Fatty Acid Composition of Thirty-Five Icelandic Fish Species

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Fat content and fatty acid composition were determined in 35 fish species caught in Icelandic waters from November 1987 to March 1988. These were not only commonly edible species, but also underutilized and less common species, in which the fatty acid composition have not been reported before. The variation in the fat content and the fatty acid composition was found to be large between and within species. The fat content and n-3 fatty acid content varies sevenfold and twentyfold, respectively. An inverse relationship was obtained between the n-3 fatty acids content and the total fat content of the fish species studied. We believe that the data reported here on 35 fish species can be useful for nutritionists and food scientists, to aid them in dietary formulation, nutrient labelling, processing and product developments, as well as for the consumers.

KEY WORDS: Fat content, fatty acid composition, fish, n-3 fatty acids.

Nutritional importance of fish consumption is associated largely with the n-3 fatty acid content (1). Therefore, the fat content and fatty acid composition is important when utilization of new species is considered. Fish can be grouped into four categories according to the lipid content: lean fish (>2%), low-fat (2–4%), medium-fat (4–8%) and high-fat (<8%) fish (1). The lipid content and the fatty acid composition of fish is not only different between species but also highly variable from fish to fish within the same species. Environmental factors (such as diet, season and temperature) as well as biological differences (such as age, sex and size) are known to affect the fatty acid composition (2–4). In turn, the diet of fish varies sometimes to a great extent, with the geographic area in which the fish live, with the season of the year and even within the same season and the same waters from one year to another. Consequently, the variation in fat content and fatty acid composition of fish can be enormous. In the northern waters where the environmental sea temperature is generally low, fish may require more highly unsaturated molecules in important lipids (5,6).

The need for thorough and reliable data on the proximate fat content and fatty acid composition of food, especially fish, is expressed throughout the literature (3–5,7). These data are needed by nutritionists and food scientists to aid them in dietary formulation, nutrient labelling, processing and product developments (1). Fatty acid composition data in the literature are limited (3–5,7), although some information has been published (2,3,8–10). No information is available on these matters on seafood from waters around Iceland. The objective of this project was to collect information on fatty acid composition of fish caught in the sea around Iceland.

MATERIALS AND METHODS

Fish samples were obtained from different areas around Iceland from November 1987 to March 1988. The samples were collected by the Marine Research Institute of Iceland (Reykjavik, Iceland) and Lysi Ltd. (Reykjavik, Iceland) and stored frozen at −21°C until analyzed. The fishing areas and dates were reported. The fish were thawed overnight before extracting the lipid. Length, weight and sex of individual fish were registered. In most cases, samples from individual fish were analyzed, and the results were pooled and presented as a mean and standard deviation (±SD). The fish were filleted, with the exception of Capelin, which was used as is, and also for Norway pout, from which the fillets were analyzed with the skin. The lipids were extracted by the method of Folch *et al.* (11) with minor modifications, and they are transesterified according to the method of Morrison and Smith (12). The fatty acid analysis was carried out with a capillary gas chromatograph (GC) (Perkin Elmer 8310, Norwalk, CT) fitted with a Durabond 225-30N fused-silica column, dimension 30 m × 0.25 μm (J&W Scientific. Inc., Folsom, CA). The nitrogen carrier gas flow was set at 100 KPa with split ratio of 1:100. The following temperature program was used: Initial temperature was 180°C, increased at 3°C/min to 210°C and finally set isothermally for 15 min. Injector temperature and the flame-ionization detector temperature were set at 225°C. The normalizing method was used to calculate the peak area percent of total area of the fatty acids. Peaks were identified by comparing the retention times with those of a mixture of standard methyl esters.

RESULTS AND DISCUSSION

Table 1 presents 35 different fish species caught in the waters around Iceland from November 1987 to March 1988 that were analyzed for fat content and fatty acid composition. In addition, squid (cephalopoda) was included in the survey. There are not only commonly edible species, like cod and haddock, but also underutilized and less common species, such as shark, torsk and jelly cat.

The fat content and fatty acid composition of the 35 fish species plus squid are summarized in Table 2. This information is, in general, in agreement with the data available on the fatty acid composition of the fish species in the literature (1,3–5,7,9,10,13). However, data are only available for part of the fish species presented here. The variation in the fat content and fatty acid composition was found to be large within the same species, especially when the number of samples increases. Fat content of muscles varies from 0.8% for greater lantern shark to 18.6% for salmon (Table 2). The fatty acid composition varies as well. For example, docosahexaenoic acid (DHA) varies from 2.3% for orange roughy to 32.8% for Norway pout of total fatty acids. The n-3 fatty acid composition varies from 7.2% for mouse catshark to 49.7% for Norway pout, and 22:1 varies from 1.0% for four-beard rackling to 15.3% for herring. Fatty acid pattern of capelin is presented separately for male and female (Table 2). There were no significant differences between male and female origin ($P > 0.05$).

