CCXLVIII. NEW ZEALAND FISH OILS.

I. THE COMPOSITION OF EEL OIL

(*ANGUILLA AUCKLANDII*).

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It has been suggested by Lovern [1932 *et seq.*] that the fats of freshwater fish are, within comparatively small limits, characteristic for that class and quite distinct as regards the relative proportions of component fatty acids from marine fats. So far as the authors are aware the data on this subject have been derived almost entirely from species inhabiting the Northern Hemisphere. The present work, however, suggests that this important generalisation with regard to the composition of freshwater fats can be extended to include species inhabiting the Southern Hemisphere.

In most parts of New Zealand, eels are the predominant freshwater fish. The two species known respectively as the short-finned or northern eel (*Anguilla australis*) and the long-finned or southern eel (*Anguilla aucklandii*) are noted for their large size when mature; specimens weighing 35 lb. or more being occasionally caught.

The composition of New Zealand eel oil does not seem to have been previously determined. Wiehr [1934] reports that the fat from *A. vulgaris* yielded 86.5% fatty acids of which the solid acids separated by Farnsteiner's method comprised 20.3%, whilst Ono [1935] gives qualitative data for the composition of Japanese eel oil. The general characteristics of various eel oils determined by previous investigators are given in Table I.

Table I. *The general characteristics of some eel oils.*

Species	Sap. equiv.	I.V.	Unsaponi- fiable (%)	Observer
<i>A. rostrata</i>	293.6	117.4	—	White [1912]
<i>A. vulgaris</i>	273.4	90.6–105.8	0.74	Wiehr [1934]
New Zealand eel	289.2	107.0	1.0	Denz and Shorland [1934]
Japanese eel (Spring)	284.7	146.2	—	Ono [1935]
„ (Summer)	290.7	158.9	—	„

Eel oil has been stated to contain not only vitamin D but also nearly as much vitamin A as good cod liver oil [Medical Research Council 1926–7]. In the case of New Zealand eels we have measured vitamin A blue values varying from 4.3 to 12.0. Most of the fat is contained in the body, the small amount of oil in the liver, however, appears to be extremely rich in vitamin A. A sample weighing 254 g. and comprising 19 livers, kindly placed at our disposal by Dr E. Marsden of the Department of Scientific and Industrial Research, Wellington, New Zealand, yielded 2% oil of blue value 1300. For a sample of small eels (average weight 1 lb.) it was found that the livers comprised only 1.8% of the total weight.

The sample used in this investigation was a specimen of *A. aucklandii* taken near Upper Hutt in the Wellington District of the North Island during February 1935. The following measurements may be given. Length, 4 ft. 3 in.; weight, 20 lb.; weight of liver 4 oz.;

$$\text{distances between dorsal fin and vent} \times \frac{100}{\text{length of fish}} = 8\%.^1$$

After removal of viscera, the bulk of which comprised liver, the remainder was steam-cooked, pressed and then extracted with light petroleum (B.P. 60–80°). The extract (7%) freed from the last traces of solvent by steam distillation, gave the following general characteristics. Sap. equiv., 290.4; i.v., 122.5; % unsaponifiable matter, 0.80. In Table II, the data for the component fatty acids of eel oil determined according to the procedure of Guha *et al.* [1930] are compared with the summarised data for five freshwater fats analysed by Lovern [1932].

Table II. *Component fatty acids of freshwater fish oils expressed as molar percentages.*

	Saturated			Unsaturated				
	C ₁₄	C ₁₆	C ₁₈	C ₁₄	C ₁₆	C ₁₈	C ₂₀	C ₂₂
<i>A. aucklandii</i>	2.4	15.9	0.8	—	21.2 (-2.0 H)	46.3 (-2.6 H)	12.9 (-6.2 H)	0.5 (-? H)
Freshwater species (Lovern)	(3.4–5.6)	(13.4–16.0)	(tr.–1.9)	(0.6–1.8) (-2.0 H)	(19.0–22.4) (-2.0 H)	(37.4–44.5) (-2.8 to -3.4 H)	(12.2–13.8) (-6.7 to -7.5 H)	(0.0–6.0) (-7.5 to -9.2 H)

It will be observed that apart from minor differences such as the relatively low molar percentages of myristic acid and the high molar percentages of C₁₈ unsaturated acids together with the low mean unsaturation of the C₁₈ and C₂₀ groups there is a general agreement between the composition of the eel oil examined and fats from typical freshwater fish in the Northern Hemisphere.

Until quite recently it appears to have been widely assumed that the C₁₈ unsaturated acids of fish oils consisted of oleic acid together with linoleic and linolenic acids characteristic of plant and animal fats. Various investigators have, however, reported occasionally the occurrence of a tetraethenoid C₁₈ acid in fish oils [cf. Toyama & Tsuchiya, 1929]. The only quantitative data with regard to the relative amounts of C₁₈ polyethenoid acids in aquatic oils appear to be those of Green & Hilditch [1936]. These investigators have shown that cod liver and whale oils contain not more than traces of linoleic and linolenic acids, the polyethenoid unsaturation being due in part at least to octadecatetraenoic (stearidonic acid). On the other hand, the C₁₈ acids of the grass-feeding carp were found to contain smaller proportions of stearidonic acid but definite amounts of linoleic and linolenic acids. In view of these results it seemed desirable to obtain further information with regard to the C₁₈ unsaturated acids of eel oil. A purified C₁₈ fraction (Sap. equiv. 308.8; i.v. 115.4) was prepared by refractionation of a C₁₈ concentrate obtained during the distillation of the ethyl esters of the "liquid" acids. The corresponding acids (3.59 g.) were brominated and fractionated into ether-insoluble and petroleum-insoluble bromides as described by Green and Hilditch [1936]. The data thus obtained are summarised in Table III.

The C₁₈ unsaturated acids (7.30 g.) were further examined by means of oxidation with alkaline permanganate (Hazura). The water-insoluble fraction (2.96 g.) M.P. 120–122° on recrystallisation from ethyl acetate gave dihydroxy-

¹ This formula is used to distinguish between the two species; in the case of *A. australis* the value seldom exceeds 4%.

Table III. *The bromo-additive products of C₁₈ unsaturated acids of eel oil.*

	Weight	M.P.	Br %	Total acids %	I.V. (calculated from Br (%))
Insoluble in ether	0.52	>190° (d)*	67.0	4.8	322.1
Insoluble in petroleum	0.26	145–147°	61.4	2.8	252.3

* (d) with decomposition and charring.

stearic acid m.p. 129–130°. No tetrahydroxystearic acid was found in the water-soluble fraction. The high melting-point and bromine content of the ether-insoluble bromides point to the presence of stearidonic acid. In the case of the petroleum-insoluble bromides, the bromine content (61.4%) is somewhat lower than required for hexabromostearic acid (63.3%). However, in view of the failure to obtain tetrahydroxystearic acid and the low melting point observed it is quite possible that the petroleum-insoluble bromides represent incompletely brominated stearidonic acids. The composition of the C₁₈ polyethenoid acids of eel oil thus appears to resemble that of cod-liver or whale oil.

SUMMARY.

The fat from a specimen of New Zealand eel (*A. aucklandii*) has been examined. The composition is shown to resemble closely that of the typical freshwater fish examined by Lovern [1932]. Oxidation with alkaline permanganate and bromination respectively have shown the C₁₈ unsaturated acids to contain in addition to oleic acid some stearidonic acid. No evidence, however, for the presence of either linoleic or linolenic acid has been found.

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