

CODEX ALIMENTARIUS COMMISSION



Food and Agriculture
Organization of
the United Nations



World Health
Organization

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Agenda Item 3

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JOINT FAO/WHO FOOD STANDARDS PROGRAMME CODEX COMMITTEE ON FATS AND OILS

Twenty-third Session

Langkawi, Malaysia, 25 February – 1 March 2013

PROPOSED DRAFT STANDARD FOR FISH OILS

Governments and interested international organizations are invited to submit comments on the Proposed Draft Standard (**Annex1**) at Step 3 in writing, preferably by email, to the Secretariat, Codex Alimentarius Commission, Joint WHO/FAO Food Standards Programme, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy, Fax +39-06-5705-4593, e-mail codex@fao.org with copy to the Malaysian Secretariat for CCFO, Food Safety and Quality Division, Ministry of Health Malaysia, Level 3, Block E7, Parcel E, Federal Government Administrative Centre, 62590 Putrajaya, Malaysia, E-mail: ccfo_malaysia@moh.gov.my, by **15 January 2013**.

Report of the CCFO Electronic Working Group on the Development of a Codex Standard for Fish Oils

Introduction

1. The 34th session of the Codex Alimentarius Commission approved the development of a Codex Standard for Fish Oils as new work as proposed by the 22nd session of the Codex Committee for Fats and Oils (CCFO). As agreed by the CCFO, an electronic Working Group (eWG) chaired by Switzerland, has prepared a Proposed Draft Standard for Fish Oils based on the project document¹, the comments received at the 22nd session of the CCFO and the discussions held within the eWG. The Proposed Draft Standard is attached to this report as Annex I and is now circulated for comments at Step 3 and it will be considered by the forthcoming 23rd session of the CCFO.
2. The following Codex Members and Observers participated in the eWG: Australia, Canada, Brazil, Chile, European Union, France, Iceland, Indonesia, Japan, Malaysia, Moldova, Norway, Switzerland, Spain, United Kingdom, United States of America, AOCS, CRN, FAO, ELC, FoodDrinkEurope, IADSA, IFT, ISDI.
3. The Proposed Draft Standard for Fish Oils was developed according to the consultation procedure that is presented in this report.

First round: beginning of discussions

4. Switzerland circulated an initial and preliminary proposed draft text developed according to the standard layout for Codex Standards as foreseen by the Codex Procedural Manual² and taking into account the issues raised in the Project Document¹, various adopted Codex Standards for named and

¹ REP 11/FO Appendix VII

² Codex Alimentarius Commission, Procedural Manual, 20th Edition, 2011

unnamed fats and oils of vegetable and animal origin, as well as general information available in the public domain.

5. Together with this initial draft prepared by Switzerland, several questions were presented to Members of the eWG with a view to developing a common position concerning the subject matter and the issues that were to be addressed in the Proposed Draft Standard for Fish Oils. These questions were based on comments received during the discussions held at the 22nd session of the CCFO.

Second round: revised draft document

6. The feedback received from the eWG Members enabled Switzerland to develop a revised Proposed Draft text that was also later submitted to eWG Members for further comments. The current text of the Proposed Draft Standard for Fish Oils (Annex I) reflects most of the comments that were submitted by Members of the eWG. (see Annex I).

7. Unfortunately, it was not possible to reach consensus on all the provisions of all the sections of the Proposed Draft Standard for Fish Oils and the text on which there was a lack of consensus is therefore included in square brackets. The following paragraphs provide a summary of the various issues raised in the eWG discussions.

Scope

8. One Member Organisation proposed that the Proposed Draft Standard should apply to the whole production chain. However, as Codex Commodity Standards usually apply to food as traded, it was considered that the proposal to include provisions on raw materials and their processing in the Draft Standard would go beyond the normal approach for this type of Codex Standard (with the exception of crude fish oils for further processing).

