The fatty acid composition of tissue lipids in red ocean perch (*Sebastus viviparus*)

by W. V. Reimold and K. Lang

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The fatty acid composition of tissue lipids in red ocean perch (Sebastes vivinarus) 1,2

by W. V. Reimold and K. Lang

with 5 figures and 2 tables

(received May 16, 1971)

Fish oils are characterized by the presence of an unusually high content of polyunsaturated fatty acids - in particular, eicosapentaenoic acid (C₂₀: 5 ω₃), docosapentaenoic acid (C₂₂: 5 ω₃) and docosahexaenoic acid (C₂₂: 6 ω₃) (7,27,34). The parent compounds for the most important

1 Small red ocean perch, red fish, Norway headdog.
2 We would like to express our thanks to the Margarine Institute for Good Nutrition for the award of a stipend.

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polysaturated fatty acids found in animals and man are \( \omega_6-\Delta^9,12 \)-octadecadienoic acid (linoleic acid) and \( \omega_3-\Delta^9,12,15 \)-octadecatrienoic (linolenic acid).

Linoleic and linolenic acid can only be synthesized by plants. Marine animals take in fatty acids predominantly of the \( \omega_3 \) family in their food (plankton), along with minute quantities of the \( \omega_5 \) family (26). The numerous polysaturated acids in marine animal lipids therefore do not arise from a de-novo synthesis (36).

Linoleic acid plays an essential role in the nutrition of man and other animals, while linolenic acid can only partially prevent or eliminate symptoms of linoleic acid deficiency (23). Polyunsaturated fatty acids are essential building blocks for cell formation; they are found in membranes and microstructures, particularly in phosphatides. The more complicated the functions of a cell, the higher its phosphatide content, and hence its polyunsaturated acid content as well, provided that sufficient quantities of the parent compounds are supplied nutritionally. Polyunsaturated fatty acids which are not immediately utilized as cell building units are stored or metabolized. Individual organs and tissues differ considerably in their fatty acid composition. The polyunsaturated acid content of marine animal lipids varies with the time of year (34). In addition, temperature and depth of water affect the fatty acid composition of fish lipids (34). The fatty acid composition of body oils and organ lipids has been previously studied in various marine animals (2, 4, 6, 12-17, 29, 31, 38-41). The polyunsaturated fatty acids in the individual tissues of Sebastus viviparus have not been studied. In the following paper the fatty acid composition of 11 different tissues in red ocean perch is reported.
Study Material and Method

1. Study of the tissue lipids in *Sebastus viviparus*

Small red ocean perch were obtained in January 1966 from the fishing trawler "Fritz Hohmann" of the shipping line Kampf and Co. Ltd, Bremerhaven. The fish came from the ocean between West Greenland and the coast of Labrador. They were deep-frozen immediately after being caught, and thawed for the first time for study purposes.

Organs and tissue samples were taken from 10 red ocean perch, weighed and then extracted with chloroform-methanol (2:1, v/v) (5).

The extracted tissue lipids were taken up in petroleum spirits, dried (over Na$_2$SO$_4$) and then the weight was recorded when it became constant.

Saponification of the extracted lipids was carried out in N$_2$ atmosphere in a reflux condenser with 0.5 n methanolic KOH. The fatty acids were separated with 10% H$_2$SO$_4$ (v/v). The fatty acids were extracted with petroleum spirits, then dried over Na$_2$SO$_4$ (11). The fatty acids were esterified with freshly-prepared diazomethane (3), then the fatty acid methyl esters were dissolved in hexane.

The determination of the fatty acid composition was carried out gas chromatographically. For each analysis, 5 μl fatty acid methyl ester was injected into a gas chromatograph, Model GC 2A with "Thermotrac" from the firm of Beckman.

A 6 ft double-column, 1/8" inner diameter was used, coated with 16.5% DEGS on Chromosorb W 42/60 mesh. Oven temperature: programmed isothermally 9 minutes at

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5 The red ocean perch studied, as well as the red ocean perch oil, were kindly supplied free of charge by Herr Dr. Wagenitz of the firm Fr. Wilhelms, Bremerhaven.
150°C, then heated to 200°C in 25-30 sec., followed by isothermal heating at 200°C. Detector: H-L, bridge current 200 mA, cell temperature 220°C. Intake heating 275°C. Carrier gas: 20 psi (42 ml/min) H₂ (super purity).