The correlation of the n-3 fatty acid as percent of total fatty acids *vs.* the fat content can be seen in Figure 1.

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TABLE 1

Latin and English Name of the Fish Species Caught in Icelandic Waters and Evaluated for Analysis

Species	Latin name	Species	Latin name
Angler	*Lophius piscatorius*	Large-eyed rabbitfish	*Hydrolagus mirabilis*
Bentnose rabbitfish	*Harriotta raleighana*	Lemmon sole	*Microstomus kitt*
Birdbeak dogfish	*Deania calceus*	Mouse catshark	*Galeus murinus*
Blueling	*Molva dyperygia*	Norway pout	*Trisopterus esmarki*
Capelin	*Mallotus villosus*	Orange roughy	*Hoplostethus atlanticus*
Catfish	*Anarhichas lupus*	Portugese shark	*Centrosymnus coclolpis*
Cod	*Gadus morhua*	Rabbit fish	*Chimaera mostrosa*
Deepwater chimaera	*Hydrolagus affinis*	Redfish	*Sebastes marinus*
Esmark eelpot	*Lycodes esmarki*	Rough dab	*Hippoglossoides platessoides*
Father lasher	*Myoxocephalus. scorpous*	Salmon	*Salmo salar*
Four-beard rackling	*Rhinonemus cimbrius*	Scabbard-fish	*Lepidorus caudatus*
Greater lantern shark	*Etmopterus princeps*	Spine eel	*Notacanthus chemnitizii*
Greater silver smelt	*Argentina silus*	Spotted catfish	*Anarhichas minor*
Greenland halibut	*Reinhardtius hippoglossoides*	Starry ray	*Raja radiata*
Haddock	*Melanogrammus aeglefinus*	Torsk	*Brosme brosme*
Herring	*Clupea harengus*	Vahl's eelpot	*Lycodes vakli gracilis*
Jelly cat	*Anarhihas denticulatus*	Whiting	*Merlangius merlangus*
Knifenose chimaera	*Rhinochimaera atlantica*		

TABLE 2

Representative Fat Content and Total Fatty Acids Profiles in Muscle of Fish Species Caught in Icelandic Waters and Evaluated for Analysis

Species	Spine eel *(Notacanthus chemnitizii)*	Greater lantern shark *(Etomopterus princeps)*	Knifenose chimaera *(Rhiniochimae atlantica)*	Rabbitfish *(Chimacra mostrosa)*	Portugese shark *(Centrosymnus coclolepis)*	Scabbard fish *(Lepidorus caudatus)*
Fat content (%)	11.0 ± 4.1	0.8 ± 0.1	1.4 ± 0.8	1.3 ± 0.4	1.4 ± 0.6	0.9 ± 0.2
No. of samples[a]	4	2	3	4	2	2
Fatty acids						
14:0[b]	3.0 ± 1.1	1.2 ± 0.3	0.9 ± 0.1	0.7 ± 0.3	0.7 ± 0.1	3.0 ± 0.9
Pristanic[c]	0.4 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	0.2 ± 0.1	0.2 ± 0.1	0.3 ± 0.1
16:0	13.7 ± 1.7	16.9 ± 1.6	18.2 ± 1.1	18.0 ± 1.1	16.9 ± 0.8	13.7 ± 1.1
16:1n-7[d]	4.4 ± 1.6	1.9 ± 0.3	2.4 ± 0.1	1.9 ± 0.6	2.6 ± 0.4	3.8 ± 1.3
16:0me-7[e]	n.d.	n.d.	n.d.	0.6 ± 0.0	n.d.	n.d.
16:2n-6	0.8 ± 0.2	0.5 ± 0.1	0.4 ± 0.1	0.5 ± 0.1	0.9 ± 0.0	0.4 ± 0.1
16:2n-4	0.3 ± 0.1	n.d.	0.1 ± 0.0	0.2 ± 0.1	n.d.	0.2 ± 0.1
Phytanic[f]	0.9 ± 0.4	0.2 ± 0.0	0.1 ± 0.0	0.2 ± 0.1	0.4 ± 0.0	0.2 ± 0.1
16:3n-4	0.3 ± 0.2	0.4 ± 0.0	0.6 ± 0.1	0.9 ± 0.5	0.7 ± 0.2	0.5 ± 0.1
16:4n-1	0.3 ± 0.0	n.d.	n.d.	0.2 ± 0.0	n.d.	n.d.
180	1.0 ± 0.0	4.4 ± 0.8	4.2 ± 0.1	5.5 ± 0.3	4.9 ± 0.3	3.0 ± 0.6
18:1n-9	18.9 ± 6.2	14.6 ± 0.7	16.8 ± 1.3	13.9 ± 5.2	17.4 ± 1.3	21.9 ± 5.7
18:1n-7	n.d.	n.d.	n.d.	3.4 ± 0.2	n.d.	n.d.
18:1n-5	n.d.	n.d.	n.d.	0.8 ± 0.1	n.d.	n.d.
18:2n-6	0.8 ± 0.2	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.2	1.1 ± 0.1	1.0 ± 0.1
18:2n-4	0.3 ± 0.1	n.d.	0.3 ± 0.1	0.3 ± 0.1	0.7 ± 0.0	n.d.
18:3n-6	n.d.	n.d.	n.d.	0.0 ± 0.0	n.d.	n.d.
18:3n-3	0.8 ± 0.2	0.2 ± 0.0	0.3 ± 0.1	0.4 ± 0.1	0.4 ± 0.0	0.5 ± 0.1
18:4n-3	1.1 ± 0.4	0.3 ± 0.1	0.5 ± 0.1	0.5 ± 0.2	0.7 ± 0.1	0.6 ± 0.1
20:0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
20:1n-9	19.4 ± 3.4	4.2 ± 0.6	4.2 ± 0.5	2.4 ± 0.8	4.7 ± 1.6	8.8 ± 0.4
20:2	0.7 ± 0.2	0.2 ± 0.0	0.5 ± 0.3	0.4 ± 0.1	0.4 ± 0.1	0.3 ± 0.1
20:3	0.3 ± 0.1	n.d.	n.d.	n.d.	n.d.	0.2 ± 0.1
20:4n-6	2.1 ± 0.4	2.8 ± 0.0	4.2 ± 2.8	4.0 ± 0.4	4.3 ± 0.8	1.1 ± 0.7
20:4n-3	0.6 ± 0.2	0.3 ± 0.3	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.7 ± 0.2
22:1n-11/9[g]	13.4 ± 4.1	4.5 ± 0.3	2.8 ± 1.0	1.3 ± 0.4	2.3 ± 0.1	9.8 ± 0.8
20:5n-3	5.3 ± 1.6	3.4 ± 0.4	6.9 ± 1.7	4.9 ± 0.9	2.2 ± 0.0	4.2 ± 0.4
22:2n-6	n.d.	n.d.	1.7 ± 0.1	0.1 ± 0.1	0.6 ± 0.1	2.5 ± 0.1
22:5n-3	n.d.	n.d.	n.d.	3.8 ± 0.6	n.d.	n.d.
22:6n-3	5.4 ± 2.7	29.7 ± 2.8	25.9 ± 4.5	29.1 ± 2.8	27.7 ± 4.8	14.6 ± 5.7
24:1	n.d.	0.9 ± 0.4	0.5 ± 0.3	0.1 ± 0.1	1.2 ± 1.5	1.3 ± 0.7
Other	6.7 ± 1.1	12.6 ± 5.8	8.6 ± 0.8	4.9 ± 3.5	10.0 ± 0.9	8.1 ± 4.0