Description

9. Fish oils may not only be derived from wild and farmed fish, but also from shellfish. Furthermore, it is important to note that not only whole fish but also by-products from fish processing may be used as raw materials. As it would not be feasible to give an exhaustive list of all permitted by-products, trimmings are given as an example. It is our understanding that other by-products may be used as long as they comply with essential requirements of Codex Standards (e.g. hygiene).

10. Several Members pointed out that fish oils used as food supplements would be considered as medicinal products in their country. It is therefore proposed to state that the Standard only applies to food supplements where they are regulated as food and to foods.

11. There was general support for the inclusion of *named fish oils* (from 13 specific sources), *fish oils (unnamed)* – from other sources), *named fish liver oils* (from cod), and *fish liver oils (unnamed)*. The list of the named fish oils could be extended if the need arises.

12. With respect to *concentrated fish oils*, one Member disagreed with the inclusion of *concentrated fish oil ethyl esters* since they are chemically synthesized from fish oil and do not occur naturally therein.

13. A few Members questioned the need to indicate minimum contents of long-chain unsaturated fatty acids for concentrated fish oils, as in their view, concentration is done with respect to only the content of certain fatty acids (DHA, EPA) and not of other constituents. These provisions are open for discussion.

14. Production processes are only included where they are essential for the definition of a specific oil. It seems to be rather complex and beyond the scope of a Codex standard to list all acceptable processing steps for a food category.

15. Further qualifying definitions are given in Section 2.6. Firstly for *crude fish oils* and *crude fish liver oils* intended for human consumption after processing and secondly for *virgin fish oils* and *extra low oxidised fish oil*, both types of fish oils are produced using specific processes.

16. Some Observer Members expressed the view that the Proposed Draft Standard was too restrictive and that it would therefore stifle innovation. However, considering the fact that Codex Standards are developed to facilitate trade in existing foods of commercial significance, it would be difficult to anticipate any future promising developments in the current proposed draft text. Nevertheless, should these future developments materialize, the CCFO could consider revising the relevant provisions of the Standard in future.

Essential Composition and Quality Factors

17. The majority of comments supported the characterization of named fish oils by their fatty acid composition (see Table 1 of the Proposed Draft Standard). Several Members questioned whether the available data were sufficiently robust to allow the identification of named fish oils based on only this information. The use of supplementary criteria for confirmation of identity was generally supported.

18. Relevant quality parameters are only acid value and peroxide values which apply to all fish oils except crude fish oils (2.6.1) and flavoured fish oils. Other parameters such as anisidine, oligomers, or total oxidation, were not generally supported and were therefore put in square brackets.

19. There was not sufficient support in favour of the inclusion of provisions for minimum vitamin A and vitamin D contents for fish liver oils. It was also noted that e.g. shark liver oil may be rich in other components than fat-soluble vitamins.

Food additives

20. In the Codex General Standard for Food Additives (GSFA), fish oils are included in category 02.1.3 *Lard, tallow, fish oil, and other animal fats*. Since category 02.1 *Fats and oils essentially free from water* is excluded from Table 3 only those additives permitted by Tables 1 and 2 may be used. The functional classes of food additives listed for category 02.1.3 were deemed to be acceptable. However, Members did not agree to the inclusion of colours and antioxidant synergists.

21. Flavourings may be added to fish oils except virgin fish oils in accordance with the general *Guidelines for the Use of Flavourings*.

Contaminants

22. In accordance with the *Procedural Manual* reference to the *General Standard for Contaminants and Toxins in Food and Feed (GSCTF)*³ was made. Nevertheless, it was recognized that this Standard has no specific entry for the category "fish oil" as addressed by the Proposed Draft Standard. Therefore, the CCFO should consider proposing an amendment to the GSCTF and thereby forward that proposal to the Codex Committee on Contaminants in Foods.

Hygiene

23. Several Codex texts that may apply to the production and distribution of fish oils are referred to. It was debated whether further provisions were required. Nevertheless, it is considered that the current Proposed Draft Standard for Fish Oils is consistent with other Codex Standards.