Part of the fatty acid mixture was identified by comparison of the retention times with known test substances (1,9). In order to determine the chain length and number of double bonds in the unknown fatty acids, the fatty acids of the red ocean perch oil were fractionated and then studied more closely (see below).

"Calibration and correction of the peak areas, which were calculated by the "height times width at half height" formula, were carried out after determination of calibration factors for the individual fatty acids by application of the Mill-calibration rule (37), using quantitative mixtures obtained from the Hormel Institute, Austin, Minn., U.S.A.. The average error in the determination of the main components was 3%.

2. Analysis of fatty acids from red ocean perch body oil

The red ocean perch oil was obtained from predominantly small fish (December, 1964). The fish were deep-frozen at sea immediately after they were caught, and thawed for the first time just before the experiments. After the whole fish were boiled at 95°C, the liquid obtained by using a screw press was separated centrifugally into water and oil phases. The oil obtained by this method was stored at -20°C.

In each case, 10 g red ocean perch body oil was saponified in a N₂ atmosphere with 1 n methanolic KCl (11). The non-saponifiable part was separated from the alkaline saponification solution by a perforator in distylether (11). After acidification with 10% H₂SO₄ (v/v) (at 0°C), the fatty acids were extracted with petroleum spirits and dried over Na₂SO₄.
After the solvent was removed, the fatty acids were taken up in acetone and separated at -20°C (18). In the residue (fraction 1) predominantly saturated fatty acids were found, in the supernate (fraction 2) the unsaturated fatty acids.

After removal of the solvent, fraction 2 was separated at -20°C in 0.5 n ethanolic KOH into two additional fractions. The supernate (fraction 2.1) contained predominantly polyunsaturated acids and the residue (fraction 2.2) predominantly mono-unsaturated acids.

After partial reduction of the ethanolic KOH solution of fraction 2.1 using a water aspirator, then refilling the solution to the original volume with H₂O, a solid, dark-brown crystalline upper phase (fraction 2.1.1) and a liquid lower phase (fraction 2.1.2) were obtained at -20°C. The polyunsaturated acids were further enriched in the lower phase.

The fractions of the red ocean perch fatty acids obtained in this way were studied further using the following methods after the fatty acids were recovered.

The Hg-adducts of the fatty acid methyl esters were formed, modified according to the method of Wagner and Pohl (42). Approximately 250 mg fatty acid methyl esters were shaken with 7 g Hg-acetate, 0.5 ml CH₃COOH, 1.25 ml H₂O and 125 ml CH₃CH₂, then stored for 48 hours at 20°C. The Hg-adducts were extracted with 30 ml chloroform after removal of the methanol (under vacuum, N₂, 20°C), and removal of the acetic acid residues by washing with 5 x 20 ml H₂O, dried over Na₂SO₄, and concentrated down to 1 ml.

Thin-layer chromatography of the Hg-adducts. Plates 20 x 20 cm. 9 g silica gel G (Merck No. 7731) + 21 g diatomaceous earth G (Merck No. 8129) + 60 ml H₂O. Drying 180 min. at 80°C, coating thickness 300 μ. Solvent isobutanol-formic acid-water (100:0.5:15.7, v/v/v), 10 hours at 4°C. Various fractions of Hg adducts were obtained, which corresponded to the different groups of
polyunsaturated acids. The separation corresponded to the number of double bonds. The fatty acid methyl esters were recovered after cleavage of the Hg-adducts with HCl. TCL fraction: 3 ml 3% \( \text{NH}_3 \) + 0.4 ml 37% HCl + H\(_2\)O to 15 ml. After one hour, extraction of the fatty acid methyl esters with petroleum spirits. Drying over Na\(_2\)SO\(_4\).