(Continued)

TABLE 2 (Continued)

Species	Bentnose rabbitfish *(Harriotta raleighana)*	Large-eyed rabbitfish *(Hydrolagus mirabilis)*	Orange roughy *(Hoplostethus atlanticus)*	Mouse catshark *(Galeus murinus)*	Birdbeak dogfish *(Deania calceus)*	Deepwater chimaera *(Hydrolagus affinis)*	Father lasher *(Myoxocephalus scorpius)*
Fat content (%)	1.0	1.3	7.5	2.1	1.2	0.9	1.0
No. of samples	1	1	1	1	1	1	2
Fatty acids							
14:0	0.8	0.9	1.0	1.6	0.6	0.7	4.6
Pristanic	n.d.	0.2	n.d.	0.2	0.1	0.1	0.4
16:0	18.5	16.6	2.7	14.5	12.5	18.0	14.3
16:1n-7	1.9	2.4	7.2	7.1	2.3	2.2	4.4
16:0me-7	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
16:2n-6	0.4	0.5	n.d.	0.3	0.6	0.4	0.4
16:2n-4	0.0	0.2	n.d.	0.3	0.3	0.2	n.d.
Phytanic	0.1	0.2	0.4	0.3	0.2	0.1	n.d.
16:3n-4	0.3	0.7	0.5	1.1	0.4	0.7	n.d.
16:4n-1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
180	4.6	5.0	1.0	3.8	4.5	5.0	4.7
18:1n-9	14.3	17.4	34.1	28.3	16.8	20.8	13.9
18:1n-7	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	5.0
18:1n-5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.2
18:2n-6	0.9	0.7	1.0	0.8	1.8	1.0	1.2
18:2n-4	n.d.	0.1	0.3	0.2	n.d.	n.d.	0.0
18:3n-6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.8
18:3n-3	0.2	0.3	0.7	0.2	0.3	0.3	0.5
18:4n-3	0.5	0.4	0.6	0.8	0.6	0.6	0.4
20:0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
20:1n-9	3.5	3.5	26.8	15.9	5.7	3.9	7.4
20:2	0.1	0.5	1.2	0.7	0.4	0.4	0.8
20:3	n.d.	n.d.	0.1	n.d.	n.d.	n.d.	1.4
20:4n-6	2.8	4.4	0.2	0.6	3.3	4.6	n.d.
20:4n-3	0.3	n.d.	0.1	0.5	n.d.	n.d.	0.4
22:1n-11/9	1.9	3.0	13.6	10.3	5.9	2.2	2.4
20:5n-3	7.7	3.6	1.0	1.3	1.2	5.0	8.4
22:2n-6	0.8	1.1	2.9	n.d.	n.d.	n.d.	0.5
22:5n-3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.7
22:6n-3	31.1	29.5	2.3	4.9	30.1	28.8	11.5
24:1	1.1	0.5	0.5	1.5	0.2	n.d.	0.7
Other	8.2	8.3	1.8	4.8	12.2	5.0	13.0