Labelling

24. This section follows the example of other Codex texts for fats and oils. No specific provisions for fish oils are required other than the voluntary labelling of contents in fat soluble vitamins for fish liver oils and the mandatory labelling of specific fatty acids in concentrated fish oils.

³ Codex STAN 193-1995

Methods of Analysis and Sampling

25. The currently valid analytical methods developed by AOAC, AOCS, ISO and the Pharmacopoeia Europaea are listed for fatty acid composition, arsenic, lead and several quality parameters. The CCFO is invited to verify whether the indicated methods of analysis are suitable and to identify others that may have been omitted.

Table 1 Fatty acid composition

26. The fatty acid composition for all named fish oils (Section 2.1) and named fish liver oils (Section 2.3) is given. The data reflect the input from several Codex Members and Observers. As stated above, the robustness of the data in general was questioned by some Members of the eWG. Nevertheless, in the absence of alternatives, the Table is proposed as integral part of the Proposed Draft Standard for Fish Oils.

27. There was a question as to whether the content of Table 1 should be intended for voluntary application by commercial partners and whether it would not be for application by governments. The feedback and arguments received were that voluntary sections should not be part of Codex standards. Thus, this option was not included.

Recommendations

28. The attached Proposed Draft Codex Standard for Fish Oils is forwarded to the Codex Secretariat for circulation for comments at Step 3 of the Codex procedure.

29. The CCFO is requested to consider the Proposed Draft Standard for Fish Oils prepared by the eWG and to examine in particular, the Sections on Contaminants, Hygiene, Sampling and Analytical Methods as well as fatty acids composition.

Acknowledgement

30. The Swiss Chair wishes to thank all Members of the eWG for their active participation in this endeavour and for their constructive contributions as well as the support provided.

PROPOSED DRAFT CODEX STANDARD FOR FISH OILS
(At Step 3)

Prepared by the Electronic Working Group

1 Scope

This Standard applies in its entirety to the fish oils described in Section 2 that are presented in a state for human consumption. {It applies partially to crude fish oils described in Section 2.6.1 that require further processing before they are placed on the market for the final consumer}. For the purpose of this Codex Standard, the term fish oils refers to oils derived from fish and shellfish as defined in Section 2 of the Code of Practice for Fish and Fishery Products (CAC/RCP 52-2003)⁴.

2 Description

Fish oils are produced from a variety of fish and shellfish species. Whole fish are the main source, but by-products such as trimmings from fish processing may also be used. Fish oils are primarily composed of glycerides of fatty acids whereas concentrated fish oils are either primarily composed of glycerides of fatty acids or of their ethylesters. Fish oils may contain other lipids and unsaponifiable constituents naturally present. This standard only applies to fish oils used in food and in food supplements where those are regulated as foods.

2.1 **Named fish oils** may be derived from specific source materials; such fish oils are then identified by a specific name that is representative of the major fish or shellfish taxon from which the oil is extracted. For named fish oils, the fatty acid profiles (Table 1) shall apply. The following named fish oils are described in this Standard:

2.1.1 **Anchovy oil** is derived from the family Engraulidae.

2.1.2 **Sardine oil** is derived from the family Clupeidae (genera *Sardina*, *Sardinops* or *Sardinella*).

2.1.3 **Wild salmon oil** or **farmed salmon oil** are derived from wild or farmed fish respectively of the family Salmonidae; **salmon oil** is a mixture of oils derived from wild and farmed fish.

2.1.4 **Jack mackerel oil** also known as **horse mackerel oil** is derived from the family Carangidae (genus *Trachurus*).

2.1.5 **Menhaden oil** is derived from the family Clupeidae (genus *Brevortia*).

2.1.6 **Tuna oil** is derived from the family Scombridae (genera *Thunnus*, *Sarda*, *Katsuwonus* and *Auxis*).

2.1.7 **Krill oil** is derived from the family Euphausiidae (mainly Antarctic).