The TCL fractions were further separated gas chromatographically on a preparative column. Model 400, F+M, Hewlett Packard. Preparative column 6 ft, \( \frac{1}{4} \)" I.D.; 20% EGS on Chromosorb. Detector: fi, temperature 240°C. Oven temperature 180°C isothermally. Inlet heating 290°C. Carrier gas N\(_2\). Sample quantity 50 μl; damping 64 x 10\(^{-2}\). The fatty acid methyl esters were collected in a cold trap (methanol - 30°C). Separation corresponds to the chain length. Next, analytical gas chromatography of the individual fractions was carried out.

One aliquot was hydrogenated in order to determine the chain length. 10 mg fatty acid methyl ester was shaken with 20 mg PtO\(_2\) (Degussa, Hanau) in 10 ml glacial acetic acid under H\(_2\) atmosphere in a micro-hydrogenator Type HYD (Sartorius, Darmstadt). The hydrogen was purified over platinum oxide in a Puricat gas purification cartridge Type 2.0 (gas flow 0.1 m\(^3\)/h) (Degussa, Hanau). After 30 min. pre-hydrogenation of the catalyst, the fatty acid methyl ester sample was added to the acidic catalyst solution by retracting a bar magnet*, then shaken for 45 minutes. The acetic acid was neutralized with 1 M NaHCO\(_3\), the hydrogenated fatty acid esters were extracted with hexane, followed by analytical gas chromatography.

To determine the number of double bonds, the fatty acid methyl esters were isomerized with 21% KOH glycol for 15 min. at 180°C in an N\(_2\) atmosphere (8), then UV spectra were taken.

The fatty acid methyl esters were studied in KBr in a Beckman IR-spectrometer to exclude the trans fatty acids.

*Literal translation
Fig. 1 Gas chromatogram of the fatty acid methyl esters from red ocean perch oil. F + K 400, 6 ft column, 3% DEGS, temperature program 150-200°C, 5°C/min. FID 192-210°C. Carrier gas N₂.

Fig. 2 Gas chromatogram of the hydrogenated fatty acid methyl esters from red ocean perch oil. Beckman GC 2A, 5 ft. column, 16.5% DEGS, temperature program 120-220°C, 10°C/min. FID* bridge current 200 mA, cell temperature 220°C, carrier gas N₂. Dotted peaks; test standard compounds C₁₀ and C₁₂.

* thermal conductivity detector
Fig. 3  UV spectrum of the red ocean perch fatty acids isomerized with 21° ECH-glycol. Spectro photometer Zeiss, N° with recording device. Isomerization in N₂ atmosphere at 180°C for 15 min.

Fig. 4  IR spectrum of red ocean perch fatty acids. KBr compacts, Beckmann spectrophotometer.

Fig. 5  Isolation of eicosapentaenoic acid (ω 3) from red ocean perch oil. Gas chromatogram. F + H 400, 35°C EGS, 30 M/min.
Results

1. Analysis of red ocean perch oil and red ocean perch fatty acids

A gas chromatogram of the fatty acids of red ocean perch oil is shown in Fig. 1. The following fatty acids were present as main components: C_{14}:0, C_{16}:0, C_{16}:1, C_{18}:1, C_{20}:1, C_{22}:1, C_{20}:5, C_{22}:6.

By alkali isomerization of red ocean perch fatty acids, it was shown that hexa-, penta-, tetra-, tri-, and di-unsaturated acids were present (Fig. 2).

After hydrogenation of red ocean perch fatty acid methyl esters, C_{14}:0, C_{16}:0, C_{17}:0, C_{18}:1, C_{20}:0, C_{22}:0 and C_{26}:0 were identified. The corresponding gas chromatogram is shown in Fig. 3.

The absence of trans fatty acids was confirmed by IR spectrographs (Fig. 4).

After deep-freeze fractionation, the individual fractions were separated further according to the degree of unsaturation using thin-layer chromatography and then by preparative gas chromatography. They were subsequently subjected to analytical study as above.

By combination of the individual fractionation steps, group separations were achieved. It was found that C_{20}:4 and C_{22}:1 have nearly the same retention times in the gas chromatograms.

In Fig. 5 a polyunsaturated fatty acid isolated from red ocean perch oil is illustrated as an example—the acid is ω3-eicosapentaenoic acid (C_{20}:5).

