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Fatty Acid Composition of 14 Kinds of Deep-Sea Fish Oils

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With 14 kinds of deep-sea fishes found off the coast of Tosa and also around the Kii Channel from 600 to 1000 m in depth, the fatty acid composition of those oil constituents was investigated by means of gas chromatography.

There is no specific component detected even though their unusual environment (less light, higher pressure, etc.) and an analogous composition is experimentally observed among those fishes examined. The average composition is found to be 20—30% of $C_{18:1}$, 15—20% of $C_{16:0}$, several percent of each of $C_{16:1}$, $C_{20:1}$, $C_{18:0}$, $C_{22:6}$, $C_{24:2\sim6}$, $C_{14:0}$, and $C_{22:1}$ acids, respectively, suggesting a similarity in composition to those of the familiar fishes living in colder area rather than fishes in a warmer area.

Because deep-sea fish have oddly shaped bodies, a high water content and a low yield, only some have been used for food and only as fish paste products. Recently however, due to the shortage of marine resources consequent to the pollution of coast fishing grounds, deep-sea fish have been considered as a new source of food products just as high sea fish. Viewing the living environment of deep-sea fish, there are several points where it differs from that of ordinary fish. By analyzing the oil of deep-sea fish we thought that we could probably find a distinctive quality, for food, in them.

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Furthermore, we had already noted, in fish obtained from ordinary markets that there was a significant difference in the fatty acid composition of oils between southern-sea fish (those which live in warm current and in comparatively southern seas) and northern-sea fish (those which live in cold currents and in comparatively northern seas).[1] We investigated the distinctive features of the deep-sea fish in comparison to these two types.

II. Sample and Experimental Procedure

The sample materials were 14 kinds (see Table 2) of deep-sea fish caught in the Kii Channel at a depth of 620 metres, in Tosa Bay at a depth of 670 metres, and off the coast of Hyuga at a depth of 800 metres. Their identification was kindly made by Mr. T. Asami and Mr. S. Kudo, technicians at the Fisheries Research Station of the Fisheries Agency, Southwestern Sea division.

The experimental procedure was as follows. We chopped the edible section of each deep-sea fish; after drying it at 80°C (after each portion of sample was collected it was kept in frozen storage prior to analysis, for approximately six months; as it was thought that the water content was of practically no significance, no measurements were made.), we extracted the oil by ether with Soxhlet's method of extraction, got methylate by the methanol sulfuric acid method, and analyzed it by gas chromatography. In the analysis we used the new two stage process of analysis with two types of columns developed by us.[2] The operating conditions were as indicated in Table 1.

Table 1.

Operating Conditions

Instrument	HITACHI Model 063	
Detector	FID	
Carrier gas	N_2, 40 ml/min	
Column size	3 mmφ×2 m	
Stationary phase	DEGS	Apiezon Grease L
Column temp.	200°C	250°C
Injection temp.	280°C	320°C

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Table 3.

Composition of fatty acids by living environment and
Determination of Significant Differences

	Deep-sea fish	Southern-sea fish	Northern-sea fish	Significant Differences **	*
C16:0 Acid	15.6	20.7	14.0	S↔N	D↔S
C16:1 Acid	6.1	11.0	8.8	D↔S	D↔N
C18:0 Acid	5.3	6.5	3.6	S↔N	----
C18:1 Acid	25.8	22.1	26.3	----	----
C19 and above	37.1	26.4	36.6	----	D↔S S↔N
Saturated Acid	30.4	38.4	28.1	D↔S S↔N	----
Monoene Acid	44.0	41.4	53.3	S↔N	D↔N
Polyene Acid	25.7	20.4	18.4	----	----

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** Significant difference below a 1% risk

* Significant difference below a 5% risk

D--Deep-sea fish
S--Southern-sea fish
N--Northern-sea fish

We arrived at the gas chromatogram peak area obtained, with a digital integrator made by Gasukuro Industries and computed from its uncorrected value the percentage contents of the fatty acids composition. p. 582

III. Results and Considerations

1. Oil Content

In the results of the analysis a striking difference was seen in the amount of oil (in dried samples). In those with a large amount, Diaphus coeruleus, Etmopterus lucifer, Trichirus lepturus, etc., the oil was more than 40% of the dried samples. In those with a small amount, Nomeus albula, Ventrifossa garmani, Ereunias gralletor, etc., about 1% of oil was found. (refer to Table 2).

2. Composition of the Fatty Acid Group

As for the composition of the fatty acids, there were no particular components and they did not differ greatly from those of ordinary fish analyzed so far. As general features, C18:1 Acid (20-30%) and C16:0 Acid (15-20%) are the main components; and to a lesser extent C16:1 Acid (5-8%), C20:1 Acid (4-8%), C18:0 (4-7%), C22:6 Acid (4-6%), C24:3-6 Acid, C14:0 Acid, C22:1 Acid (All with 3-4%) follow these.