Species	Salmon *(Salmo salar)*	Squid	Blueling *(Molva dyperygia)*	Whiting *(Merlangius merlangus)*	Angler *(Lophius piscatorius)*	Starry ray *(Raja radiata)*
Fat contents (%)	18.6	1.9	1.4	1.3	1.1	1.2 ± 0.7
No. of samples	2	2	1	1	1	8
Fatty acids						
14:0	5.3	1.2	2.3	4.6	0.8	1.3 ± 0.4
Pristanic	n.d.	0.4	0.3	0.3	0.2	0.4 ± 0.2
16:0	13.6	18.9	16.2	16.9	11.5	19.7 ± 1.3
16:1n-7	7.6	0.5	3.9	3.1	1.6	2.6 ± 0.9
16:0me-7	n.d.	0.2	0.3	n.d.	n.d.	0.3 ± 0.2
16:2n-6	n.d.	0.3	0.3	0.3	0.3	0.3 ± 0.0
16:2n-4	n.d.	0.0	0.3	0.3	0.2	0.2 ± 0.1
Phytanic	n.d.	0.8	0.2	0.1	0.2	0.1 ± 0.1
16:3n-4	n.d.	0.3	0.5	0.3	0.6	0.4 ± 0.1
16:4n-1	n.d.	0.3	0.2	0.4	n.d.	0.1 ± 0.1
180	2.4	4.9	3.2	2.5	4.1	4.6 ± 0.8
18:1n-9	18.6	2.2	10.3	10.9	10.2	9.3 ± 2.1
18:1n-7	3.6	1.0	2.5	n.d.	n.d.	5.8 ± 0.6
18:1n-5	0.7	0.3	0.5	n.d.	n.d.	0.5 ± 0.1
18:2n-6	3.4	0.6	1.0	1.0	1.2	1.6 ± 0.1
18:2n-4	0.4	0.3	0.2	0.2	0.7	0.0 ± 0.1
18:3n-6	0.9	n.d.	n.d.	n.d.	n.d.	0.1 ± 0.1
18:3n-3	n.d.	0.2	0.5	0.5	0.8	0.4 ± 0.1
18:4n-3	1.3	0.6	0.9	1.1	0.6	0.4 ± 0.3
20:0	n.d.	n.d.	n.d.	n.d.	n.d.	0.0 ± 0.0
20:1n-9	11.4	6.1	7.9	6.1	3.9	2.5 ± 0.8

(Continued)

TABLE 2 (Continued)

Species	Salmon *(Salmo salar)*	Squid	Blueling *(Molva dyperygia)*	Whiting *(Merlangius merlangus)*	Angler *(Lophius piscatorius)*	Starry ray *(Raja radiata)*
20:2	0.5	0.4	0.6	0.2	n.d.	0.4 ± 0.1
20:3	n.d.	0.9	n.d.	n.d.	n.d.	0.0 ± 0.0
20:4n-6	0.3	1.2	0.2	0.8	5.1	2.7 ± 0.5
20:4n-3	0.9	0.4	0.5	0.3	n.d.	0.4 ± 0.2
22:1n-11/9	7.3	12.9	3.8	6.4	3.4	0.6 ± 0.8
20:5n-3	3.8	2.2	7.8	9.3	6.7	6.6 ± 1.4
22:2n-6	n.d.	0.3	0.2	n.d.	1.4	0.2 ± 0.1
22:5n-3	1.4	0.4	1.2	n.d.	n.d.	2.1 ± 0.6
22:6n-3	5.1	31.4	25.2	29.6	24.7	26.2 ± 2.0
24:1	n.d.	0.2	1.0	n.d.	n.d.	0.3 ± 0.2
Other	11.5	10.6	8.0	4.8	21.8	10.0 ± 3.4