2. Tissue lipids in Sebastes viviparus

Table 1 summarizes information about the tissue lipids extracted from 10 red ocean perch. Identical aliquots of the tissue (muscle and fatty tissue) from 10 fish were combined; in a similar way, organs were removed, combined, weighed, and extracted.
<table>
<thead>
<tr>
<th>Tissue Sample</th>
<th>Colour of Extracted Lipids</th>
<th>Consistency of Extracted Lipids</th>
<th>Extracted Lipids g</th>
<th>Percentage Lipid Content g/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesenteric fat</td>
<td>bright yellow fluid</td>
<td>40.0</td>
<td>86.9</td>
<td></td>
</tr>
<tr>
<td>Epididymal fat</td>
<td>medium yellow viscous</td>
<td>40.0</td>
<td>87.1</td>
<td></td>
</tr>
<tr>
<td>Red muscle</td>
<td>yellow medium medium</td>
<td>3.3</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>White muscle</td>
<td>bright yellow medium</td>
<td>1.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Brown fatty tissue</td>
<td>yellow medium</td>
<td>10.0</td>
<td>69.9</td>
<td></td>
</tr>
<tr>
<td>Central nervous system</td>
<td>colourless fluid</td>
<td>52.0</td>
<td>64.3</td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>dark brown viscous fluid</td>
<td>1.8</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td>red-brown fluid</td>
<td>90.0</td>
<td>22.6</td>
<td></td>
</tr>
<tr>
<td>Spleen</td>
<td>brown dark viscous</td>
<td>0.6</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Kidneys</td>
<td>brown dark viscous</td>
<td>0.4</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Testicles</td>
<td>colourless/ bright yellow fluid</td>
<td>10.0</td>
<td>12.3</td>
<td></td>
</tr>
</tbody>
</table>

The highest fat content was found in the fatty tissue, the central nervous system and the liver, whereas the muscle tissue, heart, spleen and kidneys had only negligible lipid content.

The colour of the extracted lipids varies. While the lipids from the mesenteric fat and white muscle tissue were bright yellow coloured, red muscle tissue lipids were medium yellow, brown fatty tissue lipids dark yellow, the lipids from heart, spleen and kidneys were dark brown, and from the liver red-brown. Brain lipids were colourless.
From unpublished studies carried out by our research group, we knew that the colour of red ocean perch oil arises from at least three components, which can be separated by column chromatography. These are one red and two yellow dyes. Obviously the single dyes are distributed amongst the individual tissues and organs in various ways. Likewise, the consistency of the extracted lipids varies. The lipids from spleen and kidneys are viscous, those from heart and skeletal muscles are of a medium consistency, whereas those from the central nervous system, testicles, mesenteric and epididymal fat are quite fluid.

Corresponding to the differences in lipid content, colour and consistency of the lipids, the fatty acid composition of the organ lipids is also variable (Table 2).

The highest polyunsaturated acid content was found in the liver. Based on the total fatty acid content we found here 23.7% docosahexaenoic acid, 18.8% docosapentaenoic acid (ω3 + ω6); these two isomerous acids were present in a ratio of 1:2. Heart, kidneys, central nervous system, testicles and epididymal fat also had a high docosahexaenoic acid content, between 9.0% and 5.7%. The remaining tissues studied had less than 5%. In comparison to the liver, the remaining tissues and organs contained only slight amounts of docosapentaenoic acids. The corresponding values varied between 1 and 3%; the content of ω5-docosapentaenoic acid was lower in fatty tissue, muscles, central nervous system, spleen and liver than was the content of the isomerous ω6-acid. The myocardium, on the other hand, contained a higher concentration of the ω3-docosapentaenoic acid than of the ω6-acid. Kidney and testicles contain only the ω3 docosapentaenoic acid, none of the ω6-acid.