2.1.8 **Squid oil** is derived from the order Teuthida.

2.1.9 **Pollock oil** is derived from the family Gadidae (genus *Pollachius*)

2.1.10 **Herring oil** is derived from the family Clupeidae (genus *Clupea*).

2.1.11 **Capelin oil** is derived from the family Osmeridae (genus *Mallotus*).

⁴ **Fish** Any of the cold-blooded (ectothermic) aquatic vertebrates. Amphibians and aquatic reptiles are not included. **Shellfish**: Those species of aquatic molluscs and crustaceans that are commonly used for food.

- 2.1.12 **Sandeel oil** is derived from the family Ammodytidae.
- 2.1.13 **Calanus oil** is derived from the family Calanidae (genus Calanus).
- 2.2 **Fish oils** (unnamed) may be derived from a single species of fish other than the ones listed in Section 2.1 or be a mixture of fish oils derived from specified and/or unspecified source materials. This includes also mixtures with fish liver oils.
- 2.3 **Named fish liver oils** may be derived from the livers of fish and are composed of fatty acids, vitamins or other components that are representative of the livers from the species from which the oil is extracted. For named fish liver oils the fatty acid profiles (Table 1) shall apply.
- 2.3.1 **Cod liver oil** is derived from the family Gadidae (genus Gadus).
- 2.4 **Fish liver oil** (unnamed) may be derived from the livers of fish other than those used for named fish liver oils or are a mixture of named fish liver oils and/or single species fish liver oils.
- 2.4.1 **Fish liver oil devitaminised** is derived from fish liver oil that has been processed to reduce the content of vitamin A and vitamin D. [Section 3.3 does not apply]
- 2.5 **Concentrated fish oils** are derived from fish oils described in Section 2.1 to 2.4 which have been subjected to processes such as hydrolysis, fractionation, winterization and/or re-esterification to increase the concentration of specific fatty acids.
- 2.5.1 **Concentrated fish oil** contains [40 to 60 w/w %]fatty acids as sum of EPA and DHA, at least 50 w/w % of fatty acids are in the form of triacylglycerides.
- 2.5.2 **Highly concentrated fish oil** contains greater than [60 w/w %] fatty acids as sum of EPA and DHA, at least 50 w/w % of fatty acids are in the form of triacylglycerides.
- 2.5.3 **Concentrated fish oil ethyl ester** contains fatty acids as esters of ethanol of which [40 to 60 w/w %] are as sum of EPA and DHA
- 2.5.4 **Highly concentrated fish oil ethyl ester** contain fatty acids as esters of ethanol of which greater than [60 w/w %] are as sum of EPA and DHA
- 2.6 Other definitions applicable to fish oils (2.1 and 2.2.) and fish liver oils (2.3 and 2.4)
- 2.6.1 **Crude fish oils** and **crude fish liver oils** are oils intended for human consumption after they have undergone further processing, refining and purification as applicable.
- 2.6.2 **Virgin fish oils** have been treated by heating not exceeding [70°C], washing with water, settling, filtering and centrifugation only. They may contain antioxidants and pigments naturally present in the raw material.
- 2.6.3 **Extra low oxidised fish oils** are produced by mechanical maceration of the fresh raw materials at a temperature not exceeding 97°C, and a heating time not exceeding 20 minutes, and without using solvents. After centrifugation the oil may be processed by further purification steps.

3 Essential Composition and Quality Factors

3.1 GLC ranges of fatty acid composition (expressed as percentages of total fatty acids)

Samples falling within the appropriate ranges specified in Table 1 are in compliance with this Standard. Supplementary criteria, for example national geographical and/or climatic variations, may be considered, as necessary, to confirm that a sample is in compliance with the Standard.

3.2 Quality parameters

Note: this section does not apply to oils described in Section 2.6.1 and flavoured fish oils where the added flavourings will interfere with the analytical determination of oxidation parameters.

