,7	15,5	15,8

found in the *Bosmina longirostris*, collected from Lake Velencei-tó, also very little C 22 fatty acids. We are not looking at this problem as settled on the basis of these data, nevertheless they suggest that the Cladocerans contain no, or very little amounts of C 22 fatty acids.

In Copepods, which form the other main group of the fresh water planctonic crustaceans, we found a definitive different fatty acid composition. We investigated of them a mixed Copepod — sample from Lake Balaton, furthermore *Eudiaptomus gracilis* from Lake Balaton and *Cyclops vicinus* from the lakes Balaton, Belső-tó and Velencei-tó. According to *Table 1.* in all of the samples the C 22 fatty acids belong to the major components, on the other hand it also appears, that their quantity changes in the course of the year. The seasonal changes in the fatty acid composition according to which the quantity of C 20—C 22 fatty acids is in summer lower and in winter higher, we already described for the mixed curstacean plankton (FARKAS—HERODEK 1961). Now on the basis of the investigation of the separated species we assume this phenomenon to be caused by changes taking place in Copepods.

Table 2 gives our data concerning the a fatty acid composition of fishes from Lake Balaton.

Table 2 — 2. táblázat

The fatty acid composition (in weight % of) fishes from Lake Balaton — Balatoni halak zsírsavösszetétele (súly%)

Species — Faj	Date of caught Fogás ideje	Saturated fatty acids Telített zsírsavak			Unsaturated fatty acids Telítetlen zsírsavak				
		C_{14}	C_{16}	C_{18}	C_{14}	C_{16}	C_{18}	C_{20}	C_{22}
Lucioperca lucioperca L.	1959. VI. 10.	4,6	15,8	1,3	—	21,1	30,1	14,3	12,8
Perca fluviatilis L.	1959. VI. 25.	1,7	20,7	2,6	—	33,5	18,9	11,8	10,8
Esox lucius L.	—	2,3	14,5	6,4	—	18,2	25,2	16,2	17,2
Aspius aspius L.	1959. IX. 25.	1,7	14,1	5,5	—	12,8	30,4	19,5	16,0
Abramis brama L.	1959. VI. 26.	—	14,6	5,5	—	14,4	37,5	20,0	8,0
Alburnus alburnus L.	1959. VI. 19.	0,7	14,1	3,6	3,3	18,9	28,2	17,8	13,4
Cyprinus carpio L.	1959. VII. 25.	—	16,5	6,3	—	4,5	65,8	6,9	—
Pelecus cultratus L.	—	3,5	12,4	5,0	3,1	18,3	30,5	16,6	10,6

The result differs in the higher quantities of C 20—C 22 fatty acids from the main values given for fresh water fishes (LOVERN, 1951). This difference is the most expressed in the plankton feeder and predatory fishes. The carp which is neither in direct nor indirect connection with the planctonic fat, contains only very little C 20 fatty acids while no C 22 fatty acid at all was to be demonstrated from it.

Since LOVERN's investigations in 1937 it is well known, that the marine fishes contain more C 20, C 22 fatty acids than the fresh water ones. From this time on the "marine" and "fresh water" indications came into general use for types of fatty acid compositions. On the hand of a few analysis it was supposed that similar differences exist between the fat of the fresh water and marine crustaceans. KELLY, REISER and HOOD (1958) kept marine and fresh water fishes on artificial food, and concluded from it, that the differences between the fats of fresh water and marine fishes largely result from differences in their dietary fatty acids.

An attempt is made on the hand of our investigations so far to interprete the possibility of differences in the fatty acid composition of the food of fresh water and marine fishes. Both Copepods and Cladocerans play an important role in the crustacean plankton of fresh waters. In Cladocerans none or hardly some C 22 fatty acids are to be found. During the cold period the fresh water Copepods contain as much C 22 fatty acid as any marine animal, but the quantity of these acids decreases in the course of the warming up of the waters of low heat-capacity and so just at the most intensive feeding-period of the freshwater fishes there is little C 20, C 22 acid in the Copepod plankton, too. In contrary to the fresh water the role of Cladocerans in the seas is inferior. Among the marine fishes mainly fats of animals living in cold and temperate zones were investigated. In these zones Copepods form the bulk of zooplankton, which may contain in the cold water similar to the winter samples of fresh water Copepods great amounts of C 20, C 22 fatty acids. The analytical data of fishes caught from the Indian Ocean (KARKHANIS, MAGAR 1955) are fitting into this view, as they show lower quantity of C 20, C 22 fatty acids than our fishes from Lake Balaton. How far the explanation given here is adequate, could be prooved in the first place by investigations of marine crustaceans.

As to the quantity of C 20, C 22 fatty acids changing according to the temperature, we supposed that the accumulation of these highly unsaturated fatty acids of low melting points assures even in cold appropriate state of the extracellularly stored fats of Crustaceans. The mechanism of this accumulation is presently investigated.

Quite apart from the problems above mentioned one thing is certain: the "fresh water" and "marine fat type" indications can not be applied on planktonic crustaceans; speaking in these terms we should have to say that the *Cyclops vicinus* contains typical marine fat in winter.

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Summary

We investigated in fresh water lakes the fatty acid compositions in the members of the food chain phytoplankton — crustacean plankton — fish. Algae contained little C 20 and none or hardly some C 22 fatty acids. The analysis showed great differences among the curstaceans. In Cladocerans we found little if any C 22 acids, while the quantity of these acids was always significant in Copepods, and changed seasonally. The fatty acid composition of the investigated fishes was similar to their food. An attempt is made to explain the differences between the fatty acid composition of fresh water and marine fishes.

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A VÍZI SZERVEZETEKRE JELLEMZŐ ZSÍR EREDETÉRŐL

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Összefoglalás

Édesvízi tavakban megvizsgáltuk a fitoplankton — Crustacea plankton — hal táplálkozási lánc egyes tagjainak zsírsavösszetételét. Az algák kevés C_{20}-as zsírsavat tartalmaztak, és nem, vagy alig volt bennük C_{22}-es sav. A megelemzett rákok között nagy különbség mutatkozott: a Cladocerákban alig találtunk C_{22}-es zsírsavat, míg ezek a Copepodákban mindig jelentős mennyiségben voltak jelen és mennyiségük az évszakkal változott. A vizsgált halak zsírsavösszetételét a táplálékukra vezetjük vissza. Magyarázni próbáljuk a tengeri és édesvízi halak zsírsavösszetételének különbözőségét.