If these fish are viewed individually, in Ventrifossa garmani C16:0 and C18:1 Acids which are the main components, have a mean value of only about one half. On the other hand when compared to other fish C22:0, C20:3-9, C22:4, C22:5-3 Acids are plentiful. In Ereunias gralletor there is little C20:1 Acid

Table 2.

The Fatty Acid Composition of Deep-sea Fish

	Myctophida Chlorophtalmus albatrossis	Percina / deep sea bass Niphon spinosus (Serranidae)	Coryphaenoidina Hymenocephalus lethonemus	Stromateina Nomeus albula	Zeida Zenopsis nebulosa (Zeidae)	Chimaerida / elephant fish Chimaera phantasma (Chimaeridae)	Coryphaenoidina Ventrifossa garmani	Pleuronectida Chascanopsetta lugubris (Bothidae)	Nemichtkyina Hemichthys scolopaceus	Scombrina / ribbon fish-like Trichirus lepturus (unknown)	Gadina Physiculus japonicus	Cottina Ereunias grallator (Cottidae)	Myctophina lantern fish Diaphus coeruleus (Myctophidae)	Squalina Etmopterus lucifer (Squalus suckleyi group)
$C_{14:0}$	4.2	3.0	3.5	6.4	4.2	1.5	3.5	3.6	2.1	3.4	4.1	3.3	4.1	2.3
$C_{16:0}$	15.5	13.5	17.0	19.1	16.6	13.3	9.6	12.8	12.8	19.3	16.4	15.5	21.6	15.9
$C_{16:1}$	5.1	7.4	8.4	7.6	5.4	4.2	4.8	5.8	5.2	5.7	8.9	6.8	5.3	4.9
$C_{18:0}$	3.6	4.4	4.1	8.0	4.9	5.9	6.3	4.1	4.4	5.5	6.1	6.3	6.8	3.7
$C_{18:1}$	27.8	20.7	28.3	22.5	17.8	29.8	12.2	22.3	28.4	35.2	23.6	29.3	32.6	30.7
$C_{20:1}$	6.0	4.1	4.6	0	4.9	6.2	4.2	7.1	9.0	4.3	5.6	1.4	4.1	8.3
$C_{22:1}$	7.2	1.6	2.9	3.9	5.0	1.9	2.2	3.4	4.5	1.9	1.3	0	1.2	7.9
$C_{22:0}$	5.1	3.5	1.7	5.5	6.3	1.0	1.5	3.1	4.5	2.2	0	4.9	4.9	5.1
$C_{24:3\omega 0}$	4.6	8.6	2.0	0.3	10.0	4.7	0	6.1	4.4	4.4	6.4	0	0	3.4
Components that are in greater quantity than in the other fish or not seen in other fish	$C_{20:5}$ $C_{21:1}$	$C_{20:2}$ $C_{20:5}$ $C_{22:6\omega 0}$	$C_{15:2\omega 3}$ $C_{17:1}$ $C_{21:0}$	$C_{12:0}$ $C_{14:2}$ $C_{24:1}$	$C_{17:3}$ $C_{22:8\omega 9}$	$C_{17:2}$ $C_{22:8\omega 0}$	$C_{18:4}$ $C_{20:3\omega 9}$ $C_{22:0}$ $C_{22:4}$ $C_{22:5\omega 3}$ $C_{24:4}$	$C_{22:3\omega 0}$ $C_{22:4}$ $C_{24:4}$	$C_{18:2}$ $C_{18:2\omega 0}$ $C_{21:1}$		$C_{14:2}$ $C_{16:2\omega 0}$ $C_{20:2}$ $C_{20:4}$ $C_{21:0}$	$C_{18:3\omega 3}$ $C_{19:0}$ $C_{21:2}$ $C_{22:5\omega 3}$	$C_{20:3\omega 9}$ $C_{22:2}$	$C_{22:6\omega 0}$
Over C19	38.1	44.1	25.2	25.5	40.4	40.5	52.6	41.9	46.3	23.6	36.2	32.8	30.9	40.7
Saturated Acid	27.5	25.4	31.8	39.7	31.1	28.1	30.4	24.7	25.1	32.5	32.6	32.8	37.7	25.5
Monoene Acid	48.9	36.7	50.1	37.8	35.7	46.0	27.5	42.2	51.9	51.0	43.7	43.8	45.7	54.6
Polyene Acid	23.6	37.9	18.1	22.5	33.2	25.9	42.1	33.1	23.0	16.5	23.7	23.4	16.6	19.9
Oil Content	30.8	4.1	36.1	1.1	2.3	14.1	1.1	16.3	28.3	41.8	28.2	1.7	49.5	45.2

and no C22:1, C24:3-6 Acids. Compared to the others, C18:3-3, C19:0, C22:5-3 Acids are plentiful. In Physiculus japonicus C16:1 Acid is plentiful and there is no C22:6 Acid. In Diaphus coeruleus there is little C22:1 Acid and no C24:3ω6 Acid. As for the others, components hardly seen at all in other fish are indicated as special components in Table 2.