Species	Cod *(Gadus morhua)*	Haddock *(Melanogrammus aegletinus)*	Catfish *(Anarhichas lupus)*	Spotted catfish *(Anarhichas minor)*	Herring *(Clupea harengus)*	Redfish *(Sebastes marinus)*
Fat contents (%)	1.1 ± 0.2	1.1 ± 0.3	3.3 ± 0.2	6.3 ± 2.3	11.9 ± 4.8	3.9 ± 1.6
No. of samples	5	15	6	5	35	40
Fatty acids						
14:0	1.9 ± 0.4	1.2 ± 0.8	3.1 ± 0.7	4.1 ± 0.7	7.5 ± 1.1	5.0 ± 0.6
Pristanic	0.3 ± 0.0	0.3 ± 0.1	0.5 ± 0.1	0.4 ± 0.1	0.5 ± 0.1	0.5 ± 0.1
16:0	18.2 ± 1.0	15.6 ± 1.4	12.9 ± 2.0	10.9 ± 0.5	16.2 ± 2.8	14.9 ± 1.6
16:1n-7	3.1 ± 0.8	1.4 ± 0.7	4.9 ± 0.9	7.3 ± 1.5	6.2 ± 1.3	5.7 ± 1.3
16:0me-7	0.3 ± 0.0	0.4 ± 0.0	0.1 ± 0.2	0.3 ± 0.0	0.3 ± 0.1	0.3 ± 0.1
16:2n-6	0.3 ± 0.1	0.4 ± 0.1	0.8 ± 0.7	0.7 ± 0.1	0.4 ± 0.2	0.4 ± 0.1
16:2n-4	0.2 ± 0.0	0.2 ± 0.1	0.3 ± 0.4	0.4 ± 0.1	0.6 ± 0.1	0.5 ± 0.1
Phytanic	0.2 ± 0.1	0.2 ± 0.0	0.2 ± 0.2	0.4 ± 0.1	0.2 ± 0.2	0.1 ± 0.1
16:3n-4	0.2 ± 0.3	0.4 ± 0.1	0.8 ± 0.3	0.7 ± 0.1	0.4 ± 0.2	0.5 ± 0.3
16:4n-1	n.d.	0.2 ± 0.1	0.4 ± 0.6	0.1 ± 0.1	0.6 ± 0.2	0.4 ± 0.1
180	3.2 ± 0.3	4.0 ± 0.4	4.2 ± 1.4	3.1 ± 0.3	1.4 ± 0.3	3.1 ± 0.4
18:1n-9	9.5 ± 0.9	6.7 ± 1.3	9.3 ± 2.4	20.6 ± 4.0	14.2 ± 4.1	14.1 ± 2.2
18:1n-7	3.4 ± 0.2	4.8 ± 1.3	4.2 ± 1.4	n.d.	3.3 ± 1.5	4.2 ± 1.2
18:1n-5	0.4 ± 0.1	0.3 ± 0.1	0.5 ± 0.4	1.3 ± 0.2	0.4 ± 0.3	0.5 ± 0.1
18:2n-6	1.0 ± 0.0	0.8 ± 0.1	1.2 ± 0.3	1.1 ± 0.2	1.2 ± 0.2	1.5 ± 0.2
18:2n-4	n.d.	0.3 ± 0.1	0.5 ± 0.4	0.3 ± 0.1	0.1 ± 0.1	0.2 ± 0.1
18:3n-6	0.1 ± 0.1	0.2 ± 0.2	n.d.	n.d.	0.3 ± 0.4	0.1 ± 0.1
18:3n-3	0.4 ± 0.1	0.4 ± 0.2	1.2 ± 0.8	1.1 ± 0.2	0.9 ± 0.2	1.6 ± 0.4
18:4n-3	0.8 ± 0.2	0.7 ± 0.4	2.1 ± 2.1	0.9 ± 0.3	1.8 ± 0.4	1.6 ± 0.4
20:0	n.d.	n.d.	n.d.	n.d.	0.1 ± 0.1	n.d.
20:1n-9	4.2 ± 0.8	0.5 ± 0.2	0.8 ± 0.4	1.2 ± 0.4	0.3 ± 0.3	0.3 ± 0.1
20:2	n.d.	0.4 ± 0.4	0.4 ± 0.4	n.d. ± 0.0	0.2 ± 0.2	0.3 ± 0.2
20:4n-6	1.1 ± 0.1	2.9 ± 1.1	3.6 ± 0.8	1.8 ± 0.8	0.4 ± 0.1	0.7 ± 0.2
20:4n-3	0.4 ± 0.0	0.4 ± 0.1	0.5 ± 0.3	0.4 ± 0.0	0.4 ± 0.1	0.5 ± 0.1
22:1n-11/9	1.8 ± 0.4	1.2 ± 0.5	3.1 ± 1.8	4.4 ± 1.4	15.3 ± 6.3	8.2 ± 2.4
20:5n-3	15.1 ± 0.7	12.4 ± 2.9	11.2 ± 1.2	11.0 ± 2.0	5.6 ± 1.1	7.8 ± 1.5
22:2n-6	0.3 ± 0.0	0.9 ± 0.5	0.4 ± 0.5	0.3 ± 0.1	0.2 ± 0.1	0.4 ± 0.1
22:5n-3	0.8 ± 0.1	1.9 ± 0.5	1.0 ± 0.6	0.8 ± 0.1	0.4 ± 0.1	0.7 ± 0.3
22:6n-3	28.0 ± 2.3	27.8 ± 8.4	9.2 ± 1.6	5.5 ± 1.5	6.8 ± 1.4	11.9 ± 3.1
24:1	n.d.	0.7 ± 0.4	0.5 ± 0.3	0.3 ± 0.1	0.4 ± 0.2	0.6 ± 0.2
Other	4.4 ± 0.9	10.6 ± 1.0	13.6 ± 2.6	9.8 ± 5.3	3.2 ± 1.7	5.5 ± 2.4