The highest content of eicosapentaenoic acid (ω3) was found in the central nervous system, myocardium, testicles, spleen, kidneys and in red muscles (16.7-11.2%), whereas white muscles, fatty tissue and liver contained only 9.2-7.5% C20:5 ω3.
<table>
<thead>
<tr>
<th>Fatty Acid</th>
<th>Carc Use</th>
<th>Red</th>
<th>White</th>
<th>Brain</th>
<th>Control</th>
<th>Heart</th>
<th>Spleen</th>
<th>Liver</th>
<th>Kidney</th>
<th>Testicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>18:0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>18:1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>18:2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>18:3</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>19:0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>19:1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>19:2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
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<tr>
<td>19:3</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>20:1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>20:2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>20:3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
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<td>0.0</td>
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<td>21:0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
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<td>21:1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
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<td>21:2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
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<td>0.0</td>
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<td>0.0</td>
</tr>
<tr>
<td>21:3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
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</table>

- a = chain length
- b = no. of multiple bonds
- c = distance of double bond from terminal methyl group
C₂₀ and C₂₂ tetraenoic acids were found predominantly in fatty tissue and in muscles, whereas of the organs studied, only the liver contained considerable quantities (3.3% C₂₂:4). Eicosatrienoic acid was found only in trace amounts in the tissues and organs. In addition, the linolenic acid content was less than expected. Mesenteric fat contained 6.2%, myocardium 1.2% and the remaining tissues less than 1%.

Of the dinoic acids, the content of linoleic acid was greatest. The highest concentration was found in white muscles (12.3%), myocardium (4.5%) and kidneys (5%). In contrast, C₁₆:2, C₂₀:2 and C₂₂:2 were present only in minute or trace amounts.

Oleic acid was the mono-unsaturated acid present in the highest concentration. The highest oleic acid content was in the spleen (41.7%). Then came the testicles (27.9%), epididymal fat (24.3%), kidneys, heart, muscles and the other tissues. Corresponding to its higher polyunsaturated acid content, the liver contained only 12.7% oleic acid.

Of the other mono-unsaturated acids, eicosamonoenoic acid was present in the highest concentration. 10-20% was present in all tissues and organs.

In contrast, the concentration of docosamonoenoic acid and palmitoleic acid in all organs was less. Palmitic acid was the dominant saturated fatty acid. Epididymal fat and testicles had the highest concentration (15.2-17%), whereas the liver contained only 3.2%. The myristic acid content was generally 2.5-5%. The liver and myocardium had the lowest concentrations (0.5 and 1.1%).
Discussion

Fish oils have been studied by various research groups, with respect to their fatty acid composition and physiological-nutritive properties. In particular, the lipids of herrings, sardines, cod and whale have been most frequently analysed (4,10,19,20,22,23,24,30,35,43). The liver oils of various species have generated great interest because of the abundance of polyunsaturated acids (12,15,21,25,26,22,32,33). Since the fatty acid composition of the liver lipids has been studied most extensively, in comparison to the other organs and tissues of marine animals, the comparison of red ocean perch lipids to those of other fish must centre around the liver lipids.

In comparison to red ocean perch liver oil, cod liver oil contains only half as much docosahexaenoic acid (23.7% in Sebastus viviparus, 10-12% in cod-liver oil, 22.5% in herring liver oil) (26).

Whereas 12.4% C\textsubscript{22}:6 ω6 and 6.4% C\textsubscript{22}:5 ω3 are present in red ocean perch lipids, only 1-2% of these polyunsaturated acids are present in cod-liver oil (25). Klenk and Eberhagen (21) determined that ω3-eicosapentaenoic acid was the main-component of cod-liver oil (76% of the poly-unsaturated acid content), 8-10% eicosapentaenoic acid is present in cod-liver oil, 7.5% in red ocean perch liver extract.

It is worth mentioning that there is an abundance of an eicosatetraenoic acid in red ocean perch fatty tissue, and in the muscle lipids. In sardine oil, a C\textsubscript{20}:4 ω6 acid was also identified (41). Considerable amounts of C\textsubscript{20}:4 were also found in herring oil (26).

Trienoic acids can be identified in red ocean perch tissue only in trace quantities. Less than 0.5% C\textsubscript{16}:3 was contained in the organs, 0.5-2% C\textsubscript{18}:3 was present in the various tissues. 6.2% C\textsubscript{18}:3 ω3 was found in essential fat only. Obviously the linolenic acid ingested
was converted into polyunsaturated oils in the fish by very active enzyme systems. Only minute quantities of \( C_{16} : 5 \omega 6 \) or \( \omega 3 \) were found in cod-liver oil or herring oil as well (25,26).