3. Fluctuation of Fatty Acids Composition due to the Living Environment

Next, in order to determine whether or not these deep-sea fish showed a distinctive pattern due to their particular living environment, we compared these deep-sea fish with the other ordinary fish[1] so far.

We carried out an investigation of significant differences in the mean values of C16:0, C16:1, C18:1, C19 and higher, of saturated acids, of monoene acids, of polyene acids which constitute the main components. We conducted this investigation with regard to the three following groups: deep-sea fish on the one hand and 10 kinds of northern fish and 10 kinds of southern fish which were the most important fish analyzed so far, on the other. The results are as seen in Table 3.

As evident by this table...

C16:0: Plentiful in southern-sea fish; a significant difference can be seen between deep-sea fish and southern-sea fish, and between northern-sea fish and southern-sea fish.

C16:1: Decreasing in order from southern-sea fish, northern-sea fish to deep-sea fish; a significant difference can be seen between deep-sea fish and southern-sea fish and between deep-sea fish and northern-sea fish.

C18:0: Little in northern-sea fish; a significant difference can be seen between northern-sea fish and southern-sea fish, but a significant difference is not evident deep-sea and either of the others.

C18:1: Little in southern-sea fish; no significant difference is seen between any of them, but it is thought than deep-sea fish are close to northern-sea fish.

C19 and higher: Little in southern-sea fish; a significant difference can be seen between deep-sea fish and southern-sea fish and between northern-sea fish and southern-sea fish.

Saturated Acid: Plentiful in southern-sea fish; a significant difference can be seen between deep-sea fish and southern-sea fish and between northern-sea fish and southern-sea fish; as expected, deep-sea fish tend to be closer to northern-sea fish.

Monoene Acid: Plentiful in northern-sea fish; a significant difference can be seen between deep-sea fish and northern-sea fish and between northern-sea fish and southern-sea fish; only in this aspect do deep-sea fish more closely resemble southern-sea fish.

Polyene Acid: It is thought to be more plentiful in deep-sea fish than in northern-sea fish or southern-sea fish, but no significant difference can be seen.

From the above, the deep-sea fish used this time, and regarded as southern-sea fish from the viewpoint of their living environment were in fact recognized as being closer to the northern-sea fish. This is because the water temperature of the environment in which deep-sea fish live is as low as the temperature of the living environment of northern-sea fish. By containing large amounts of polyene acids, etc., with a low melting point, they are adapted to their environment and show a tendency toward the same fatty acid group composition as that of northern-sea fish. Furthermore, the deep-sea fish used this time, regardless of individual differences, indicated a tendency towards analogous fatty acid compositions. This is thought to be due to the fact that their living environments are relatively the same.

4. Dietetic Features

Presently deep-sea fish are mainly consumed for the purpose of offsetting the lack of marine resources but, as stated above, deep-sea fish contain a comparatively large amount of polyene acids. These polyene acids have the function of keeping the cholesterol level[3] in the blood serum from rising.

Accordingly, we can probably say that deep-sea fish is food p. 583
with a dietetic value. However, as stated above, there are still the questions of their external appearance, and low yield; solutions to these various problems are hoped to be reached through studies of

preparation methods and through development.

Furthermore, experiments concerning the amino acid composition in the deep-sea fish protein are in process.

IV Summary

The fatty acid composition of the oil of 14 kinds of deep-sea fish was measured by gas chromatography. The following results were obtained:

1) There were no components peculiar to deep-sea fish; they did not differ greatly from ordinary fish.
2) Amongst the three groups of deep-sea fish, southern-sea fish and northern-sea fish, the result regarding significant differences in the main components, was that with respect to C16:0, C16:1, C19 and above and to saturated acid, a definite difference could be discerned between the deep-sea fish and southern-sea fish; deep-sea fish show a tendency to be closer to northern-sea fish.
3) Since they contain large amounts of polyene acids which keep the blood serum cholesterol level from rising, deep-sea fish can also be thought to have a dietetic value.

In conducting this experiment we wish to express our sincere gratitude to Mr. T. Asami and S. Kudo, technicians at the Fisheries Research Station of the Fisheries Agency, Southwestern Sea division for donating samples and also to Professor Hashimoto of the Fishery Science Department of Tokyo University for making things so convenient

for us.

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