3.2.1 All fish oils, fish liver oils and concentrated fish oil (Section 2.1. to 2.5) with the exception of oils with a high phospholipid concentration shall comply with the following:

Acid value	≤ 3 mg KOH/g
Peroxide value	≤ 5 meq/kg
[Anisidine value	≤ 20
Total oxidation value (ToTox) ⁵	≤ 26
Oligomers:	≤ 1.5 % for fish oils and liver oils (Sections 2.1 – 2.4)
	≤ 3 % for concentrated and highly concentrated fish oils (Section 2.5.1 and 2.5.2)]

3.2.2 Fish oils with a high phospholipid concentration such as krill oil or squid oil, shall comply with the following:

Acid value	≤ 20 mg KOH/g
Peroxide value	≤ 5 meq/kg

3.3 [Vitamins

Fish liver oils (Sections 2.3 and 2.4) shall comply with following:

Vitamin A	≥ 40 µg of retinol equivalents/ml
Vitamin D	≥ 1.0 µg/ml]

4 Food Additives

Note: this section does not apply to fish oils described in Section 2.6.1

Antioxidants, antioxidant synergists, colours, chelating agents, and antifoaming agents used in accordance with Tables 1 and 2 of the Codex General Standard for Food Additives in food category 02.1.3 *Lard, tallow, fish oil, and other animal fats*. Additives may not be added to virgin oils as defined in Section 2.6.2.

Flavourings may be used in fish oils in accordance with the Guidelines for the Use of Flavourings (CAC/GL 66-2008).

5 Contaminants

Note: this section does not apply to fish oils described in Section 2.6.1.

The products covered by this Standard shall comply with the Maximum Levels of the Codex General Standard for Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995).

⁵ Total oxidation value (ToTox) = 2 x Peroxide value + Anisidine value

6 Hygiene

6.1 General hygiene

It is recommended that the products covered by the provisions of this Standard be prepared and handled in accordance with the appropriate sections of the Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969), the Code of Practice for Fish and Fishery Products (CAC/RCP 53-2003) and the Recommended International Code of Hygienic Practice for the Storage and Transport of Edible Oils and Fats in Bulk (CAC/RCP 36-1987).

6.2 Microbiological criteria

Note: this section does not apply to fish oils described in Section 2.6.1.

The products should comply with any microbiological criteria established in accordance with the Principles for the Establishment and Application of Microbiological Criteria for Foods (CAC/GL 21-1997).

7 Labelling

7.1 Name of the food

The product shall be labelled in accordance with the Codex General Standard for the Labelling of Pre-packaged Foods (Ref. CODEX STAN 1-1985). The name of the fish oil shall conform to the descriptions given in Section 2 of this Standard.

7.2 Labelling on non-retail containers

Information on the above labelling requirements shall be given either on the container or in accompanying documents, except that the name of the food, lot identification and the name and address of the manufacturer or packer shall appear on the container.

However, lot identification and the name and address of the manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

7.3 Other labelling requirements

For fish liver oils (Sections 2.3 and 2.4, only applicable if naturally present or restored) the content in vitamin A and vitamin D [*may*] be given.

For concentrated fish oils (Section 2.5.) the content of DHA and EPA shall be given.

8 Methods of Analysis and Sampling

8.1 Determination of fatty acid composition

According to applicable ISO methods including ISO:5508:1990 (Animal and vegetable fats and oils -- Analysis by gas chromatography of methyl esters of fatty acids) or AOCS methods including Ce 1b-89 (Fatty acid composition of Marine Oils by GLC), Ce 1j-07 (Determination of cis-, trans-, Saturated, Monounsaturated, and Polyunsaturated Fatty Acids in Extracted Fats by Capillary GLC), Ce 2b-11 (Direct Methylation of Lipids in Foods by Alkali Hydrolysis), Ce 1-62 (Fatty Acid Composition by Packed Column Gas Chromatography) and Ce 2-66 (Preparation of Methyl Esters of Fatty Acids).