Species	Capelin male *(Mallotus villosus)*	Capelin female *(Mallotus villosus)*	Lemmon sole *(Microstomus kitt)*	Rough dab *(Hippoglossoides platessoides)*	Torsk *(Brosme brosme)*
Fat contents (%)	13.5 ± 3.4	15.3 ± 5.3	1.7 ± 0.8	2.4 ± 0.5	1.0 ± 0.2
No. of samples	9	9	3	5	6
Fatty acids					
14:0	6.9 ± 0.5	7.1 ± 0.7	2.3 ± 0.4	4.2 ± 0.5	1.3 ± 0.2
Pristanic	0.3 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.2 ± 0.0	0.2 ± 0.1
16:0	13.4 ± 0.9	13.4 ± 0.9	14.3 ± 1.6	12.0 ± 0.4	17.7 ± 1.5
16:1n-7	10.7 ± 0.9	10.9 ± 1.1	3.7 ± 0.2	7.7 ± 1.0	2.4 ± 0.6
16:0me-7	0.4 ± 0.1	0.4 ± 0.0	n.d.	n.d.	0.2 ± 0.0
16:2n-6	0.4 ± 0.1	0.4 ± 0.0	0.6 ± 0.1	0.4 ± 0.1	0.2 ± 0.0

(Continued)

TABLE 2 (Continued)

Species	Capelin male *(Mallotus villosus)*	Capelin female *(Mallotus villosus)*	Lemmon sole *(Microstomus kitt)*	Rough dab *(Hippoglossoides platessoides)*	Torsk *(Brosme brosme)*
Fatty acids					
16:2n-6	0.4 ± 0.1	0.4 ± 0.0	0.6 ± 0.1	0.4 ± 0.1	0.2 ± 0.0
16:2n-4	0.6 ± 0.1	0.6 ± 0.1	0.4 ± 0.0	0.4 ± 0.0	0.2 ± 0.0
Phytanic	0.1 ± 0.2	0.1 ± 0.1	0.4 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
16:3n-4	0.2 ± 0.2	0.2 ± 0.1	0.5 ± 0.0	0.4 ± 0.0	0.6 ± 0.1
16:4n-1	0.9 ± 0.2	1.0 ± 0.3	0.2 ± 0.1	0.4 ± 0.0	0.0 ± 0.0
180	1.2 ± 0.2	1.1 ± 0.2	3.4 ± 0.8	1.7 ± 0.3	4.3 ± 0.4
18:1n-9	10.5 ± 1.8	10.2 ± 1.6	3.8 ± 0.4	17.6 ± 2.2	11.9 ± 1.2
18:1n-7	3.1 ± 0.3	2.7 ± 0.9	4.5 ± 0.6	n.d.	3.8 ± 0.3
18:1n-5	0.7 ± 0.2	0.7 ± 0.1	n.d.	n.d.	0.4 ± 0.1
18:2n-6	1.2 ± 0.3	1.1 ± 0.1	0.5 ± 0.0	1.1 ± 0.1	1.1 ± 0.1
18:2n-4	0.1 ± 0.1	0.1 ± 0.1	0.3 ± 0.1	0.2 ± 0.1	0.2 ± 0.2
18:3n-6	0.4 ± 0.2	0.2 ± 0.1	n.d. ± 0.0	0.6 ± 0.1	0.1 ± 0.1
18:3n-3	0.8 ± 0.6	0.7 ± 0.2	0.5 ± 0.1	0.6 ± 0.3	0.5 ± 0.2
18:4n-3	2.1 ± 0.3	2.2 ± 0.4	0.8 ± 0.3	1.3 ± 0.2	0.6 ± 0.2
20:0	n.d.	n.d.	n.d.	n.d.	0.0 ± 0.0
20:1n-9	12.9 ± 1.0	13.0 ± 1.2	3.9 ± 0.1	10.3 ± 0.9	3.6 ± 0.5
20:2	0.2 ± 0.2	0.2 ± 0.1	0.7 ± 0.1	0.3 ± 0.0	0.3 ± 0.0
20:3	0.2 ± 0.1	0.1 ± 0.1	0.6 ± 0.2	0.7 ± 0.3	n.d.
20:4n-6	0.2 ± 0.1	0.2 ± 0.1	3.4 ± 0.6	1.3 ± 0.2	1.6 ± 0.1
20:4n-3	0.4 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.5 ± 0.1	0.4 ± 0.1
22:1n-11/9	14.5 ± 2.5	15.0 ± 2.1	2.1 ± 0.3	3.5 ± 3.6	1.7 ± 0.8
20:5n-3	7.3 ± 0.9	7.7 ± 1.0	11.6 ± 0.8	10.0 ± 1.2	9.1 ± 0.8
22:2n-6	0.3 ± 0.1	0.3 ± 0.0	0.9 ± 0.0	0.9 ± 0.3	0.2 ± 0.1
22:5n-3	0.5 ± 0.1	0.5 ± 0.1	2.9 ± 0.2	1.2 ± 0.2	1.0 ± 0.1
22:6n-3	4.7 ± 0.4	4.9 ± 0.7	15.0 ± 4.9	11.9 ± 1.6	30.9 ± 1.4
24:1	0.5 ± 0.1	0.5 ± 0.1	0.8 ± 0.4	1.1 ± 0.2	0.6 ± 0.3
Other	4.4 ± 2.3	4.0 ± 1.9	21.7 ± 9.9	9.7 ± 3.8	10.5 ± 2.1

