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SEASONAL CHANGES IN THE FATTY ACID COMPOSITION OF FRESH WATER CRUSTACEANS

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In one of our previous papers dealing with the fatty acid composition of the fresh water Crustaceans we demonstrated the changes in the ratio of solid to liquid fractions according to a yearly cycle. The relative quantity of saturated acids increases with the increasing and decreases with the decreasing temperature. (FARKAS, HERODEK 1959).

From the qualitative paper chromatographic analyses we assumed the accumulation of C_{20}, C_{22} polyunsaturated acids in the winter samples. In our present paper we publish newer data concerning this problem obtained by iodine value measurements and by quantitative paper chromatography of the solid and hydrogenated liquid fractions.

Material and Methods

Crustacean plankton was collected with a net Nr 6. The quantity of the phytoplankton samples sufficient for analyses was gained from 50 l water of the Belsőtó-pond by centrifuging it at 30,000 turns/min. The *Astacus leptodactylus* ESCH. were captured in Lake Balaton. We used to each analyses the hepatopancreas of 5 (of about 15 cm length) males. The samples were dryed in a vacuum exsiccator and the mixture of the total fatty acid was prepared in the usual way working all through in inert atmosphere. This mixture was fractionated according to TWITCHELL and the so obtained liquid fraction was hydrogenated employing palladium catalysator. The solid and the hydrogenated liquid fractions were paper chromatographed according to KAUFMANN, (KAUFMANN, NITSCH, 1954) their development was achieved with the $Cu(CH_3COO)_2$-rubeanic acid technique. The quantitative evaluation of the paper chromatograms was carried out photometrically, (SEHER, A., 1960) the iodine values were determined according to KAUFMANN.

Results and discussion

The yearly changes in the iodine values of the fat of the crustacean plankton and in the temperature of Lake Balaton are presented in *Fig. 1.*

The shape of the two curves indicates a rather convincing reason to search for correspondance between temperature and the fatty acid composi-

tion of natural fats. Oh the other hand if we compare the changes of the iodine (FARKAS, HERODEK 1959) values with that of the proportion of the solid fraction already published before it becomes evident that even within the liquid fraction a high increase of the iodine value is to be found. This proves that the displacement in the ration of the fractions originates not simply in the dehydrogenation of the saturated to the corresponding monoenoic acids but that there takes place an accumulation of the polyunsaturated acids.

Table I. was drawn from the weight ratio of the two fractions and from the data of the quantatitive paper chromatograms of the solid and hydrogenated liquid fractions showing the fact of definite seasonal changes in the distribution according to chain length too.

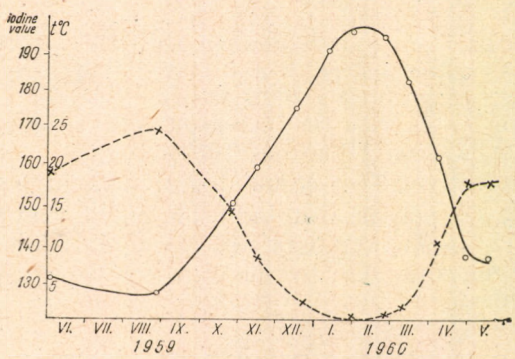

Fig. 1. Changes in the iodine value of the crustacean plankton fat and in the water temperature of Lake Balaton in 1959—1960.

1. ábra A rákplankton zsír jódszámának és a víz hőmérséklesének változása a Balatonban 1959—1960-ban.

Рисунок 1. Образование иодного числа жира планктона Crustacea и температуры воды озера Балатон в 1959—60 годах

In each of the three samples *(i.e.* crustacean plankton from Lake Balaton, crustacean plankton from Belsőtó-pond and the hepatopancreas of *Astacus leptodactylus* ESCH.) we found in colder water significantly higher levels in C_{20}, C_{22} acids than in warmer water. This means that a large part of the unsaturated fatty acids accumulating during the cooling down period in autumn consists of C_{20}, C_{22} acids. The process therefore, resulting in the fatty acid composition of low melting point in winter is also not to be considered as a repeated desaturation of fatty acids with the given chain length.

In the last year we demonstrated the existence of a yearly cycle of the fat percentage of the dry matter showing a winter maximum. (FARKAS, T., S. HERODEK 1960) According to this fact not only the relative but also the absolute quantity of unsaturated acids increases during the cooling down period in autumn. We also stated that these changes are not to be attributed to the fluctuation in the composition of crustacean plankton as to species involved and in all probabililities the changes in the fatty acid composition of the food either. It seems con-

sequently justified to believe that the temperature affects directly the fat metabolism of crustaceans. In order to be able to check the closer nature of this effect we should have to know more about the origine of the fatty acid occuring in the crustaceans.

In this connection we analysed the fat of the phytoplankton of Belsőtó-pond and found a much lower level of the iodine value and that of the $C_{20=22}$ acids than in the crustacean plankton collected at the same time and place. In spite of this the possibility still remains that the bulk of the fat of crustaceans originates from the plankton algae and that the animals deposit preferentially from the alimentary fats the highly unsaturated acids of longer chain.