8.2 Determination of arsenic

According to AOAC 952.13 (Silver Diethyldithiocarbamate Method); AOAC 942.17 (Molybdenum Blue); or AOAC 986.15 (Spectroscopy/Atomic Absorption Spectroscopy).

8.3 Determination of lead

According to AOAC 994.02 (Atomic Absorption Spectroscopy); or ISO 12193:2004 (Animal and vegetable fats and oils -- Determination of lead by direct graphite furnace atomic absorption spectroscopy); or AOCS Ca 18c-91 (Determination of Lead by Direct Graphite Furnace Atomic Absorption Spectrophotometry).

8.4 Determination of acid value

According to AOCS Ca 5a-40 (Free Fatty Acids), AOAC 2000 Cd 3a-63 (Acid Value), AOCS Cd 3d-63 (Acid Value); ISO 660:2009 (Animal and vegetable fats and oils -- Determination of acid value and acidity); European Pharmacopoeia 2.5.1 (Acid value)

8.5 Determination of peroxide value

According to AOCS CD 8b-90 (Peroxide Value Acetic Acid-Isooctane Method); ISO 3960:2007 (Animal and vegetable fats and oils -- Determination of peroxide value -- Iodometric (visual) endpoint determination); European Pharmacopoeia 2.5.5 (Peroxide value).

8.6 [Determination of p-anisidine value

AOCS Cd 18 - 90 (11)

8.7 Determination of oligomers

Information missing]

8.8 Determination of vitamin A

PhEur 2.2.29 liquid chromatography, monograph Cod liver oil (type A)

8.9 Determination of vitamin D

PhEur 2.2.29 liquid chromatography, monograph Cod liver oil (type A)

Table 1: Fatty acid (FA) composition of named fish oil and fish liver oil categories as determined by gas liquid chromatography from authentic samples (expressed as percentage of total fatty acids) (see Section 3.1 of the Standard)

Fatty acids	Anchovy	Sardine	Wild Salmon	Farmed Salmon	Jack Mackerel	Menhaden
C14:0 myristic acid	5.0-11.5	4.0-21.5	2.0-4.5	2.5-5.5	4.5-9.0	6.5-12.5
C15:0 pentadecanoic acid	ND-1.5	ND-1.5	ND-1.0	ND-0.5	ND-1.0	ND-1.5
C16:0 palmitic acid	14.0-22.0	9.0-25.5	12.0-13.5	7.0-16.5	12.5-22.0	14.0-23.0
C16:1 (n-7) palmitoleic acid	5.0-12.0	5.5-17.5	4.5-5.0	3.0-8.0	4.5-9.0	7.5-15.5
C17:0 heptadecanoic acid	ND-2.0	ND-1.5	ND-1.0	ND-0.5	ND-1.5	ND-2.5
C18:0 stearic acid	1.0-7.0	1.5-9.0	2.5-5.0	2.0-5.0	1.5-5.5	2.5-4.5
C18:1 (n-7) vaccenic acid	na	na	na	na	na	na
C18:1 (n-9) oleic acid	5.0-17.0	4.0-17.5	16.0-17.5	16.0-40.0	6.0-21.0	3.5-16.0
C18:2 (n-6) linoleic acid	ND-3.5	0.2-4.5	1.5-2.0	2.5-11.0	0.5-2.0	0.5-2.0
C18:3 (n-3) linolenic acid	ND-7.0	ND-3.0	11.5-14.0	0.5-6.0	ND-1.0	ND-2.0
C18:3 (n-6) γ -linolenic acid	ND-5.0	ND-1.0	5.0-5.5	ND-0.5	1.0-2.5	ND-1.0
C18:4 (n-3) stearidonic acid	ND-5.0	ND-3.5	2.0-2.5	0.5-1.5	1.0-5.0	1.5-5.0
C20:0 arachidic acid	na	0.2-1.5	na	na	na	na
C20:1 (n-9) eicosenoic acid	ND-4.0	ND-2.5	4.5-6.0	1.5-7.0	2.0-2.5	0.5-2.0
C20:1 (n-11) eicosenoic acid	ND-4.0	3.0-4.0		0.5-7.0		0.5-2.0
C20:4 (n-6) arachidonic acid	ND-2.0	ND-3.0	5.0-5.5	ND-1.0	0.5-1.5	0.5-4.0
C20:4 (n-3) eicosatetraenoic acid	ND-2.0	ND-1.0	14.0-16.5	0.5-2.0	0.5-1.0	0.5-2.5
C20:5 (n-3) eicosapentaenoic acid	5.0-26.0	8.0-25.0	8.5-9.5	6.0-9.0	5.0-24.0	11.0-18.5
C21:5 (n-3) heneicosapentaenoic acid	ND-4.0	ND-1.0	ND-1.0	ND-1.0	ND-0.5	0.5-1.0
C22:0 docosanoic acid	na	0.44	na	na	na	na
C22:1 (n-9) erucic acid	ND-5.0	ND-4.5	4.0-6.0	ND-4.0	ND-1.0	ND-0.5
C22:1 (n-11) cetoleic acid	ND-5.0	ND-4.1		0.5-7.0		ND-0.5
C22:5 (n-3) docosapentaenoic acid	ND-4.0	0.5-4.0	2.5-3.0	1.5-5.0	0.5-3.5	1.5-4.0
C22:6 (n-3) docosahexaenoic acid	4.0-23.0	2.5-15.5	10.5-11.0	3.0-14.5	5.5-23.0	4.0-14.5
Phospholipid fraction	na	na	na	na	na	na