Species	Esmark eelpot *(Lycodes esmarki)*	Vahl's eelpot *(Lycodes vakli gracilis)*	Norway pout *(Trisopterus esmarki)*	Four-beard rackling *(Rhinonemus cimbrius)*	Jelly cat *(Anarhichas denticulatus)*	Greater silver smelt *(Argentina silus)*	Greenland halibut *(Reinhardtius hippoglossoides)*
Fat contents (%)	5.5 ± 0.6	1.2	1.7	1.1 ± 0.2	1.2	3.3 ± 0.2	13.1 ± 0.0
No. of samples	3	5	5	3	1	5	5
Fatty acids							
14:0	5.8 ± 1.0	2.0	1.5	1.1 ± 0.1	1.7	5.3 ± 0.6	5.1 ± 0.6
16:0	11.9 ± 0.2	13.9	17.2	16.8 ± 1.1	18.2	15.2 ± 1.4	21.1 ± 0.8
6:1n-7	11.6 ± 0.9	3.7	2.6	2.3 ± 1.1	4.7	4.6 ± 0.2	10.4 ± 1.7
18:0	2.7 ± 1.1	5.3	3.5	4.1 ± 0.0	4.2	2.3 ± 0.1	2.2 ± 0.9
18:1n-9/7/5	23.3 ± 0.4	14.0	14.6	13.5 ± 2.4	14.9	16.5 ± 0.7	14.9 ± 4.3
18:22n-6	1.1 ± 0.1	1.0	1.0	0.8 ± 0.0	1.0	1.4 ± 0.2	1.1 ± 0.4
18:3n-3	0.9 ± 0.1	0.8	0.5	0.6 ± 0.1	n.d.	1.2 ± 0.1	0.8 ± 0.3
18:4n-3	1.4 ± 0.1	0.7	0.8	0.3 ± 0.4	1.3	1.7 ± 0.3	1.8 ± 0.2
20:0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
20:1n-9	8.4 ± 0.8	5.5	3.2	3.5 ± 0.6	2.0	10.4 ± 0.9	11.0 ± 2.7
20:2	n.d.	n.d.	0.2	0.5 ± 0.3	n.d.	0.5 ± 0.3	0.3 ± 0.5
20:3	n.d.	n.d.	n.d.	0.8 ± 1.1	n.d.	0.2 ± 0.3	0.1 ± 0.2
22:1n-11/9	4.2 ± 0.8	1.7	2.0	1.0 ± 0.4	3.5	14.3 ± 1.4	9.0 ± 2.4
20:4n-6/3	1.1 ± 0.2	6.4	0.8	3.4 ± 0.1	3.1	n.d.	n.d.
20:5n-3	8.1 ± 0.1	12.3	14.4	10.8 ± 2.5	10.7	5.3 ± 0.1	6.5 ± 0.2
22:5n-3	0.9 ± 0.1	2.7	1.4	2.1 ± 0.1	1.8	0.9 ± 0.2	0.8 ± 0.2
22:6n-3	6.2 ± 1.5	14.7	32.8	28.7 ± 2.4	25.6	9.8 ± 1.4	5.7 ± 0.7
24:1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other	12.9 ± 2.1	15.3	3.5	10.0 ± 8.0	7.3	10.6 ± 1.7	18.2 ± 7.5

[a]Data are the mean of indicated number of samples.
[b]Ratio of carbon atoms to double bonds.
[c]2,6,10,14-Tetramethylpentadecanoic acid.
[d]Number of carbon atoms from the methyl end of the acyl chain to the nearest double bond.
[e]Methyl group on C_7.
[f]3,7,11,15-Tetramethylhexadecanoic acid.
[g]Isomers not separated.