Table I. — I. táblázat

Date ~ Dátum	Water t° C² Víz	Iodine value jódszám	Saturated — Telített			Unsaturated — Telítetlen				
			C_{14}	C_{16}	C_{16}	C_{14}	C_{16}	C_{18}	C_{20}	C_{22}
Crustacean plankton from Lake Balaton										
1960. VI. 1.	17,0	131,4	5,7	17,8	5,1	—	8,4	32,0	17,7	13,3
1960. VIII. 29.	24,5	127,0	3,5	17,0	4,4	1,9	18,5	30,0	13,3	11,4
1960. X. 24.	13,5	153,4	5,4	13,6	2,1	2,4	8,4	32,9	16,2	17,0
1960. XII. 20.	4,5	173,0	7,7	11,4	1,4	—	0,6	33,6	21,7	23,6
Crustacean plankton from Belsőtó-pond:										
1960. IX. 4.	23,5	—	—	17,2	7,5	—	3,3	29,5	19,4	23,1
1960. X. 28.	13,9	135,7	—	18,2	3,8	—	4,0	21,1	21,2	31,7
1960. XII. 8.	5,0	154,0	—	17,0	3,1	—	1,4	19,6	23,0	35,9
Phytoplankton from Belsőtó-pond	5,0	103,2	—	12,3	7,4	—	7,1	54,7	13,8	4,9
Astacus lepto-dactylus:										
1960. IX. 20.	18,2	105,2	—	17,1	3,8	—	13,8	42,4	15,3	7,6
1961. III. 1.	6,0	134,0		10,1	2.3		11,0	42,2	26,3	8,1

If the situation is this we assume that the selectivity at colder temperature is shifting even more to the advantage of the above mentioned acids. On the other hand we even might suppose that the Crustaceans themselves produce the main bulk of the $C_{20=22}$ polyenoic acids from acids taken up from the algae via an elongations in divinyl methane rhythm of a higher rate than that is the case in mammals. A further possibility is that the Crustaceans are capable for the total synthesis of all unsaturated acids. Eventually these processes or the incorporation into the depot fats are influenced by the temperature. These questions can be solved only experimentally with animals kept under laboratory conditions.

Summary

We stated in the iodine value of the fat of crustacean plankton from Lake Balaton a yearly cycle showing a winter maximum. The iodine values which raise to a very high level during the cooling down of the water in autumn prove the accumulation of polyunsaturated fatty acids. In the course of the

quantitative paper chromatographic analyses we found towards the winter a strong increase in the proportion of C_{22-22} acids. Similar changes were observed in the fatty acid composition of the crustacean plankton from Belsőtó-pond as well as in that of *Astacus leptodactylus* Esch. We interpret the phenomenon as an example of correspondence between the temperature and the natural fats and attribute great importance to the highly unsaturated fatty acids of long chain in the cold adaptation of poikilothermic water animals.

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ÉVSZAKOS VÁLTOZÁSOK AZ ÉDESVIZI RÁKOK ZSIRSAVÖSSZETÉTELÉBEN

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Összefoglalás

A balatoni Crustacea plankton zsírjának jódszámában téli maximummal évi ciklust mutattunk ki. Az őszi lehűlés folyamán igen magasra emelkedő jódszámértékek többszörösen telítetlen zsírsavak felhalmozódását bizonyítják. A hidrogénezett folyékony frakció mennyiségi papírkromatografálásával kimutattuk, hogy télre erősen megnő a C_{20}, C_{22}-es zsírsavak mennyisége. A belsőtavi Crustacea plankton és az *Astacus leptodactylus* Esch. zsírsavösszetételében is a fentieknek megfelelő változásokat észleltünk. A jelenséget mint a hőmérséklet és a természetes zsírok összetétele közötti kapcsolat egyik megnyilvánulását értelmezzük, és a vízi állatok alacsony hőmérséklethez való alkalmazkodásában nagy fontosságot tulajdonítunk az erősen telítetlen hosszú szénláncú zsírsavaknak.

Т. Фаркаш—Ш. Херодек:

СЕЗОННЫЕ ИЗМЕНЕНИЯ СОСТАВА ЖИРНЫХ КИСЛОТ У ПРЕСНОВОДНЫХ РАКОВ

Резюме

В иодном числе жира планктона Crustaceae озера Балатона обнаружен годовой цикл с максимумом в зимнее время. Сильно повышающиеся величины иодного числа во время осеннего охлаждения свидетельствуют о накоплении многократно ненасыщенных жирных кислот. Путем количественного бумажного хроматографирования гидрированной жидкой фракции доказано, что на зиму качество жирных кислот C_{20} и C_{22} значительно увеличивается. В составе жирных кислот планктона Crustaceae и Astacus leptodactylus Esch. в озере Belsőtó наблюдались изменения такого же рода. Это считается манифестацией связи между температурой и составом естественных жиров; в приспособлении водных животных к низкой температуре следует придать сильно ненасыщенным жирным кислотом с длинной углеродной цепью большое значение.