na = not available

ND = non-detect, defined as $\leq 0.05\%$

(Table 1 continued)

Fatty acids	Tuna	Krill	Squid	Pollock	Herring	Capelin
C14:0 myristic acid	2.0-5.0	ND-9.5	1.0-6.0	4.0-5.5	3.0-10.0	5.0-8.5
C15:0 pentadecanoic acid	ND-2.0	ND-0.3	ND-1.0	ND-0.5	ND-0.5	ND-0.5
C16:0 palmitic acid	14.0-24.0	6.0-18.5	10.0-20.0	8.0-11.0	8.0-25.0	8.0-13.0
C16:1 (n-7) palmitoleic acid	1.0-12.5	ND-5.5	1.0-8.0	9.0-12.0	3.5-12.0	5.0-12.5
C17:0 heptadecanoic acid	1.0-3.0	ND-2.0	ND-1.0	ND-1.0	ND-0.5	na
C18:0 stearic acid	1.0-7.5	0.5-2.0	1.0-6.0	1.0-2.0	0.5-4.0	0.5-2.0
C18:1 (n-7) vaccenic acid	2.0 – 7.0	na	na	na	na	na
C18:1 (n-9) oleic acid	10.0-25.0	2.5-11.0	6.0-25.0	7.0-13.5	4.0-22.0	12.0-18.0
C18:2 (n-6) linoleic acid	ND-3.0	ND-2.0	ND-2.0	0.5-1.5	ND-2.0	1.0-2.0
C18:3 (n-3) linolenic acid	ND-2.0	ND-1.5	ND-2.0	ND-0.5	ND-2.0	0.5-1.0
C18:3 (n-6) γ -linolenic acid	ND-4.0	ND-0.5	ND-1.0	ND-0.5	ND-2.0	na
C18:4 (n-3) stearidonic acid	ND-2.0	ND-3.5	ND-3.0	1.0-2.0	0.5-5.0	2.0-7.0
C20:0 arachidic acid	ND-2.5	na	na	na	na	na
C20:1 (n-9) eicosenoic acid	ND-2.5	ND-3.5	ND-7.0	4.0-5.5	8.5-14.0	15.0-20.0
C20:1 (n-11) eicosenoic acid	ND-3.0	ND	ND-13.0	10.0-16.0	na	na
C20:4 (n-6) arachidonic acid	ND-3.0	ND-1.5	ND-3.0	na	ND-0.5	ND-0.5
C20:4 (n-3) eicosatetraenoic acid	ND-1.0	ND-1.0	ND-2.0	0.3-0.5	ND-1.5	ND-1.0
C20:5 (n-3) eicosapentaenoic acid	2.5-9.0	> 9.0	7.0-15.0	9.5-11.0	4.0-15.0	4.0-9.0
C21:5 (n-3) heneicosapentaenoic acid	ND-0.5	ND-2.0	ND-1.0	na	ND-1.0	ND-1.0
C22:0 docosanoic acid	na	na	na	na	na	na
C22:1 (n-9) erucic acid	ND-1.0	ND-2.0	ND-3.0	0.5-1.5	na	na
C22:1 (n-11) cetoleic acid	ND-1.0	ND-2.0	2.0-10.0	11.5-15.5	11.0-27.0	13.0-20.0
C22:5 (n-3) docosapentaenoic acid	ND-3.0	ND-2.5	0.5-3.0	0.5-1.0	ND-1.5	ND-1.0
C22:6 (n-3) docosahexaenoic acid	21.0-42.5	> 4.0	12.5-34.5	4.5-5.5	2.0-12.0	2.5-11.0
Phospholipid fraction	na	> 30.0	na	na	na	na