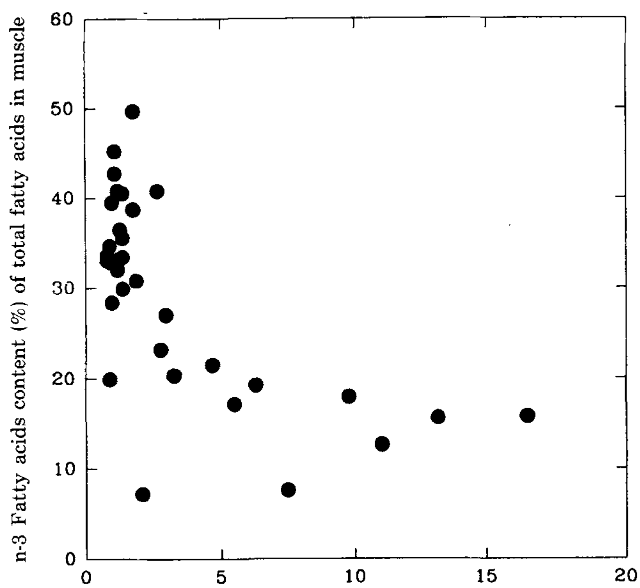

FIG. 1. n-3 Fatty acid content as percentage of total fatty acids in muscle of 33 fish species plotted *vs.* their fat content.

There is an inverse relationship between the n-3 fatty acids content and the total fat content of the species studied. In general, the phospholipid proportion of edible fish tissue is more or less constant. The variation in the fat content is related to the "depot" fat (triglycerides), and fish with higher fat content include a higher amount of triglycerides than lean fish (1). Lipid can be regarded as depot fat (triglycerides), *i.e.*, an energy reserve, when it forms more than 0.5–1% of the fresh muscle weight (14,15). The phospholipids contain higher contents of the polyunsaturated n-3 fatty acids than the triglycerides (5,10,15), but the composition of the depot fat (triglycerides) is more affected by dietary fat than is that of phospholipids (9). Also, it must be considered that the different fatty acids are not absorbed to the same extent (16). This explains the diversity in the fatty acid pattern. In marine fish lipids, the dominant polyunsaturated fatty acids are those of the n-3 series found chiefly in two fatty acids, eicosapentaenoic acid (EPA) and DHA (9). The larger, longer-lived species, such as cod and haddock, appear to accumulate more DHA than EPA in their lipids. In this case, the rule is DHA > EPA. However, fish such as capelin (shorter-living species feeding directly on or near the marine phytoplankton food base, where EPA is prevalent among the fatty acids) accumulate EPA in their depot fat, and only a portion is extended to DHA. Therefore, DHA < EPA (1). This trend can be seen for some of the species investigated (Table 2).

The fact that there is an inverse relationship (Fig. 1) between n-3 fatty acid and fat content implies that it is not less important, from the nutritional point of view, to place attention upon getting species with high-proportions of n-3 fatty acid than to focus primarily on the fat content.

In Table 3, the n-3 fatty acid content is presented as a proportion of the muscle weight. This presentation of the data might give the consumer a better idea of the nutritional value of the different species, because nutritionally important fatty acids are presented as portion of the edible part of the fish. The data on n-3 fatty acid content in species caught in Icelandic waters (Table 3) were compared to the data available in the literature. The n-3 fatty acid contents were in the same range as reported earlier and not higher than expected because of the low sea temperature in the waters around Iceland.

TABLE 3

n-3 Fatty Acids Content (g/100 g muscle) and Lipid Content in the Fish Species Caught in Icelandic Waters and Evaluated for Analysis

Species	Lipid content g/100/g muscle	n-3 Fatty acid content g/100/g muscle
Greater lantern shark	0.8	0.29
Scabbard-fish	0.9	0.17
Deepwater chimaera	0.9	0.29
Dentnose rabbitfish	1.0	0.38
Father lasher	1.0	0.31
Torsk	1.0	0.44
Angler	1.1	0.31
Cod	1.1	0.47
Haddock	1.1	0.41
Four-beard rackling	1.1	0.44
Birdbeak dogfish	1.2	0.37
Starry ray	1.2	0.43
Vahl's eelpot	1.2	0.46
Jelly cat	1.2	0.36
Rabbitfish	1.3	0.40
Large-eyed rabbitfish	1.3	0.42
Whiting	1.3	0.50
Knifenose chimaera	1.4	0.43
Portugese shark	1.4	0.39
Blue ling	1.4	0.47
Mouse catshark	2.1	0.14
Lemmon sole	1.7	0.49
Norway pout	1.7	0.79
Squid	1.9	0.70
Rough dab	2.4	0.46
Catfish	3.3	0.84
Greater silver smelt	3.3	0.63
Redfish	3.9	0.82
Esmark eelpot	5.5	0.88
Spotted catfish	6.3	0.90
Orange roughly	7.5	0.57
Spine eel	11.0	1.30
Greenland halibut	13.1	1.88
Herring	11.9	1.97
Capelin	13.5	1.97
Salmon	18.6	2.20

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