Dienoic acids with chain lengths of \( C_{16}, C_{18} \) and \( C_{20} \) were found in red ocean perch lipids. The variable content of \( C_{16} : 2 \) in the muscles was particularly striking. Whereas 12.5% of this fatty acid was found in white muscles, only 1.2% was present in red muscles. The different fatty acid composition of red and white muscles in herring has also been reported. The differences in the \( C_{22} : 1 \) content are particularly large (22.1% for white, 10.5% for the red muscles in herring) (26). Different fatty acid compositions in white and red muscles as well as in white and brown fatty tissue correspond to differences in metabolic function, which have not yet been studied in detail. This is also true of the different fatty acid composition of the organs, which varies from species to species, as well as with environmental conditions for individual fish. In cold water, the polyunsaturated fatty acid content of the fish increases; in deep water it decreases. In winter and in the summer months, the polyunsaturated and monounsaturated fatty acid content increases, but decreases in the intervening months (25,34).

Many fish have a particularly large number of branched fatty acids. The dolphin family is characterized by isovaleric acid-containing triglycerides (34). Only minute quantities of branched fatty acids are found in red ocean perch lipids.

The liver of Squalus acanthias (dogfish) contains large amounts of eicosamonoenoic and docosamonoenoic acids, and only small amounts of polyunsaturated fatty acids (32,33). Red ocean perch tissue contains 10-20% eicosamonoenoic acids, 0-6% docosamonoenoic acids, and 12-23% \( C_{18} : 1 \). Red ocean perch spleen is unique, containing 41.4% oleic acid.
Palmitic acid is the most abundant of the C\textsubscript{14}, C\textsubscript{16}, and C\textsubscript{18} saturated fatty acids in red ocean perch tissue as well as in numerous other marine species. Red ocean perch liver contains the least palmitic acid (3.2\%) whereas herring liver lipids contain 21.5\% (25). In most fish, \( C\textsubscript{16}:0 \) is incorporated in triglycerides predominantly in position 2; the long-chain fatty acids such as docosanoic acid are predominantly incorporated in position 3. The polyunsaturated acids \( C\textsubscript{20}:5, C\textsubscript{22}:5 \) and \( C\textsubscript{22}:6 \) are also found most often in position 2 in marine animal triglycerides. Corresponding studies of red ocean perch lipids have not yet been carried out.

Summary

The lipid content and fatty acid composition were studied in 11 types of tissue in small red ocean perch (\textit{Sebastes viviparus}). The highest fat content was found in fatty tissue, central nervous system and liver.

The liver had the highest polyunsaturated fatty acid content. It contained 23.7\% docosahexaenoic acid and 18.8\% docosapentaenoic acid. Heart, kidney, central nervous system and testicles contained between 9.0 and 5.7\% docosahexaenoic acids.

Central nervous system, myocardium, testicles, spleen, kidney and red muscle had the highest content of eicosapentaenoic acid (16.7-11.2\%). White muscle, fatty tissue and liver contained only 9.2-7.5\% eicosapentaenoic acid. \( C\textsubscript{20}- \) and \( C\textsubscript{22}- \)tetraenoic acids were predominantly found in fatty tissue, in muscle and in the liver. Eicosatrienoic acid was present in the organs only in trace amounts. The linolenic acid content of mesenteric fat was 5.2\%; in the myocardium it was 1.8\% and in the remaining tissues it was less than 1\%. 
White muscle had the highest linoleic acid content (12.5%); the myocardium had 4.5%, and kidneys 5.6%. Other dienoic acids could be identified only in trace amounts.

Oleic acid was the most abundant of the mono-unsaturated acids; of the total fatty acids contained in the spleen, 41.7% was oleic acid. The testicles contained 27.9%, epididymal fat contained 24.3%. Corresponding to its higher polyunsaturated acid content, the liver contained only 12.7% oleic acid.

The eicosamonoenoic acid content in all organs was between 10-20%.

Palmitic acid was the most abundant saturated fatty acid. Epididymal fat and testicles had the highest content (15.2-17%). The lowest concentrations were found in liver and myocardium (0.5-1.1%).

The results were compared with the fatty acid composition of other marine animal lipids obtained from the literature.

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