na = not available

ND = non-detect, defined as $\leq 0.05\%$

(Table 1 continued)

Fatty acids	Sand Eel	Cod Liver	Calanus
C14:0 myristic acid	5.5-8.5	2.0-6.0	13.0-19.0
C15:0 pentadecanoic acid	ND-1.0	ND-0.5	0.6-1.0
C16:0 palmitic acid	10.5-19.0	4.0-14.0	7.8-11.3
C16:1 (n-7) palmitoleic acid	5.0-10.0	4.5-11.5	2.0-6.1
C17:0 heptadecanoic acid	ND-0.5	na	0.3-0.5
C18:0 stearic acid	0.5-3.0	1.0-4.0	0.6-0.9
C18:1 (n-7) vaccenic acid	na	2.0 – 7.0	na
C18:1 (n-9) oleic acid	5.5-12.0	12.0-21.0	2.3-4.5
C18:2 (n-6) linoleic acid	0.5-3.5	0.5-3.0	0.8-1.6
C18:3 (n-3) linolenic acid	0.5-1.5	ND-2.0	1.4-3.7
C18:3 (n-6) γ -linolenic acid	na	na	0.6-1.0
C18:4 (n-3) stearidonic acid	2.5-5.5	0.5-4.5	11.3-18.5
C20:0 arachidic acid	na	na	na
C20:1 (n-9) eicosenoic acid	10.0-14.5	1.0-17.0	3.2-5.5
C20:1 (n-11) eicosenoic acid	na	1.0-5.5	1.1-12.5
C20:4 (n-6) arachidonic acid	ND-0.5	ND-1.5	ND-2.5
C20:4 (n-3) eicosatetraenoic acid	ND-1.0	ND-2.0	1.0-1.6
C20:5 (n-3) eicosapentaenoic acid	7.0-11.0	7.0-16.0	8.4-14.5
C21:5 (n-3) heneicosapentaenoic acid	ND-1.0	ND-1.5	0.5-2.5
C22:0 docosanoic acid	na	na	na
C22:1 (n-9) erucic acid	na	ND-1.5	ND-0.5
C22:1 (n-11) cetoleic acid	14.5-18.0	5.0-12.0	7.0-10.8
C22:5 (n-3) docosapentaenoic acid	ND-1.0	0.5-3.0	0.5-0.9
C22:6 (n-3) docosahexaenoic acid	6.5-14.0	5.0-18.0	7.1-10.1
Phospholipid fraction	na	na	na

na = not available

ND = non-detect, defined as $\leq 0.05\%$